

A proposed chemical storage facility for Victoria

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NOTE: In June 1997, the Victorian Government announced it was abandoning plans to relocate the facility. It has represented a great deal of wasted effort on the part of government, industry and the public. We have no position other than to say that *we are not against the facility - it's simply that the NEED FOR IT HAD NOT BEEN PROVEN.*

Background and not updated

*The case for Point Lillias has first to be proven **and** then prioritised against other public funding activities that could help the petrochemical industry in Victoria. Victorian's looking at why Bass Strait gas (very cheap for many years) failed to stimulate any industry providing only cheap petrol (or government revenue and supernormal profits for some), may find my [introduction](#) to a guest speaker on the North West Shelf gas development of interest.*

Canberra's stand on this could have ramifications on a raft of other national interest issues. We will comment on these later.

We hope the analysis provided with our ~~compliments~~ is of help. Feedback is always welcomed.

The need for a facility

The facility should be predicated on:

1. **Safety need** - to reduce risks to persons and the environment



August 10, 1999

Blaze rocks S.E.

Thousands forced out of homes

By GLEN WHELAN, CAMERON MAXWELL AND JASON VAN RASSEL — Calgary Sun

Massive explosions at a southeast oil recycling plant blackened city skies and sent thousands fleeing from one of Calgary's worst fires ever.



A string of explosions rocked an oil recycling plant Monday, injuring a least five people and sending a huge plume of toxic black smoke into the sky. Police began evacuating residents from nearby neighbourhoods as flames continued to leap from the Hub Oil Plant. Jim Wells, Calgary Sun

Five workers at Hub Oil were injured, one seriously, when the blast rocked the refinery and shook the ground around 5805 17 Ave. S.E., only a few hundred metres away from the nearest houses.

As thousands of Calgarians scattered from the path of the giant toxic cloud that followed, firefighters searched in vain for two plant workers who were inside at the time.

"We're all holding in," said Jackie Ball, the mother-in-law of Ryan Eckhard, a two-year Hub worker who was missing.

"We're hoping it turns out good, but right now we're still waiting. That's the hard part -- the waiting."

The 26-year-old Eckhard has a wife and three girls; a three-year-old and two twins about to turn one.

Family members of the other worker, Ryan Silver, also spent the day in anguish over the fate of their missing loved one, a three-year plant veteran.

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"It's tough," said sister Tanya after hours without any news. "We're all just hoping for the best."

What grew into Calgary's most spectacular fire ever started around 11:30 a.m., likely triggered inside storage barrels at the oil recycling plant.

The blaze forced frustrated firefighters to back away and eventually call five alarms as barrels and containers full of used oil and other chemicals exploded, sending fireballs and smoke up 100 metres in the air.

Police and fire crews blocked off the area and began evacuating residents. Vibrations and heat from the blasts could be felt a kilometre away.

More than 2,000 people were evacuated in an area reaching from 52 St. S.E. east to 68 St., and 17 Ave. S.E. to 8 Ave. S.E.

Disaster Services set up the Penbrooke Community Centre as an evacuation centre, but later redirected displaced residents to Jack James high school when the toxic plumes of smoke loomed closer.

By 5:30 p.m., approximately 350 people had found refuge at the school in the 5800 block of 8 Ave. S.E., where the Red Cross had erected registration stations for evacuees and their families.

Last night, many of those in the shelter were staying overnight.

Health officials also urged people in the city's northeast to close their windows and doors and go to hospital if they felt sick.

Alberta Environmental Protection and the fire department's hazardous materials unit were on scene as the HAWCS helicopter flew overhead to get a closer look.

Kevin Pilger of the environment department said the smoke did not appear to present a serious danger.

Pilger described the fire as "a very clean burn" but said officials were monitoring air quality for carbon monoxide, hydrogen sulphide and sulphur dioxide.

Penbrooke resident Barb Johnson initially headed toward the blast to see what happened, watching from a field northeast of the site.

"There was a brick building on fire -- you could see the flames shooting out," said Johnson, 46.

"There was a white tank that hadn't been touched but all of a sudden it went up -- boom!"

Calling themselves "damn lucky to be alive," injured Hub Oil workers recounted harrowing tales of escaping -- and even rescuing

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others – from the explosion.

Dean Siemens, 29, was thrown to the ground, burned and dazed by the explosion.

"It wasn't until I got up I noticed my hands were burned," said the boiler operator, who figured he was only metres from the blast.

Firefighters, working with oil fire specialists Safety Boss, finally started tackling the blaze at 8:30 p.m., when the last of the oil and chemical containers had detonated.

It took just over a half hour to contain the fire, as 25 firefighters, five pumpers, an ariel sprayer and and airport truck containing 2,000 litres of fire-snuffing foam surrounded the complex and attacked it.

A second wave of men went in at 9:10 p.m. to finish the job.

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August 10, 1999

Disaster plan put to test

City erred on side of caution to keep residents free of danger

By **MICHAEL PLATT and KEVIN MARTIN** -- Calgary Sun

The city's seldom-used disaster services plan kicked into gear for yesterday's spectacular fire as health and environment officials calmed fears the huge plume of smoke was dangerously toxic.

Kevin Pilger, of Alberta Environment, said regular ground level air checks as the fire blazed detected no abnormal levels of toxic fumes.

"We did pick up some levels of carbon monoxide but nothing more than you'd find in normal traffic.

"I don't suspect we will have long term environmental impacts."

Calgary's medical officer of health agreed.

"The levels are well below the acceptable levels that Alberta Environment sets," said Dr. Brent Friesen of the Calgary Regional Health Authority.

Favourable weather conditions -- clear skies and steady breezes -- helped ensure the smoke was adequately dissipated, said Pilger.

Firefighters were initially responsible for triggering the emergency process, a city-wide alert reserved only for the most dire of Calgary disasters.

"The firefighters reached the scene and called in a second alarm," said Brian Wieser, a disaster services officer with the city.



An oil storage tank erupts in a fireball yesterday at an oil recycling plant in Calgary.
CARLOS AMAT, Sun Media

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"We then followed with the Calgary Peace Time Disaster plan, although we (didn't) declare a State of Emergency."

All hospitals were placed on alert, a process that reserves emergency room space for possible casualties, while four CRHA nurses were dispatched to the scene.

Community and Social Development was then brought in to co-ordinate evacuation of nearby communities and provide food and shelter.

The Red Cross was also alerted, and a contact line -- 541-6100 -- has been set up to locate missing people and reunite families.

The city continues to monitor the situation, and Wiese said the disaster team is erring on the side of caution, because so many people are at risk.

The CRHA will also do further tests to find out whether any dioxins were released in the fire.

Anyone seeking further information can call the CRHA at 265-4636.

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Forced to flee

Waiting game ends

Neighbours saw plant as headache

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August 10, 1999

Blasts rock cowtown

Five injured, two missing, 2,000 flee homes

CALGARY (CP) -- The sky above Calgary filled with a billowing cloud of toxic black smoke Monday as a string of explosions rocked an oil recycling plant.

Two workers were missing and one man was admitted to hospital with burns to his back and arms. Three other men and a woman were treated and released.

More than 2,000 residents from nearby neighbourhoods were evacuated as flames leapt from the Hub Oil plant in the city's southeast. Vibrations and heat from the lunch-hour blasts could be felt a kilometre away.

The evacuation was not mandatory, however, and at some homes children played in their yards as thin blobs of cooled oil dripped from the sky.

Brent Friesen, medical health officer for the Calgary Regional Health Authority, said preliminary air quality testing showed nothing alarming, but he said he couldn't give specific numbers.

"It is well within accepted levels," he said. "As the fire is extinguished we might see some more pollutants coming until it is completely put out."

Friesen noted the plant, which is within city limits, has long been a source of worry for neighbours, adding the health authority and Alberta Environment recently recommended against the building of a



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240-unit
condominium
complex next door.

A string of explosions rocked an oil recycling plant Monday, injuring a least five people and sending a huge plume of toxic black smoke into the sky. Police began evacuating residents from nearby neighbourhoods as flames continued to leap from from the Hub Oil Plant.

"Residents in the area ... complained of odours and other problems," he said. "I think this does reinforce the need to look at the industrial activity that is occurring and making sure that the setback distance for nearby residences provides an adequate degree of protection."

Jim Wells, Calgary Sun

Clint Sheffield, 69, who was shaving in his home a block away when the blast knocked pictures off the wall, called it an environmental disaster waiting to happen.

"It (the plant) will be gone now," said Sheffield. "People will get their wish."

Onkar Ghuman, who runs a nearby gas station, said he feared for his life.

"I saw sunshine and then this thundering, then this big ball of fire keep spreading, coming toward me," Ghuman told CBC Newsworld. "I saw death right there in my eyes. I thought I was a goner."

One Hub Oil worker said that when he heard the first blast, he hit the ground and then ran.

"I never ran so hard yelling, 'Oh my God! Oh my God!'" said the man, who identified himself only as Chris.

"There were things exploding beside me."

The first fire crew that arrived on the scene was forced to abandon its ladder truck, which was badly damaged in the inferno.

Capt. John Conley of the Calgary fire department said the blaze was believed to have started in a couple of oil storage tanks, but he had no word on the cause.

In a kind of chain reaction, as many as 15 or 20 more tanks blew up throughout the afternoon, shooting debris into the air each time. At one point an orange fireball rocketed 100 metres straight up.

A heavy diesel smell hung in the air as crews from 26 firefighting rigs — including foam trucks brought in from the international airport — stood by.

Eight hours after the blaze started, 28 crew members and a line of fire-fighting equipment lined up as the assault on the inferno was launched.

Officials from two oilfield fire-fighting firms — including Safety Boss, which gained fame fighting oil fires in Kuwait after the Gulf War — were also on hand to volunteer their services.



An oil storage tank erupts in a fireball yesterday at an oil recycling plant in Calgary.
CARLOS AMAT, Sun Media

Police went door to door to evacuate area residents, directing them first to a community centre and then to two different high schools as the smoke shifted.

Brian Wiese, a disaster services officer for the city, said the smoke would contain hydrocarbons, which carry large amounts of carbon monoxide.

"People don't have to leave but it's best that they don't stay home," he said.

At the evacuation centre, hamburgers from nearby fast-food restaurants were gobbled up almost as quickly as they were delivered.

Officials discouraged evacuees from bringing food from home out of fear it might be contaminated.

Further afield, health officials urged people in the city's northeast to close their windows and doors and go to hospital if they felt sick.

Alberta Environment and the fire department's hazardous materials unit were on scene as helicopters flew overhead to get a closer look.

There was traffic chaos as evacuees trying to figure out where to go ran into residents driving back from work to see if their homes and families were OK.

"It's poor organization," said Sheffield. "Everyone is just driving around in circles. They don't tell you where to go."

One RCMP officer was clearly frustrated as she tried to direct traffic: "This isn't poorly planned — it's just mayhem," she said.

Near the evacuation centres, some residents sat on their front porches, watching the smoke and drinking beer.

"May as well sit back and have a cold one," said Stan Bedstrom.

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News **Calgary Herald** **Front Page**

Tuesday 10 August 1999

Deadly blasts rock Hub Oil

Juliet Williams, Calgary Herald

Firefighters brought a massive blaze at an oil recycling plant under control just before 11 p.m. Monday — 10102 hours after the fire erupted, triggering more than 40 explosions and forcing the evacuation of 250 people in southeast Calgary.

At press time, firefighters expected to be at the scene all night extinguishing hot spots.

Two men, employees of Hub Oil Co. Ltd., at 5805 17th Ave. S.E., were still unaccounted for at 11 p.m. Monday night and feared dead.

"We'd like to hope for a miracle," fire chief Wayne Morris said at a late-night news conference.

The fire began about 11:30 a.m., sending a huge plume of black smoke into the sky. Blasts rocked the site throughout the day, as tanks of oil, diesel fuel, jet fuel, propane and sulphuric acid exploded.

The first shift of seven rigs and 25 firefighters began advancing on the blaze at 8:30 p.m., using water and fire-fighting foam to bring down the largest flames



Shannon Oatway, Calgary Herald / Fireballs erupted throughout Monday afternoon at Hub Oil, a recycling plant at 5805 17th Ave. S.E. Two men are feared dead and five other people were injured in the inferno that could be seen 50 kilometres away.



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down the largest refinery.

Fire officials waited for the final blasts before moving in. They were given the all clear by Morris about 6:45 p.m., and began their assault at 8:30.

"We decided we had a safe window to get in," said fire Capt. John Conley. "In 21 years I've never seen anything of this magnitude."

The department lost an aerial truck, which was consumed by flames after explosions forced firefighters back.

The two missing men did not report to family or friends, or at any of the emergency stations.

Another five people — four men and a woman who were working at Hub Oil — suffered burns and shrapnel wounds. One man was admitted to Peter Lougheed hospital with extensive burns to his back.

Premier Ralph Klein said he was keeping close tabs on the tragedy from Quebec, where he was attending the annual premiers conference. He pledged whatever help he could offer.

"Requests from the City of Calgary for further assistance from the Government of Alberta will be handled swiftly," Klein said.

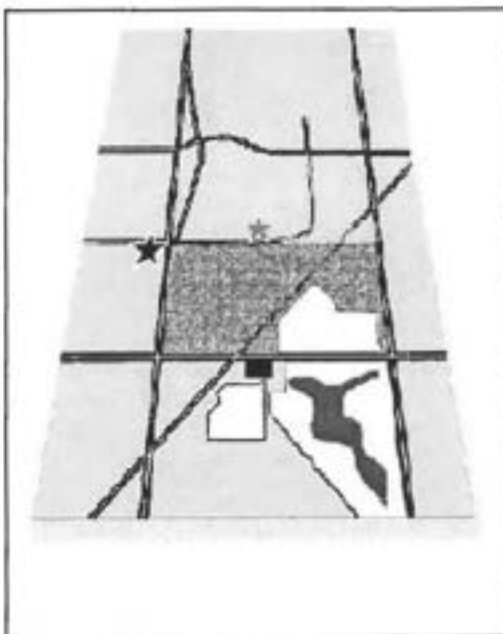
It was the largest industrial fire ever seen in Calgary, with flames reaching 125 metres. The one-acre site encompasses an entire square city block.

About 200 people were evacuated from the community of Penbrooke Meadows to the north of the massive plume, but city officials said as many as 1,000 may have left their homes.

Photo: Larry MacDougall / Burning Hub Oil refinery



Shannon Duncan, Calgary Herald / A police officer and firefighter comfort a man near the Hub Oil refinery fire on Monday.



Evacuation Area; Hub Oil Company Ltd.

At about 10:30 p.m. "the fire department announced that part of the evacuation zone was deemed clear enough to come home," said Chris Branch of the city of Calgary community and social development department late Monday evening. "The entire zone will reopen tomorrow morning, but they don't know when."

Initially crews sent evacuees to Penbrooke Meadows Community Centre.

They were later transferred to Jack James Junior High School, 5105 8 Ave. S.E., and Albert Park/Radisson Heights community centre to get them out of the path of the smoke.

"It's been a little tough to do," said Conley of the co-ordination required to move large numbers of residents.

Noella Hayden, a resident of a trailer park in the 6200 block of 17th Avenue, said she was sleeping with her baby when she heard the explosion.

Within moments, she had been told by someone to go to Jack James High School. "We were taken care of all day. We were given hotdogs, chips and pop from the cafeteria, with fruit for the kids."

Verna Walsh, who lives in a trailer on 17th Avenue with her husband and her son's common-law wife Elizabeth Wells, complained that authorities seemed confused about where evacuees should go.

"A woman came to the door and told her to evacuate," said Walsh, who was at work at the time. "They told her to walk east. They didn't tell her where to go. She's from Peterborough, Ont. She's only been here five days."

"They could have got a bus into the trailer park to bring people out, but there was no organization," said Wells's husband, Michael van Eerden.

The family expected to spend the night at the Highlander Hotel in northwest Calgary.

Luella Blair said she was told "we have to come back in the morning and wait to find out if we can go home." At press time, she didn't know where she would spend the night.

Late Monday, Conley said most residents along 8th Avenue between 52nd and 68th Streets had been allowed to return to their homes. Police also re-opened 52nd Street after closing it for most of the day.

Nearby businesses and homes were immediately evacuated, as police used loudspeakers to get hundreds of onlookers away from the scene.

Jason Hannah, a city worker, was taking his lunch break from replacing water mains in a trailer about two blocks from the explosion on 17th Avenue when the trailer was jolted.

He stepped outside to see a great ball of fire and large pieces of shrapnel flying through the air.

"I'm scared to death," said Hannah. "My heart jumped about three beats. I don't ever want to come back to this site again."

Cory Skillen and Mark Coates ran for their lives from the site after windows shattered and supplies fell from shelves in their warehouse adjacent to

Hub Oil. "It was too hot. We could feel it burning," said Skillen.

By 5 p.m., fire officials warned residents to stay indoors all night if they were within an area of roughly 100 square kilometres northeast of the fire because of health concerns, and advised people to close all windows and doors.

Police closed an 18-block by 15-block area.

Rachelle Webb rushed to the scene to look for her son Christian Webb, 17, who was working at his job crushing oil filters at Hub Oil. He escaped without injury, she learned in a frantic phone call just minutes after hearing about the explosion.

Webb said Christian later told her: "Mom, I wanted to go through a window. There were flames everywhere."

"He said it was like (the movie) Backdraft. He didn't know where to go."

The searing heat from gigantic flames could be felt from eight blocks away whenever one of the storage tanks blew up, and the roaring noise rocked buildings and vehicles in the area.

"It shook the whole building," said Jim Willis, a plant manager at neighbouring Meyers sheet metal. "There was a loud explosion . . . and all our power went off. We just asked everybody to get out of the building."

Shirley Heaston, who lives in Penbrooke Meadows, said: "My entire house shook. It was like a bomb going off and I thought the house was in the process of blowing up. My computer went on and off three times."

As many as 80 city police officers assisted by Strathmore Mounties cordoned off roads and cleared people from the area.

At one point, 58 firefighters in 23 trucks -- including the airport units -- were on standby.

The fire was contained to the one-acre site thanks to moderate winds that sent the plume in a northerly direction for most of the day.

"We've just seen a succession of tank after tank exploding," fire department spokesman Capt. John Conley said earlier in the day. "It's very frustrating for us to sit by, but the possibility of injuries is so dramatic we can't go in."

Alberta Environment sent in a crew to monitor health and environmental effects from the fire and smoke. Oil droplets were reported falling on houses north of the site, said Kevin Pilger, an Alberta Environment investigator.

Pilger said hydrogen sulphide and sulphur dioxide were the major health concerns. Conley said tests had confirmed the air quality met safety standards.

The HAWC1 police helicopter flew over the fire all day with Hub Oil officials to get a clear picture of which tanks had exploded. Firefighters waited until they believed all the tanks had exploded -- especially a 5,000 gallon tank of sulphuric acid.

At press time, Hub Oil owner Diane Lewis could not be contacted by the Herald.



Tuesday 10 August 1999

Two feared dead in blasts

Thousands of Calgary residents evacuated

Reg Curren and Carol Harrington
CP

The sky above Calgary filled with a billowing cloud of toxic black smoke for almost 10 hours Monday after a string of explosions rocked an oil-recycling plant, leaving two workers missing.

The two men had been on the job earlier in the day at Hub Oil.

One other man was admitted to hospital with burns to his back and arms. Three men and a woman were treated for burns and shrapnel wounds.

Late Monday, the fire was finally extinguished after a 75-minute, all-out assault by a crew of 28 firefighters and a string of huge pumper and foam trucks.

More than 2,000 residents from nearby neighbourhoods were evacuated as flames leapt from the plant in the city's southeast. Most were eventually allowed home, but about 250 from homes nearest the plant were told to find other accommodations for the night.

Relatives of the two missing men were trying to remain optimistic.

"We're hoping it turns out good, but right now we're still waiting," said Jackie Ball, the mother-in-law of Ryan Eckhard, 26, who had worked at the plant for two years.

"That's the hard part --the waiting."

Eckhard has a wife and three girls; a three-year-old and twins about to turn a year old.

"It's tough," said Tanya Silver, sister of the second man, three-year plant veteran Ryan Silver. "We're all just hoping for the best."

Vibrations and heat from the more than 40 lunch-hour blasts could be felt a kilometre away.



CP / A string of explosions Monday sent toxic smoke spewing over Calgary.



The evacuation was not mandatory, however, and at some homes children played in their yards as thin blobs of cooled oil dripped from the sky.

Brent Friesen, medical health officer for the Calgary Regional Health Authority, said preliminary air quality testing showed nothing alarming, but he said he couldn't give specific numbers.

"It is well within accepted levels," he said. "As the fire is extinguished we might see some more pollutants coming until it is completely put out."

Friesen noted the plant, which is within city limits, has long been a source of worry for neighbours, adding the health authority and Alberta Environment recently recommended against the building of a 240-unit condominium complex next door.

"Residents in the area É complained of odours and other problems," he said. "I think this does reinforce the need to look at the industrial activity that is occurring and making sure that the setback distance for nearby residences provides an adequate degree of protection."

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Officials from two oilfield fire-fighting firms -- including Safety Boss, which gained fame fighting oil fires in Kuwait after the Gulf War -- were also on hand to volunteer their services.


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Disclaimer: These guidelines were developed under contract using generally accepted secondary sources. The protocol used by the contractor for surveying these data sources was developed by the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Department of Energy (DOE). The information contained in these guidelines is intended for reference purposes only. None of the agencies have conducted a comprehensive check of the information and data contained in these sources. It provides a summary of information about chemicals that workers may be exposed to in their workplaces. The secondary sources used for supplements III and IV were published before 1992 and 1993, respectively, and for the remainder of the guidelines the secondary sources used were published before September 1995. This information may be superseded by new developments in the field of industrial hygiene. Therefore readers are advised to determine whether new information is available.

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CHLORINE

INTRODUCTION

This guideline summarizes pertinent information about chlorine for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine whether new information is available.

SUBSTANCE IDENTIFICATION

* Formula

Cl₂

* Structure

Not applicable.

* Synonyms

Bertholite, molecular chlorine

* Identifiers

1. CAS No.: 7782-50-5

2. RTECS No.: PG2100000

3. DOT UN: 1017 20

4. DOT label: Poison gas

* Appearance and odor

Chlorine is a greenish-yellow gas with a characteristic pungent odor. It condenses to an amber liquid at approximately -34 degrees C (-29.2 degrees F) or at high pressures. Odor thresholds ranging from 0.08 to part per million (ppm) parts of air have been reported. Prolonged exposures may result in olfactory fatigue.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 70.9

2. Boiling point (at 760 mm Hg): -34.6 degrees C (-30.28 degrees F)

3. Specific gravity (liquid): 1.41 at 20 degrees C (68 degrees F) and a pressure of 6.86 atm

4. Vapor density: 2.5

5. Melting point: -101 degrees C (-149.8 degrees F)

6. Vapor pressure at 20 degrees C (68 degrees F): 4,800 mm Hg

7. Solubility: Slightly soluble in water; soluble in alkalis, alcohols, and chlorides.

8. Evaporation rate: Data not available.

* Reactivity

1. Conditions contributing to instability: Cylinders of chlorine may burst when exposed to elevated temperatures. Chlorine in solution forms a corrosive material.

2. Incompatibilities: Flammable gases and vapors form explosive mixtures with chlorine. Contact between chlorine and many combustible substances (such as gasoline and petroleum products, hydrocarbons, turpentine, alcohols, acetylene, hydrogen, ammonia, and sulfur), reducing agents, and finely divided metals may cause fires and explosions. Contact between chlorine and arsenic, bismuth, boron, calcium, activated carbon, carbon disulfide, glycerol, hydrazine, iodine, methane, oxomonoisilane, potassium, propylene, and silicon should be avoided. Chlorine reacts with hydrogen sulfide and water to form hydrochloric acid, and it reacts with carbon monoxide and sulfur dioxide to form phosgene and sulfuryl chloride. Chlorine is also incompatible with moisture, steam, and water.

3. Hazardous decomposition products: None reported.

4. Special precautions: Chlorine will attack some forms of plastics, rubber, and coatings.

* Flammability

Chlorine is a non-combustible gas.

The National Fire Protection Association has assigned a flammability rating of 0 (no fire hazard) to chlorine; however, most combustible materials will burn in chlorine.

1. Flash point: Not applicable.

2. Autoignition temperature: Not applicable.

3. Flammable limits in air: Not applicable.

4. Extinguishant: For small fires use water only; do not use dry chemical or carbon dioxide. Contain and let large fires involving chlorine burn. If fire must be fought, use water spray or fog.

Fires involving chlorine should be fought upwind from the maximum distance possible. Keep unnecessary people away; isolate the hazard area and deny entry. For a massive fire in a cargo area, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from the area and let the fire burn. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of chlorine may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool fire exposed containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving chlorine.

EXPOSURE LIMITS

* OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for chlorine is 1 ppm (3 milligrams per cubic meter (mg/m³)) as a ceiling limit. A worker's exposure to chlorine shall at no time exceed this ceiling level [29 CFR 1910.1000, Table Z-1].

* NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for chlorine of 0.5 ppm mg/m³ as a TWA for up to a 10-hour workday and a 40-hour workweek and a short-term exposure limit (STEL) of 1 ppm (3 mg/m³) [NIOSH 1992].

* ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned chlorine a threshold limit value (TLV) of 0.5 ppm (1.5 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek and a short-term exposure limit (STEL) of 1.0 ppm (2.9 mg/m³) for periods not to exceed 15 minutes. Exposures at the STEL concentration should not be repeated more than four times a day and should be separated by intervals of at least 60 minutes [ACGIH 1994, p. 15].

* Rationale for Limits

The NIOSH limits are based on the risk of severe eye, mucous membrane and skin irritation [NIOSH 1992].

The ACGIH limits are based on the risk of eye and mucous membrane irritation [ACGIH 1991, p. 254].

HEALTH HAZARD INFORMATION

* Routes of Exposure

Exposure to chlorine can occur through inhalation, ingestion, and eye or skin contact [Genium 1992].

* Summary of toxicology

1. Effects on Animals: Chlorine is a severe irritant of the eyes, mucous membranes, skin, and lungs in experimental animals. The 1 hour LC₅₀ is 239 ppm in rats and 137 ppm in mice [Sax and Lewis 1989]. Animals surviving sublethal inhalation exposures

for 15 to 193 days showed marked emphysema, which was associated with bronchiolitis and pneumonia [Clayton and Clayton 1982]. Chlorine injected into the anterior chamber of rabbits' eyes resulted in severe damage with inflammation, opacification of the cornea, atrophy of the iris, and injury to the lens [Grant 1986].

2. Effects on Humans: Severe acute effects of chlorine exposure in humans have been well documented since World War I when chlorine gas was used as a chemical warfare agent. Other severe exposures have resulted from the accidental rupture of chlorine tanks. These exposures have caused death, lung congestion, and pulmonary edema, pneumonia, pleurisy, and bronchitis [Hathaway et al. 1991]. The lowest lethal concentration reported is 430 ppm for 30 minutes [Clayton and Clayton 1982]. Exposure to 15 ppm causes throat irritation, exposures to 50 ppm are dangerous, and exposures to 1000 ppm can be fatal, even if exposure is brief [Sax and Lewis 1989; Clayton and Clayton 1982]. Earlier literature reported that exposure to a concentration of about 5 ppm caused respiratory complaints, corrosion of the teeth, inflammation of the mucous membranes of the nose and susceptibility to tuberculosis among chronically-exposed workers. However, many of these effects are not confirmed in recent studies and are of very dubious significance [ACGIH 1991]. A study of workers exposed to chlorine for an average of 10.9 years was published in 1970. All but six workers had exposures below 1 ppm; 21 had TWAs above 0.52 ppm. No evidence of permanent lung damage was found, but 9.4 percent had abnormal EKGs compared to 8.2 percent in the control group. The incidence of fatigue was greater among those exposed above 0.5 ppm [ACGIH 1991]. In 1981, a study was published involving 29 subjects exposed to chlorine concentrations up to 2.0 ppm for 4- and 8-hour periods. Exposures of 1.0 ppm for 8 hours produced statistically significant changes in pulmonary function that were not observed at a 0.5 ppm exposure concentration. Six of 14 subjects exposed to 1.0 ppm for 8 hours showed increased mucous secretions from the nose and in the hypopharynx. Responses for sensations of itching or burning of the nose and eyes, and general discomfort were not severe, but were perceptible, especially at the 1.0 ppm exposure level [ACGIH 1991]. A 1983 study of pulmonary function at low concentrations of chlorine exposure also found transient decreases in pulmonary function at the 1.0 ppm exposure level, but not at the 0.5 ppm level [ACGIH 1991]. Acne (chloracne) is not unusual among persons exposed to low concentrations of chlorine for long periods of time. Tooth enamel damage may also occur [Parmeggiani 1983]. There has been one confirmed case of myasthenia gravis associated with chlorine exposure [NLM 1995].

* Signs and symptoms of exposure

1. Acute exposure: Acute exposure to low levels of chlorine results in eye, nose, and throat irritation, sneezing, excessive salivation, general excitement, and restlessness. Higher concentrations causes difficulty in breathing, violent coughing, nausea, vomiting, cyanosis, dizziness, headache, choking, laryngeal edema, acute tracheobronchitis, chemical pneumonia. Contact with the liquid can result in frostbite burns of the skin and eyes [Genium 1992].

2. Chronic exposure: Chronic exposure to low levels of chlorine gas can result in a dermatitis known as chloracne, tooth enamel corrosion, coughing, severe chest pain, sore throat, hemoptysis and increased susceptibility to tuberculosis [Genium 1992].

EMERGENCY MEDICAL PROCEDURES

* Emergency medical procedures: [NIOSH to supply]

5. Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures, the location and proper use of

emergency equipment, and methods of protecting themselves during rescue operations.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve chlorine and lead to worker exposures to this substance:

* The manufacture and transportation of chlorine

Use as a chlorinating and oxidizing agent in organic and inorganic synthesis; in the manufacture of chlorinated solvents, automotive antifreeze and antiknock compounds, polymers (synthetic rubber and plastics), resins, elastomers, pesticides, refrigerants, and in the manufacture of rocket fuel

Use as a fluxing, purification, and extraction agent in metallurgy

Use as a bacteriostat, disinfectant, odor control, and demulsifier in treatment of drinking water, swimming pools, and in sewage

Use in the paper and pulp, and textile industries for bleaching cellulose for artificial fibers; use in the manufacture of chlorinated lime; use in tinning and dezincing iron; use to shrink-proof wool

Use in the manufacture of pharmaceuticals, cosmetics, lubricants, flameproofing, adhesives, in special batteries containing lithium or zinc, and in hydraulic fluids; use in the processing of meat, fish, vegetables, and fruit

Use as bleaching and cleaning agents, and as a disinfectant in laundries, dishwashers, cleaning powders, cleaning dairy equipment, and bleaching cellulose

Methods that are effective in controlling worker exposures to chlorine, depending on the feasibility of implementation, are as follows:

* Process enclosure Local exhaust ventilation General dilution ventilation Personal protective equipment

Workers responding to a release or potential release of a hazardous substance must be protected as required by paragraph (g) of OSHA's Hazardous Waste Operations and Emergency Response Standard [29 CFR

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.
4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.
5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL SURVEILLANCE

OSHA is currently developing requirements for medical surveillance. When these requirements are promulgated, readers should refer to them for additional information and to determine whether employers whose employees are exposed to chlorine are required to implement medical surveillance procedures.

* Medical Screening

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures. To detect and control work-related health effects, medical evaluations should be performed (1) before job placement, periodically during the term of employment, and (3) at the time of job transfer or termination.

* Preplacement medical evaluation

Before a worker is placed in a job with a potential for exposure to chlorine, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, eyes, teeth, respiratory system, and cardiovascular system. Medical surveillance for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society.

A preplacement medical evaluation is recommended to assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to chlorine at or below the prescribed exposure limit. The health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions which should not be regarded as absolute contraindications to job placement include a history and other findings consistent with diseases of the skin, eyes, teeth, respiratory system, or cardiovascular system.

* Periodic medical evaluations

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to chlorine exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of chlorine on the skin, eyes, teeth, respiratory system, or cardiovascular system. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

* Termination medical evaluations

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

* Biological monitoring

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. No biological monitoring test acceptable for routine use has yet been developed for chlorine.

WORKPLACE MONITORING AND MEASUREMENT

Determination of a worker's exposure to airborne chlorine is made using a midsize fritted glass bubbler (MFGB) containing a 0.1 percent solution of sulfamic acid. Samples are collected at a maximum flow rate of 1.0 liter/minute until a maximum collection volume of 15 liters is collected for short-term (STEL or ceiling) samples, or 300 liters is collected for TWA samples. Analysis is conducted using an ion specific electrode (ISE). This method is described in the OSHA Computerized Information System (OSHA and is fully validated. NIOSH Method No. 6011 (for chlorine or bromine) can also be used for the determination of a worker's exposure to airborne chlorine. This method requires sample collection on a silver membrane filter using flow rates of between 0.3 and 1.0 liter/minute until a minimum collection volume of 2 liters or a maximum collection volume of 15 liters is reached. Analysis for this method is conducted using ion chromatography [NIOSH 1994].

PERSONAL HYGIENE PROCEDURES

If chlorine contacts the skin, workers should flush the affected area immediately with plenty of water, followed by washing with soap and water.

Clothing contaminated with chlorine should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the hazardous properties of chlorine, particularly its potential for causing severe irritation to the eyes, skin, and mucous membranes.

A worker who handles chlorine should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, applying cosmetics, or taking medication.

Workers should not eat, drink, use tobacco products, apply cosmetics, or take medication in areas where chlorine or a solution containing chlorine is handled, processed, or stored.

STORAGE

Chlorine should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard [29 CFR 1910.1200]. Containers of chlorine should be protected from exposure to weather, extreme temperatures changes, and physical damage, and they should be stored separately from flammable gases and vapors, combustible substances (such as gasoline and petroleum products, hydrocarbons, turpentine, alcohols, acetylene, hydrogen, ammonia, and sulfur), reducing agents, finely divided metals, arsenic, bismuth, boron, calcium, activated carbon, carbon disulfide, glycerol, hydrazine, iodine, methane,

oxomonoisilane, potassium, propylene, silicon, hydrogen sulfide and water, carbon monoxide and sulfur dioxide, moisture, steam, and water. Workers handling and operating chlorine containers, cylinders, and tank wagons should receive special training in standard safety procedures for handling compressed corrosive gases. All pipes and containment used for chlorine service should be regularly inspected and tested. Empty containers of chlorine should have secured protective covers on their valves and should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving chlorine, persons not wearing protective equipment and fully-encapsulating, vapor-protective clothing should be restricted from contaminated areas until cleanup has been completed. The following steps should be undertaken following a spill or leak:

1. Notify safety personnel.
2. Remove all sources of heat and ignition.
3. Keep all combustibles (wood, paper, oil, etc.) away from the leak.
4. Ventilate potentially explosive atmospheres.
5. Evacuate the spill area for at least 50 feet in all directions.
6. Find and stop the leak if this can be done without risk; if not, move the leaking container to an isolated area until gas has dispersed. The cylinder may be allowed to empty through a reducing agent such as sodium bisulfide and sodium bicarbonate.
7. Use water spray to reduce vapors; do not put water directly on the leak or spill area.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

* Emergency planning requirements

Employers owning or operating a facility at which there are 100 pounds or more of chlorine must comply with EPA's emergency planning requirements [40 CFR Part 355.30].

* Reportable quantity requirements for hazardous releases

A hazardous substance release is defined by EPA as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers) of hazardous substances. In the event of a release that is above the reportable quantity for that chemical, employers are required to notify the proper Federal, State, and local authorities [40 CFR

The reportable quantity of chlorine is 10 pounds. If an amount equal to or greater than this quantity is released within a 24-hour period in a manner that will expose persons outside the facility, employers are required to do the following:

Notify the National Response Center immediately at (800) or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6]. Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40]. Notify the community emergency coordinator to the local emergency planning committee (or relevant local emergency response personnel) of any area likely to be affected by the release [40

CFR 355.40].

* Community right-to-know requirements

Employers who own or operate facilities in SIC codes 20 to 39 that employ 10 or more workers and that manufacture 25,000 pounds or more of chlorine per calendar year or otherwise use 10,000 pounds or more of chlorine per calendar year are required by EPA [40 CFR Part 372.30] to submit a Toxic Chemical Release Inventory form (Form R) to EPA reporting the amount of chlorine emitted or released from their facility annually.

* Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA has specifically listed many chemical wastes as hazardous. Although chlorine is not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (703) 412-9810 (in the Washington, D.C. area) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

RESPIRATORY PROTECTION

* Conditions for respirator use

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of chlorine exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should only use

respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

* Respiratory protection program

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training

of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the latest edition of the NIOSH Respirator Decision Logic [NIOSH 1987b] and the NIOSH Guide to Industrial Respiratory Protection [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Workers should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with chlorine. The selection of the appropriate personal protective equipment (PPE) (e.g., gloves, sleeves, encapsulating suits) should be based on the extent of the worker's potential exposure to chlorine. The resistance of various materials to permeation by both chlorine liquid and chlorine gas is shown below:

Material Breakthrough time (hr) Chlorine liquid responder

Chlorine gas butyl rubber neoprene teflon viton saranex barricade chemrel responder trellchem HPS nitrile rubberH (PE/EVAL) polyethylene polyvinyl chloride

Material is estimated (but not tested) to provide at least four hours of protection. Not recommended, degradation may occur.

To evaluate the use of these PPE materials with chlorine, users should consult the best available performance data and manufacturers' recommendations. Significant differences have been demonstrated in the chemical resistance of generically similar PPE materials (e.g., butyl) produced by different manufacturers. In addition, the chemical resistance of a mixture may be significantly different from that of any of its neat components.

Any chemical-resistant clothing that is used should be periodically evaluated to determine its effectiveness in preventing dermal contact. Safety showers and eye wash stations should be located close to operations that involve chlorine.

Splash-proof chemical safety goggles or face shields (20 to 30 cm long, minimum) should be worn during any operation in which a solvent, caustic, or other toxic substance may be splashed into the eyes.

In addition to the possible need for wearing protective outer apparel (e.g., aprons, encapsulating suits), workers should wear work uniforms, coveralls, or similar full-body coverings that are laundered each day. Employers should provide lockers or other closed areas to store work and street clothing separately. Employers should collect work clothing at the end of each work shift and provide for its laundering. Laundry personnel should be informed about the potential hazards of handling contaminated clothing and instructed about measures to minimize their health risk.

Protective clothing should be kept free of oil and grease and should be inspected and maintained regularly to preserve its effectiveness.

Protective clothing may interfere with the body's heat dissipation, especially during hot weather or during work in hot or poorly ventilated work environments.

REFERENCES

ACGIH [1991]. Documentation of the threshold limit values and biological exposure indices. 6th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ACGIH [1994]. 1994-1995 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ATS [1987]. Standardization of spirometry -- 1987 update. American Thoracic Society. *Am Rev Respir Dis*

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Clayton G, Clayton F [1981-1982]. *Patty's industrial hygiene and toxicology*. 3rd rev. ed. New York, NY: John Wiley & Sons.

DOT [1993]. 1993 Emergency response guidebook, guide 20. Washington, DC: U.S. Department of Transportation, Office of Hazardous Materials Transportation, Research and Special Programs Administration.

Forsberg K, Mansdorf SZ [1993]. *Quick selection guide to chemical protective clothing*. New York, NY: Van Nostrand Reinhold.

Genium [1992]. Material safety data sheet No. 53. Schenectady, NY: Genium Publishing Corporation.

Grant WM [1986]. *Toxicology of the eye*. 3rd ed. Springfield, IL: Charles C Thomas.

Hathaway GJ, Proctor NH, Hughes JP, and Fischman ML [1991]. *Proctor and Hughes' chemical hazards of the workplace*. 3rd ed. New York, NY: Van Nostrand Reinhold.

Lewis RJ, ed. [1993]. *Lewis condensed chemical dictionary*. 12th ed. New York, NY: Van Nostrand Reinhold Company.

Lide DR [1993]. *CRC handbook of chemistry and physics*. 73rd ed. Boca Raton, FL: CRC Press, Inc.

Mickelsen RL, Hall RC [1987]. A breakthrough time comparison of nitrile and neoprene glove materials produced by different glove manufacturers. *Am Ind Hyg Assoc J* 941-947

Mickelsen RL, Hall RC, Chern RT, Myers JR [1991]. Evaluation of a simple weight-loss method for determining the permeation of organic liquids through rubber films. *Am Ind Hyg Assoc J* 445-447

NFPA [1986]. *Fire protection guide on hazardous materials*. 9th ed. Quincy, MA: National Fire Protection Association.

NIOSH [1987a]. *NIOSH guide to industrial respiratory protection*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-116.

NIOSH [1987b]. *NIOSH respirator decision logic*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108.

NIOSH [1992]. *Recommendations for occupational safety and health: Compendium of policy documents and statements*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

NIOSH [1994]. *NIOSH manual of analytical methods*. 4th ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113.

NIOSH [1995]. *Registry of toxic effects of chemical substances: Chlorine*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, Technical Information Branch.

NJDH [1992]. *Hazardous substance fact sheet: Chlorine*. Trenton, NJ: New Jersey Department of Health.

NLM [1995]. *Hazardous substances data bank: Chlorine*. Bethesda, MD: National Library of Medicine.

USCO	Chemical Information	Respirator
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A Service from the [Canadian Centre for Occupational Health & Safety \(CCOHS\)](#)[Chemicals & Materials](#) > [Chemical Profiles](#) > [Chlorine](#) > Working Safely with Chlorine

Working Safely with Chlorine

- [What is the American Conference of Governmental Industrial Hygienists \(ACGIH\) recommended exposure limit for Chlorine?](#)
- [What are the fire and explosion dangers associated with Chlorine?](#)
- [Is Chlorine stable when exposed to air, moisture, or heat?](#)
- [Are there any conditions to avoid when using Chlorine?](#)
- [Does Chlorine have an odour threshold \(at what level can I smell it\)?](#)
- [Is the odour of Chlorine reliable as a warning property?](#)
- [How can I work with Chlorine safely?](#)
- [What can be done to control hazardous conditions?](#)

▲What is the American Conference of Governmental Industrial Hygienists (ACGIH) recommended exposure limit for Chlorine?

TIME-WEIGHTED AVERAGE (TLV-TWA): 0.5 ppm (1.5 mg/m³) - Carcinogenicity Designation A4

SHORT-TERM EXPOSURE LIMIT (TLV-STEL) : 1 ppm (2.9 mg/m³) - Carcinogenicity Designation A4

TLV Basis - CRITICAL EFFECT(S): Irritation

CARCINOGENICITY DESIGNATION A4 - Not Classifiable as a Human Carcinogen: Inadequate data on which to classify the substance as a human and/or animal carcinogen.

NOTE: In many jurisdictions, exposure limits are similar to the ACGIH TLVs. Since the manner in which exposure limits are established, interpreted, and implemented can vary, obtain detailed information from the appropriate government agency in each jurisdiction.

▲What are the fire and explosion dangers associated with Chlorine?

Chlorine does not burn. However, chlorine is a strong oxidizing agent and poses a serious fire and explosion risk because it promotes combustion, like oxygen. Most combustible materials will ignite and/or burn in chlorine atmospheres, forming irritating and toxic gases. Containers or cylinders may rupture violently due to over-pressurization, if exposed to fire or excessive heat for a sufficient period of time. Intense local heat (above 200 deg C) on the steel walls of chlorine cylinders can cause an iron/chlorine fire

resulting in rupture of the container. Chlorine gas is heavier than air and will collect and persist in pits, hollows, depressions, and other confined or low-lying areas.

▲Is Chlorine stable when exposed to air, moisture, or heat?

Chlorine is normally stable. It reacts with water to form a corrosive solution of hydrochloric acid and hypochlorous acid, which can decompose to chlorine, oxygen and chloric acid.

▲Are there any conditions to avoid when using Chlorine?

Temperatures greater than 121 deg C, moisture

▲Does Chlorine have an odour threshold (at what level can I smell it)?

Reported odour threshold values are inconsistent. 0.08 ppm (detection). Other reports give the odour threshold as 0.2-0.4 (method not given).

▲Is the odour of Chlorine reliable as a warning property?

NOT RELIABLE - after repeated exposures, olfactory fatigue, olfactory deficiency and tolerance to the irritating effects may occur.

▲How can I work with Chlorine safely?

This material is a VERY TOXIC, CORROSIVE, COMPRESSED GAS. It is also a STRONG OXIDIZER. Before handling, it is extremely important that engineering controls are operating and that protective equipment requirements and personal hygiene measures are being followed. People working with this chemical should be properly trained regarding its hazards and its safe use.

If chlorine is released, immediately put on a suitable respirator and leave the area until the severity of the release is determined. In case of leaks, escape-type respiratory protective equipment should be available in the immediate work area.

Immediately report leaks, spills or failures of the engineering controls. Facilities for the emergency disposal of chlorine from leaking containers should be provided in areas of use.

Unprotected persons should avoid all contact with this chemical including contaminated equipment. Be aware of typical signs and symptoms of poisoning and first aid procedures. Seek medical attention for all exposures even if an exposure did not seem excessive. Symptoms of a severe respiratory injury can be delayed. Any signs of illness should be reported immediately to supervisory personnel.

Consider using a closed handling systems for processes involving this material. If a closed handling system is not possible, use the smallest possible amounts in a well-ventilated area separate from the storage area. Prevent the release of gas into the workplace air. Consider the installation of a leak detection system with an alarm.

This material is highly reactive. Do not use with incompatible materials such as ammonia and hydrocarbon gases (e.g., acetylene, ethylene).

No contact with materials which can burn. Eliminate all ignition sources. Post "NO SMOKING" sign in area.

Maintain handling equipment. Prevent leaks of grease or other lubricants from equipment where this chemical is used. Do not handle cylinders with oily hands. Do not allow contact with materials such as cleaning solvents, paints or thinners.

Inspect cylinders for damage or leaks before handling. Use the type of containers recommended by the manufacturer. Use corrosion-resistant transfer equipment. Regularly check storage tanks and transfer equipment for evidence of corrosion or leakage. Below 121 deg C (250 deg F), iron, copper, steel, lead, nickel, platinum, silver and tantalum are resistant to dry chlorine gas or liquid.

Do not heat compressed gas cylinders. Cylinder temperature should not exceed 52 deg C (125 deg F).

Leave cylinder cap on cylinder until cylinder is secured and ready for use. Always secure cylinders to a wall, rack or other solid structure in an upright position.

Use the appropriate pressure regulator. Ensure equipment is compatible with cylinder pressure and contents. Follow supplier recommendations. Before connecting the cylinder for use, make sure that back feed from the system into the cylinder is prevented.

Do not open cylinder if damaged. Never use excessive force when opening. Open cylinder valve slowly to prevent rapid decompression and damage to valve seat. Keep cylinder valves clean and free from contaminants (particularly oil and water). Make sure valves on gas cylinders are fully opened when gas is used. Open and shut valves at least once a day, while cylinder is in use, to avoid valve 'freezing'.

Shut flow off at cylinder valve and not just at the regulator after use. Replace outlet caps or plugs and cylinder caps as soon as cylinder is disconnected from equipment.

Make sure cylinders are labelled clearly. Avoid damaging cylinders. Move cylinders by hand truck or cart designed for that purpose. Do not drop cylinders or permit them to bang against each other. Do not lift cylinders by the cap or with a lifting magnet.

Keep empty cylinders under slightly positive pressure. Do not use cylinders as rollers or for any other purpose than to contain the gas as supplied.

Follow handling precautions on Material Safety Data Sheet. Have suitable emergency equipment for fires, spills and leaks readily available. Practice good housekeeping. Maintain handling equipment. Comply with applicable regulations.

▲What can be done to control hazardous conditions?

Engineering methods to control hazardous conditions are preferred. Methods include mechanical ventilation (dilution and local exhaust), process or personnel enclosure, control of process conditions, and process modification (e.g., substitution of a less hazardous material). Administrative controls and personal protective equipment may also be required.

Because of the high potential hazard associated with this substance, stringent control measures such as enclosure or isolation may be necessary. Supply sufficient replacement air to make up for air removed by exhaust systems. Systems must be kept "dry" to prevent metal corrosion.

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▲ Document last updated on October 22, 1998

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CHLORINE

Substance Chlorine
CAS 7782-50-5

Formula Cl₂

Physical Properties Greenish colored gas or amber liquid
bp -34.1 °C, mp -101 °C
Slightly soluble in water (0.7 g/100 mL)

Odor Highly pungent, bleach-like odor detectable at 0.02 to 3.4 ppm (mean = 0.08 ppm)

Vapor Density 2.4 (air = 1.0)

Vapor Pressure 4800 mmHg at 20 °C

Toxicity Data LC₅₀ inhal (rat) 293 ppm (879 mg/m³; 1 h)

PEL (OSHA) 1.0 ppm (3 mg/m³)

TLV-TWA (ACGIH) 0.5 ppm (1.5 mg/m³)

STEL (ACGIH) 1 ppm (2.9 mg/m³) *short term exposure limit*

Major Hazards Highly irritating and corrosive to the eyes, skin, and respiratory tract; reacts violently with readily oxidized substances.

Toxicity Chlorine is a severe irritant of the eyes, skin, and mucous membranes. Inhalation may cause coughing, choking, nausea, vomiting, headache, dizziness, difficulty breathing, and delayed pulmonary edema, which can be fatal. Exposure to ~500 ppm for 30 min may be fatal, and 1000 ppm can be lethal after a few breaths. Chlorine is highly irritating to the eyes and skin; exposure to 3 to 8 ppm causes stinging and burning of the eyes, and contact with liquid chlorine or high concentrations of the vapor can cause severe burns. Chlorine can be detected by its odor below the permissible limit; however, because of olfactory fatigue, odor may not always provide adequate

warning of the presence of harmful concentrations of this substance.

Chronic exposures in animals up to 2.5 ppm for 2 years caused effects only in the upper respiratory tract, primarily the nose. Higher concentrations or repeated exposure has caused corrosion of the teeth. There is no evidence for carcinogenicity or reproductive or developmental toxicity of chlorine in humans.

Flammability and Explosibility Chlorine is noncombustible but is a strong oxidizer and will support combustion of most flammable substances.

Reactivity and Incompatibility Chlorine reacts violently or explosively with a wide range of substances, including hydrogen, acetylene, many hydrocarbons in the presence of light, ammonia, reactive metals, and metal hydrides and related compounds, including diborane, silane, and phosphine.

Storage and Handling Chlorine should be handled in the laboratory using the "basic prudent practices" described in Chapter 5.C, supplemented by the procedures for work with compressed gases discussed in Chapter 5.H. All work with chlorine should be conducted in a fume hood to prevent exposure by inhalation, and splash goggles and impermeable gloves should be worn at all times to prevent eye and skin contact. Cylinders of chlorine should be stored in locations appropriate for compressed gas storage and separated from incompatible compounds such as hydrogen, acetylene, ammonia, and flammable materials.

Accidents In the event of skin contact, immediately wash with soap and water and remove contaminated clothing. In case of eye contact, promptly wash with copious amounts of water for 15 min (lifting upper and lower lids occasionally) and obtain medical attention. If chlorine is inhaled, move the person to fresh air and seek medical attention at once.

In case of accidental release of

chlorine gas, such as from a leaking cylinder or associated apparatus, evacuate the area and eliminate the source of the leak if this can be done safely. Full-face supplied-air respiratory protection and protective clothing may be required to deal with a chlorine release. Cylinders with slow leaks should be carefully removed to a fume hood or remote outdoor locations. Chlorine leaks may be detected by passing a rag dampened with aqueous ammonia over the suspected valve or fitting. White fumes indicate escaping chlorine gas.

Disposal Excess chlorine in cylinders should be returned to the manufacturer for disposal.

The information in this LCSS has been compiled by a committee of the National Research Council from literature sources and Material Safety Data Sheets and is believed to be accurate as of July 1994. This summary is intended for use by trained laboratory personnel in conjunction with the NRC report *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*. This LCSS presents a concise summary of safety information that should be adequate for most laboratory uses of the title substance, but in some cases it may be advisable to consult more comprehensive references. This information should not be used as a guide to the nonlaboratory use of this chemical.

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OSHA comments from the June 19, 1988 Final Rule on Air Contaminants Project extracted from 54FR2324 et. seq. This rule was remanded by the U.S. Circuit Court of Appeals and the limits are not currently in force.

CHLORINE

CAS: 7782-50-5; **Chemical Formula:** Cl₂

The previous OSHA limit for chlorine was 1 ppm as a ceiling limit. OSHA proposed to revise this limit to 0.5 ppm measured over 15 minutes, which was the limit recommended by NIOSH (1976b/Ex. 1-276) in its criteria document; NIOSH (Ex. 8-47, Table N1) concurred with the proposed limit. However, the final rule establishes a PEL of 0.5 ppm TWA with a 15-minute short-term exposure limit of 1 ppm for chlorine. Chlorine is a greenish-yellow, noncombustible gas at atmospheric pressure; it has a suffocating odor. At -35 C, it condenses to an amber liquid.

Exposure to chlorine at concentrations around 5 ppm has been associated with respiratory symptoms, erosion of the teeth, and inflammation of the mucous membranes (Flury and Zernick 1931c/Ex. 1-1199; Patty 1963c/Ex. 1-854). Ferris, Burgess, and Worcester (1967/Ex. 1-316) reported slight effects on the respiratory system in workers exposed to chlorine concentrations ranging from negligible to 7 ppm. Rupp and Henschler (1967/Ex. 1-1122) reported burning of the eyes among human subjects exposed to 0.5 ppm; an unspecified number of these subjects reported painful eyes after 15 minutes' exposure to this level. In a separate test, subjects reported respiratory irritation on exposure to 0.5 ppm, and a concentration of 1 ppm was described as being uncomfortable.

At the time of OSHA's proposal, the limits adopted by the ACGIH were a 1-ppm TLV-TWA and a 3-ppm TLV-STEL; these limits were based on the reports described above and were established to "minimize chronic changes in the lungs, accelerated aging, and erosion of the teeth" (ACGIH 1986/Ex. 1-3, p. 117). NIOSH (1976b/Ex. 1-276) reviewed these studies, as did others (Matt 1889, as cited in Flury and Zernick 1931c/Ex. 1-1199; Beck 1959, as cited in NIOSH 1976b/Ex. 1-276) that reported ocular and respiratory irritation associated with exposure to chlorine levels of around 1 ppm for 30 minutes or less. NIOSH (1976b/Ex. 1-276) recommended a 15-minute 0.5-ppm limit to prevent possible eye and respiratory tract irritation.

The United Paperworkers International Union (UPIU) (Ex. 8-37) cited the NIOSH Criteria Document (Ex. 1-276) and ACGIH Documentation (Ex. 1-3) as evidence that exposure to 0.5 ppm chlorine causes respiratory irritation. The UPIU also submitted several studies indicating that decrements in pulmonary function may persist for several days or weeks following acute exposure to concentrations of chlorine requiring medical treatment. In addition, the UPIU cited a number of studies indicating that pulp mill workers and chlorine production plant workers experience declines in pulmonary function as a result of chronic exposure to low levels of chlorine (Ex. 8-37); however, interpretation of many of these studies is complicated by a lack of exposure data or the presence of confounding exposure to other respiratory toxins, such as sulfur dioxide. The UPIU (Ex. 8-37) supported the promulgation of a 0.2 ppm limit for chlorine.

In 1986, the ACGIH proposed revising the TLVs for chlorine to 0.5 ppm as an 8-hour TWA and 1 ppm as a 15-minute STEL. This proposal was based on a review of two recent studies. One study, a 1981 doctoral dissertation by Anglen (Ex. 108A), was sponsored by the Chlorine Institute and was conducted on

29 human subjects. This study reported statistically significant changes in pulmonary function and subjective irritation resulting from exposure to 1 ppm chlorine for eight hours. No significant ocular effects were noted at this exposure level and duration. Exposure to 0.5 ppm for eight hours was not associated with significant declines in pulmonary function, and subjective irritation was also less severe at this level than at 1 ppm (Anglen 1981, Ex. 108A). During the eight-hour exposure to 1 ppm, sensory responses of itching or burning of the throat were reported to be "just perceptible" or "distinctly perceptible." A short-term (30-minute) exposure to 2 ppm produced no increase in subjective irritation compared with controls.

These findings were confirmed in a study of eight healthy volunteers exposed to 0.5 or 1 ppm chlorine concentrations (Rotman, Fliegelman, Moore et al. 1983/Ex. 108B). Significant declines in pulmonary function were associated with exposure to 1 ppm but not to 0.5 ppm.

The Chlorine Institute (Ex. 3-828) described a recent animal study conducted by the Chemical Industry Institute of Toxicology (CIIT). In this study, groups of 20 rats were exposed to 1, 3, or 9 ppm chlorine for six hours/day, five days/week, for six weeks. Exposure to the two highest levels resulted in significant decreases in body weight. Inflammation of the upper and/or lower respiratory tract was observed in the 9-ppm group and, to a lesser extent, in the 3- and 1-ppm groups. Pathological and clinical changes were not observed in the 1-ppm group, but were seen in the 3- and 9-ppm groups.

Several rulemaking participants urged OSHA to adopt the more recent ACGIH limits of 0.5 ppm TWA and 1 ppm STEL (Exs. 3-677, 3-741, 3-828, and 3-1150; Tr. pp. 10-165 to 10-170; Tr. pp. 10-178 to 10-180). For example, the Chlorine Institute commented as follows:

The imposition of an instantaneous ceiling PEL is inappropriate. The Chlorine Institute's University of Michigan and CIIT studies demonstrate conclusively that sensory effects and adverse pulmonary function effects are directly related to prolonged chlorine exposures and are correctly controlled by a PEL expressed as a Time Weighted Average (TWA).... The Chlorine Institute supports...[the ACGIH limits] as the correct PEL for adoption by OSHA, and we submit that the evidence is conclusive that such a PEL is totally protective of worker health in chlorine-producing and chlorine-using industries (Ex. 3-828, p. 3).

In its posthearing comment, NIOSH (Ex. 150) reaffirmed its recommended TWA of 0.5 ppm as a 15-minute limit, based on the findings of Rupp and Henschler (1967/Ex. 1-1122):

The studies of Anglen (1981) and Rotman (1983), as summarized by the ACGIH, if considered alone, would support the ACGIH TWA TLV of 0.5 ppm with a STEL of 1 ppm. However, in the studies of Rupp and Henschler (1967), exposure to chlorine at concentrations of approximately 0.5 ppm resulted in conjunctival pain in several subjects after 15 minutes; in their second study, subjects reported respiratory irritation after exposure to 0.5 ppm for 25 minutes.... The Rupp and Henschler study (1967), although it has been criticized for lack of a control group (Ex. 3-685) confirms the Anglen (1981), Rotman et al. (1983), and CIIT studies (Ex. 3-828) that there is a significant risk of irritation and a risk of respiratory inflammation at the present PEL of 1 ppm ceiling. Reduction of the current PEL to 0.5

ppm ceiling will reduce the risk of respiratory irritation and pulmonary function changes, and minimize the subjective complaints of irritation (Ex. 150, Comments on Chlorine).

The Dow Chemical Company submitted a critical review of the NIOSH (1976b/Ex. 1-276) criteria document on chlorine and the Rupp and Henschler (1967/Ex. 1-1122) study that was prepared in 1979 by Dr. Ralph G. Smith, who directed the University of Michigan (Anglen 1981) study (Ex. 3-741, Appendix B; Tr. pp. 10-165 to 10-170). In his review, Dr. Smith criticized the Rupp and Henschler (1967/Ex. 1-1122) study because the design of the exposure facility led to uncertainties in determining actual exposure levels present in the test room. He also remarked that the chlorine was passed through "liquid paraffin," which may have produced chlorinated hydrocarbons. In addition, Dr. Smith felt that the air compressor used may have caused contamination of the air in the test room by carbon monoxide and other impurities. Dr. Smith believed these observations were important "because one of the effects allegedly resulting from short exposures to low levels of chlorine was headaches, a symptom which we have never had reported to us by a subject in the University of Michigan (Anglen 1981) exposures" (Ex. 3-741, Appendix B, pp. 9-10).

After reviewing the evidence and testimony presented in the record on the effects of exposure to chlorine gas, OSHA concludes that there is clearly a significant risk of pulmonary function impairment and sensory irritation at the current 1-ppm ceiling PEL; such effects have been demonstrated by the Anglen (1981/Ex. 108A) and Rotman, Fliegelman, Moore et al. (1983/Ex. 108B) studies in human subjects exposed to 1 ppm for 8 hours, an exposure level and duration that would be permitted by the former PEL. In addition, pulmonary inflammation has been observed in rats exposed daily for six weeks to 1 ppm chlorine. Therefore, OSHA finds that it is necessary to revise its current limit for chlorine.

The human studies by Anglen (1981/Ex. 108A) and by Rotman, Fliegelman, Moore et al. (1983/Ex. 108B) also indicate that exposure to 0.5 ppm chlorine for as long as 8 hours is not associated with impairment of pulmonary function or significant sensory irritation; these findings are in contrast to the earlier German reports upon which the NIOSH REL of 0.5 ppm (15 minutes) is based. However, the German studies, in particular those of Rupp and Henschler (1967/Ex. 1-1122), appear to have had methodological shortcomings that call into question the finding that exposure to 0.5 ppm chlorine is associated with significant acute effects. Therefore, OSHA judges, based on the more recent University of Michigan study, that an exposure limit of 0.5 ppm TWA with a 1-ppm 15-minute STEL will reduce the risk of irritation and pulmonary function decline in workers, and is today revising its limit for chlorine to these values. OSHA considers the effects of respiratory irritation and the declines in pulmonary function associated with chlorine exposure to be material impairments of health.

HHMI LABORATORY SAFETY**LCSS: CHLORINE**

Substance

Chlorine
CAS 7782-50-5

Formula

Cl_2

Physical Properties

Greenish colored gas or amber liquid
bp -34.1 °C, mp -101 °C
Slightly soluble in water (0.7 g/100 mL)

Odor

Highly pungent, bleach-like odor detectable at 0.02 to 3.4 ppm (mean = 0.08 ppm)

Vapor Density

2.4 (air = 1.0)

Vapor Pressure

4800 mmHg at 20 °C

Toxicity Data

LC₅₀ inhal (rat)
293 ppm (879 mg/m³; 1 h)

PEL (OSHA)
1.0 ppm (3 mg/m³)

TLV-TWA (ACGIH)
0.5 ppm (1.5 mg/m³)

STEL (ACGIH)
1 ppm (2.9 mg/m³)

Major Hazards

Highly irritating and corrosive to the eyes, skin, and respiratory tract; reacts violently with readily oxidized substances.

Toxicity

Chlorine is a severe irritant of the eyes, skin, and mucous membranes. Inhalation may cause coughing, choking, nausea, vomiting, headache, dizziness, difficulty breathing, and delayed pulmonary edema, which can be fatal. Exposure to ~500 ppm for 30 min may be fatal, and 1000 ppm can be lethal after a few breaths. Chlorine is highly irritating to the eyes and skin; exposure to 3 to 8 ppm causes stinging and burning of the eyes, and contact with liquid chlorine or high concentrations of the vapor can cause severe burns. Chlorine can be detected by its odor below the permissible limit; however, because of olfactory fatigue, odor may not always provide adequate warning of the presence of harmful concentrations of this substance.

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Storage and Handling

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Accidents

In the event of skin contact, immediately wash with soap and water and remove contaminated clothing. In case of eye contact, promptly wash with copious amounts of water for 15 min (lifting upper and lower lids occasionally) and obtain medical attention. If chlorine is inhaled, move the person to fresh air and seek medical attention at once.

In case of accidental release of chlorine gas, such as from a leaking cylinder or associated apparatus, evacuate the area and eliminate the source of the leak if this can be done safely. Full-face supplied-air respiratory protection and protective clothing may be required to deal with a chlorine release. Cylinders

with slow leaks should be carefully removed to a fume hood or remote outdoor locations. Chlorine leaks may be detected by passing a rag dampened with aqueous ammonia over the suspected valve or fitting. White fumes indicate escaping chlorine gas.

Disposal

Excess chlorine in cylinders should be returned to the manufacturer for disposal. For more information on disposal procedures, see Chapter 7 of this volume.

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The Chlorine Institute (Ex. 3-828) described a recent animal study conducted by the Chemical Industry Institute of Toxicology (CIIT). In this study, groups of 20 rats were exposed to 1, 3, or 9 ppm chlorine for six hours/day, five days/week, for six weeks. Exposure to the two highest levels resulted in significant decreases in body weight. Inflammation of the upper and/or lower respiratory tract was observed in the 9-ppm group and, to a lesser extent, in the 3- and 1-ppm groups. Pathological and clinical changes were not observed in the 1-ppm group, but were seen in the 3- and 9-ppm groups.

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The Dow Chemical Company submitted a critical review of the NIOSH (1976b/Ex. 1-276) criteria document on chlorine and the Rupp and Henschler (1967/Ex. 1-1122) study that was prepared in 1979 by Dr. Ralph G. Smith, who directed the University of Michigan (Anglen 1981) study (Ex. 3-741, Appendix B; Tr. pp. 10-165 to 10-170). In his review, Dr. Smith criticized the Rupp and Henschler (1967/Ex. 1-1122) study because the design of the exposure facility led to uncertainties in determining actual exposure levels present in the test room. He also remarked that the chlorine was passed through "liquid paraffin," which may have produced chlorinated hydrocarbons. In addition, Dr. Smith felt that the air compressor used may have caused contamination of the air in the test room by carbon monoxide and other impurities. Dr. Smith believed these observations were important "because one of the effects allegedly resulting from short exposures to low levels of chlorine was headaches, a symptom which we have never had reported to us by a subject in the University of Michigan (Anglen 1981) exposures" (Ex. 3-741, Appendix B, pp. 9-10).

After reviewing the evidence and testimony presented in the record on the effects of exposure to chlorine gas, OSHA concludes that there is clearly a significant risk of pulmonary function impairment and sensory irritation at the current 1-ppm ceiling PEL; such effects have been demonstrated by the Anglen (1981/Ex. 108A) and Rotman, Fliegelman, Moore et al. (1983/Ex. 108B) studies in human subjects exposed to 1 ppm for 8 hours, an exposure level and duration that would be permitted by the former PEL. In addition, pulmonary inflammation has been observed in rats exposed daily for six weeks to 1 ppm chlorine. Therefore, OSHA finds that it is necessary to revise its current limit for chlorine.

The human studies by Anglen (1981/Ex. 108A) and by Rotman, Fliegelman, Moore et al. (1983/Ex. 108B) also indicate that exposure to 0.5 ppm chlorine for as long as 8 hours is not associated with impairment of pulmonary function or significant sensory irritation; these findings are in contrast to the earlier German reports upon which the NIOSH REL of 0.5 ppm (15 minutes) is based. However, the German studies, in particular those of Rupp and Henschler (1967/Ex. 1-1122), appear to have had methodological shortcomings that call into question the finding that exposure to 0.5 ppm chlorine is associated with significant acute effects. Therefore, OSHA judges, based on the more recent University of Michigan study, that an exposure limit of 0.5 ppm TWA with a 1-ppm 15-minute STEL will reduce the risk of irritation and pulmonary function decline in workers, and is today revising its limit for chlorine to these values. OSHA considers the effects of respiratory irritation and the declines in pulmonary function associated with chlorine exposure to be material impairments of health.

Presentation for Mar 31/98 - Corrie Kost [REDACTED]

Your Worship & Members of Council

I come before you this evening as a concerned resident of the District of North Vancouver. I do not necessarily represent the views of any other organizations of which I am a member. Neither do I claim any professional status at this hearing. I come here because I believe my interest in property may be affected by this proposed bylaw.

I will begin by quoting Objective 12.2 from the District's OCP

To ensure that the Port's activities are compatible with the well-being, public health and safety, and liveability of the community.

Logic would dictate that since Council would be adamantly opposed to a Chlorine plant being built anywhere in DNV today, it would imply that they should disallow any more development in areas which would put more people at risk. An undesirable business which has the potential for widespread devastation, no matter how unlikely that possibility, and no matter how good their record, should not be encouraged to stay. Thus I should end my presentation at what appears to be an open and shut case decision and leave it at that. However, as past records of council has shown, logic is not all that persuasive. So I will continue...

Council has before it several options:

- you could adopt this bylaw (worst case)
- you could reject this bylaw (best case)
- you could adjourn, after public input, for more public meetings into matters which have to date not been properly clarified or even reviewed by district residents. This is my next best option.

Unfortunately, I have heard that any further delays in this matter would result in the immediate revocation of all current covenants and agreements in place between the District and the parties seeking the rezoning of this land. I therefore fear that if this is the case, council may be railroaded into making a premature choice on this issue, especially one which would result in the adoption of this bylaw. Note that the choice of rejecting this bylaw still allows for future options. Some councillors may fear that rejection of this bylaw could result in the plant reverting back to its previous, more risky operation. I doubt that this would be allowed to happen. There are other factors at work which would likely prevent this from happening.

This is a multifaceted issue. Some of the aspect are

- RISK ASSESSMENT
- TRANSPORTATION
- LIVEABILITY
- FINANCING/TAXES
- ETHICS

Although I will touch somewhat on all these I will concentrate on RISK ASSESSMENT

RISK ASSESSMENT

It would seem that after all the public meetings and the various quantitative risk analysis (QRA) reports that both the public and council would have a full understanding of this aspect of the rezoning issue. Unfortunately such is not the case.

All the reports suffer major defects:

- they lack the necessary scientific details required to fully understand and reproduce the results
- they fail to describe the sources, extent and magnitude of significant uncertainties associated with the assessment.
- they lack discussion of negative societal impacts (footprint of the risks matter)
- they lack consideration of impact on future generations (i.e ignores sustainability)

QRA's only try to quantify **fatal** risks. The number of expected fatalities is simply the risk multiplied by the population it impacts. However, Risk Assessment should not be based on purely the number of dead bodies generated but should encompass risks to health, safety, and the environment. All QRA's to date only address the former. I refer Council to the Principles of Risk Assessment and Risk Communication adopted by the US DOE (see <http://www.em.doe.gov/irm/principl.html> and my attachment A).

The District prides itself on leadership in safety and environmental stewardship. **Why are we willing to accept district staff's recommendation that we use the minimal industry guidelines (MAICC) to protect our human species while higher standards are used to protect our fish.** Why are we second rate?

It has not been made public what the private sector assessment is for this plant. Such an assessment is no doubt done by the Insurance Industry. They are not in the business of subsidizing Chlorine Plants and so the premiums charged would give an independent check on how they view the risk.

It should be noted that Chlorine is one of only 12 chemical substances proposed to be examined by the National Advisory Committee for Acute Exposure Guideline Levels for Hazardous Substances (NAC/AEGL). This committee was formed by the EPA in 1997. For details I refer council to url <http://www.micromedex.com/cmdx-c/neh-fma03.htm>

In the meantime Council may find it of interest that the US National Institute for Occupancy Safety and Health 1980 "Registry of Toxic Effects of Chemical Substances" listed the following inhalation LC₅₀ (concentration of chlorine in air lethal to 50% of the test populations) for Human as 840ppm/ 30 minutes (although figures as low as 500ppm/5 minutes had been reported). This information can be found on page 22 in THE CHLORINE MANUAL - 6th edition. To repeat, that was in 1980. The current figures are 1000ppm/2 minutes. It should also be noted that I have attached a document that shows that the IDHL (Immediately Dangerous to Life or Health) concentration was reduced from 30ppm to 10ppm since the time when the QRA was conducted by BOVAR in 1994. It thus appears that the risks in the past were substantially underestimated. This should sound a warning bell for council to adopt a conservative approach since many of the land uses of current OCP's were likely based on significantly underestimated risk assessments.

Various reports contain what I would term as incomplete, confusing, and perhaps deceptive and misleading statements.

For example:

Page 3 of Oct 21/96 report states that the 1978 on-site inventory of up to 1780 tons has been reduced to 550 tons since 1995. However, we are told elsewhere that on average there are now roughly ten rail cars on site in a full (90 ton each) condition over the course of the year. This would imply "on-site" storage of 1440 tons, not the quoted 550 tons. I refer you to page 3 of the July 11/97 A.D. Little report.

Question 20a asked "what is the ratio of fatalities to injuries in chemical exposure incidents?" to which the reply was "The ratio of fatalities to injuries in chemical exposure incidents cannot be predicted on a theoretical basis. The outcome depends on the chemical, the potential health effects, exposure concentration and duration of exposure". All I can say is..you know all these elements for both injuries and fatalities... we do know the chemical right? It's still chlorine for both right? We know the exposure concentrations and duration of exposure to determine fatalities. So what's the hold-up?

The risk calculations were unable to provide margins of error because as it states in reply to question 24(b) of the Sep 23/97 public information meeting "There are too many unknowns in a risk assessment and too many variables...". Similarly, on page 30 of the July 4/97 Bovar report it states "The uncertainties in estimating the chance of rare events, and in projecting the effects on human populations, are considerable." I agree, that large uncertainties does not necessarily imply large risks. It's just that it could. Models, are not the same as the real thing. You have only to examine the papers presented at recent conferences, such as the Air & Waste Management Association's 90th Annual meeting held last June on Toronto (eg. attached) Wouldn't it then be more prudent (for staff to recommend to council) that there be an additional safety margin based on the best guess as to what those uncertainties are?

In reply to a question about a scenerio that could see a minor cloud envelope the Second narrows bridge the respondent deliberately chose to use as an example a break which was subsequently shown to be incapable of reaching the bridge! This I would consider an evasive response. As a possible example I would refer council to Figure 7 of Scenario # 2 in an attached document (UCRL-53685).

Finally, it states in response to Q3 of the Oct 30/97 Public meeting that "people would be exposed for less than 1 hour". How do you reconcile this with published reports (eg UCRL-53685 - Emergency Response Planning for Potential Accidental Liquid Chlorine Releases - Lawrence Livermore National Laboratory - May/86) which states "these concentrations persist over periods of approximately two to three hours".

Note that partial answers to the public information meetings held last September and October were only provided fairly recently. Some information, such as the "updated" Pamphlet 74 which

illustrate downstream chlorine plots for 14 different scenarios, promised since early January, has not yet been made available. Copies of the "outdated" versions could not be made. From these few examples one can see that the public meetings were of an inadequate nature to have a meaningful dialogue.

Since the requested information about other Chlorine plants in North America has not been supplied, I have conducted what I believe is a fair representative survey of the communities surrounding 10 of the some 40 plants in existence today. The summary is shown in Table 1. Note that the MIACC guidelines would allow low density housing in the 10^{-5} to 10^{-6} range. But what does this mean? According to Q23 of the Sep 23/97 public information meeting this would allow densities from 12-24 units/acre. Allowing for road overhead, let us assume a lower 15 units/acre. This represents $640 \times 15 \sim 10,000$ units/square mile or about 30,000 people/square mile. As one can see, no such case can be found anywhere in North America. I can only conclude that either:

- a) This plant is much safer than most or
- b) The population densities around typical plants is typically kept much lower than the MIACC guidelines.

I therefore suggest that "low density housing" be defined as no more than 4-6 units/acre (ie. RS3) and not the 12-24 (ie. RM) put forth by staff.

We are of course currently speaking of land uses which do not allow a residential component. Nevertheless, many of the proposed allowed uses would result in a substantial number of people being exposed to an unnecessary risk. The ones that particularly concern me are ones like the retail food outlets and restaurants. In the previous proposal, and under very similar risks, these uses would only be allowed if the plant were to close down. It was never stated that anything short of that would remove such a restriction. Now we have a revised bylaw which lumps them into the same pot.

Without hopefully being accused of being an environmental Chicken Little, I will now try to put the 10^{-5} to 10^{-6} range risk in perspective by comparing it to two other involuntary risk imposed on many of us -lightning/earthquakes and second-hand smoke.

Lightning/Earthquakes

Large parts of the District have a risk greater than 1 chance in a million due to the presence of this chlorine plant. This is about ten times more likely than being struck by lightning which is already dreaded by many of our residents. It is also 5 times more likely than being killed by an earthquake. We spend many \$millions trying to counteract earthquake risks. Does this make sense to ignore this much higher risk?

Second-hand smoke:

Let us assume that this plant imposes a 10^{-5} risk on the some 4000 residents within a 1 mile radius. Thus statistically, we can expect 1 death every 25 years. From the media, I gather we can expect about 1 death/year for our 80,000 residents from exposure to second hand smoke.

Prorating this again gives about 1 death every 20 years for the same group of 4000 residents.

Now you say ahah! - Council is set to ban second-hand by the year 2000, why not this plant? The answer is partly confused by economics. Banning smoking in public places, in the long term at

160 40
least, will cause no economic hardship on our pubs and restaurants. Banning CXY (assuming such a thing could be done) will mean the loss of 40 full-time jobs (12 on the North Shore) and about 1\$million in taxes/yr. Another way to view this is from a cold-calculated financial point of view. Transportation studies put the economic value of preventing 1 fatality at about 3\$million. Viewed in that light, CXY has placed it at \$25million (in tax benefits). However, even this has to be viewed in a proper perspective. The expenditure on road safety is done with public money - the public making the choices between safety and money. We should set far higher standard for private industries.

FINANCIAL/TAXES:

I see a huge vacuum here. Where is the BUSINESS PLAN for this area? What is the bottom line for the tax-payer?

ETHICS:

I now touch lightly on an aspect which I urge Council to explore more in detail. Foremost is the question of "grandfathering" land uses which are subject to rezoning. Does a company have the right to pollute or otherwise threaten the well-being of adjacent residents when it becomes known that those hazards have been under-estimated? Also, and more specifically to this case, note that because this plant was there 40 years ago, adjacent properties purchased since that time have a far weaker case for compensation. The District's lands however were in the hands of owners (the public) before this plant was constructed. They would appear to have a much stronger case for compensation.

CONCLUSION:

I am not opposed to a business park in this area. I am opposed to the proposed uses of these lands. I recommend council reject this bylaw. The previously abandoned Bylaw 6762, which would not have allowed restaurants and retail food outlets until the plant ceased operation, would have been more tolerable. Zoning of these lands should be based on more conservative criteria than those suggested by the MIACC guidelines. I firmly believe better solutions are available.

APPENDIX A

Principles of Risk Assessment

- Departmental programs should employ the best reasonable obtainable information from the natural, physical, and social sciences to assess risks to health, safety, and the environment.
- Characterizations of risks and of changes in the nature or magnitude of risks should be both qualitative and quantitative -- that is, both descriptive and mathematical -- consistent with available data. The characterizations should be broad enough to inform the range of activities to reduce risks.
- Judgements used in developing a risk assessment, such as assumptions, defaults, and uncertainties, should be stated explicitly. The rationale for these judgements and their influence on the risk assessments should be articulated.
- Risk assessments should encompass all appropriate hazards to human health and the environment (such as acute and chronic risks, including cancer and non-cancer risks). In

addition to considering the full population at risk, attention should be directed to subpopulations (including future generations) that may be particularly susceptible to such risks and/or may be more highly exposed.

- Peer-review of risk assessments can ensure that the highest professional standards are maintained. Therefore, programs should develop procedures to maximize its use.
- Departmental programs should strive to adopt consistent approaches to evaluating the risks posed by hazardous agents or events.

Principles for Risk Communication

- Risk communication should involve the open, two-way exchange of information between professional, including both policy makers and "experts" in relevant disciplines, and the public.
- Risk management goals should be stated clearly, and risk assessments and risk management decisions should be communicated accurately and objectively in a meaningful manner. To maximize public understanding and participation in risk management, programs should:
 - explain the basis for significant assumptions, data, models, and inferences used or relied upon in the assessment or decision;
 - describe the sources, extent and magnitude of significant uncertainties associated with the assessment or decision;
 - make appropriate risk comparisons, taking into account, for example, public attitudes with respect to voluntary versus involuntary risks; and
 - provide timely, public access to relevant supporting documents, a reasonable opportunity for public comments, and mechanism to incorporate public comments.

TABLE 1
COMPARISION TO SOME OF THE 40 US CHLORINE PLANTS

LOCATION	EPA ID#	HOUSEHOLD UNITS INSIDE 1MILE RADIUS	FUGITIVE EMISSION 1000 LBS/YR	STACK EMISSIONS 1000 LBS/YR	PLANT CAPACITY 1000 TONS/YR
N. VANCOUVER BC	NA	1297		1	100
WESTLAKE LOUISIANA	LAD982296428	55	7700	14000	1265
CALVERT CITY KENTUCKY	KYD006370167	2	130	8900	115
PLAQUEMINE LOUISIANA	LAD057117434	3	10	14000	1115
ORRINGTON MAINE	MED000242701	503	8	1040	80
HENDERSON NEVADA	NVD062081500	204	226	434	115
NIAGARA FALLS NEW YORK	NYD002123503	3411	14	11915	85
NIAGARA FALLS NEW YORK	NYD000824482	1272	1400	2000	330
PORTLAND OREGON	ORD009031840	838	200	850	150
LONGVIEW WASHINGTON	WAD009041450	0	1043	15153	140
BELLINGHAM WASHINGTON	WAD009252297	4531	230	3600	90

SOME OF THE SIGNIFICANT INCIDENT REPORTS

This search was taken from RTK NET's (the Right-To-Know Network)'s copy of EPA's ARIP database. See URL <http://www.rtk.net/datadoc/arip.html>

Facility: OCCIDENTAL
Address: 1683 RIVER ROAD, ROUTE 9
City: DELAWARE CITY
County: NEW CASTLE
Phone: (302) 834-3800 SIC(s): 2812
Owner: K.W. SANDERS
Primary Product: CHLORINE
Release : 1683 RIVER ROAD, ROUTE 9
City: DELAWARE CITY
County: NEW CASTLE
Release start date: 07/21/1994 Time: 09:45
Release end date : 07/21/1994 Time: 10:05
Chemical Name: CHLORINE
Concentration (%):
Air: 750.00
Land: 0.00
Total: 750.00 (lbs)
Physical State: GAS
Surface Water: 0.00 (lbs)
Treatment Facility: 0.00 (lbs)
CAS Number: 7782505
Reporting Year: 1994
State: DE Zip: 19706
Dun & Bradstreet #: 16-157-0841
Number of employees: 170
State: DE Zip: 19706
Phone: (302) 834-3800

	Responders	Employees	Contractors	Public	Total
Injuries :	2	2	0	0	4
Hospitalized:	0	0	0	0	0
Deaths :	0	0	0	0	0
Evacuated :		0	0	0	0
Shelter-in-place:		0	0	0	0
Facility Cost: \$3,000,000	Public Cost:		\$	Total Cost: \$3,000,000	

Authorities notified-

Name	Date	Time	Contact Name
Federal: NRC	07/21/1994	11:15	PO MAULDIN
DE EMA	07/21/1994	10:15	
NEW CASTLE CO LEPC	07/21/1994	10:00	BILL MCCracken

Miscellaneous-

ERNS ID: NRC ID: 250973 ARIP ID: 4930
Latitude: 39:36 Longitude: 075:37
Release caused by: A (A=Equipment Failure, B=Operator Error)
Location of loss of containment: PROCESS VESSEL: WALL
EPA Region: 03 ERNS Report Date: 07/21/1994 Time: 13:15

Facility: HANLIN CHEMICALS Reporting Year: 1991
 Address: PO DRAWER J, STATE ROUTE 2
 City: MOUNDSVILLE State: WV Zip: 26041
 County: MARSHALL Dun & Bradstreet #: 06-107-7475
 Phone: (304) 843-1310 SIC(s): 2812 2819 2869
 Owner: P.P. HOWELL Number of employees: 212
 Primary Product: CHLOR/ALKALI AND CHLOROMETHANES PRODUCTION
 Release : PO DRAWER J, STATE ROUTE 2
 City: MOUNDSVILLE State: WV Zip: 26041
 County: MARSHALL Phone: (304) 843-1310
 Release start date: 01/09/1991 Time: 19:15
 Release end date : 01/10/1991 Time: 01:15
 Chemical Name: CHLORINE CAS Number: 7782505
 Concentration (%): 100% Physical State: GAS
 Air: 13,000.00 Surface Water: 0.00 (lbs)
 Land: 0.00 Treatment Facility: 0.00 (lbs)
 Total: 13,000.00 (lbs)

	Responders	Employees	Contractors	Public	Total
Injuries :	0	6	0	0	6
Hospitalized:	0	0	0	0	0
Deaths :	0	0	0	0	0
Evacuated :		0	0	0	0
Shelter-in-place:		0	0	0	0

 No cost for property damage was reported.

Authorities notified-

Name	Date	Time	Contact Name
WV EMS	02/09/1991	21:26	TOM BURNS
LEPC	02/09/1991	21:08	RECORDED

Miscellaneous-
 ERNS ID: 91154 NRC ID: 58817 ARIP ID: 3397
 Latitude: 39:54 Longitude: 80:48
 Release caused by: A (A=Equipment Failure, B=Operator Error)
 Location of loss of containment: STORAGE VESSEL: VENT

Facility: OCCIDENTAL Reporting Year: 1994
 Address: PO BOX 74
 City: HAHNVILLE State: LA Zip: 70057
 County: ST CHARLES PARISH Dun & Bradstreet #: 03-905-6619
 Phone: (504) 783-7200 SIC(s): 2812 2819
 Owner: JOHN O. FOSTER Number of employees: 300
 Primary Product: CHLORINE
 Release : LA HWY 18 & LA HWY 3142
 City: TAFT State: LA Zip: 70057
 County: ST CHARLES PARISH Phone: (504) 783-7200
 Release start date: 03/19/1994 Time: 00:22
 Release end date : 03/19/1994 Time: 02:57
 Chemical Name: CHLORINE CAS Number: 7782505
 Concentration (%): 100% Physical State: GAS
 Air: 1,300.00 Surface Water: 0.00 (lbs)
 Land: 0.00 Treatment Facility: 0.00 (lbs)
 Total: 1,300.00 (lbs)
 Chemical Name: CHLOROFORM CAS Number: 67663
 Concentration (%): 100 Physical State: GAS
 Air: 3,400.00 Surface Water: 0.00 (lbs)
 Land: 0.00 Treatment Facility: 0.00 (lbs)
 Total: 3,400.00 (lbs)

	Responders	Employees	Contractors	Public	Total
Injuries :	1	2	0	0	3
Hospitalized:	0	1	0	0	1
Deaths :	0	0	0	0	0
Evacuated :		0	0	0	0
Shelter-in-place:		0	0	0	0
Facility Cost: \$5,600,000	Public Cost:		\$	Total Cost: \$5,600,000	

Authorities notified-

Name	Date	Time	Contact Name
Federal: NRC	03/19/1994	03:55	MR LONG
LA SERC	03/19/1994	02:30	MICHELLE GAUTREAUX
EOC/LEPC	03/19/1994	00:29	EOC COMMUNICATIONS PERSONNEL

Miscellaneous-

ERNS ID: NRC ID: 231175 ARIP ID: 4926
 Latitude: 29:59 Longitude: 090:27
 Release caused by: A (A=Equipment Failure, B=Operator Error)
 Location of loss of containment: PROCESS VESSEL: WALL
 EPA Region: 06 ERNS Report Date: 03/19/1994 Time: 03:55
 When release occurred-
 DURING ROUTINE OPERATION
 Status of process line-
 SHUT DOWN FOR REPAIRS; WITH PLANS TO RESTART
 How release was discovered-
 EXPLOSION/FIRE

Facility: PIONEER CHLOR ALKALI Reporting Year: 1991
 Address: 8000 LAKE MEAD BLVD.
 City: HENDERSON State: NV Zip: 89015
 County: CLARK Dun & Bradstreet #: 06-208-1500
 Phone: (702) 565-8781 SIC(s): 2812 2819 2869
 Owner: CLIFFORD H. BARR Number of employees: 170
 Primary Product: CHLORINE, SODIUM HYDROXIDE, HYDROCHLORIC ACID
 Release : 8000 LAKE MEAD BLVD.
 City: HENDERSON State: NV Zip: 89015
 County: CLARK Phone: (702) 565-8781
 Release start date: 05/06/1991 Time: 01:10
 Release end date : 05/06/1991 Time: 07:30
 Chemical Name: CHLORINE CAS Number: 7782505
 Concentration (%): 100% Physical State: GAS
 Air: 84,000.00 Surface Water: 0.00 (lbs)
 Land: 0.00 Treatment Facility: 0.00 (lbs)
 Total: 84,000.00 (lbs)

	Responders	Employees	Contractors	Public	Total
Injuries :	0	1	0	759	760
Hospitalized:	0	0	0	15	15
Deaths :	0	0	0	0	0
Evacuated :		10	1	378	389
Shelter-in-place:		0	0	770	770
Facility Cost: \$2,425,000	Public Cost: \$1,125,000	Total Cost: \$2,425,000			

Authorities notified-

Name	Date	Time	Contact Name
NV SERC	05/06/1991		
CLARK CO. ACB	05/06/1991	08:00	LORI ANDERSON

Miscellaneous-
 ERNS ID: 913937 NRC ID: 70909 ARIP ID: 3903
 Latitude: 36:02 Longitude: 115:00
 Release caused by: A (A=Equipment Failure, B=Operator Error)
 Location of loss of containment: PIPING: ELBOW

March 29/98

To: Irwin Torry
District of North Vancouver

From: Corrie Kost


As a result of a conversation with Mayor Don Bell I attach a number of questions about the QRA's. I hope you can find some of the answers by the time of Tuesday's public hearing.

Outstanding Risk Question:

1. It has been stated that the atmospheric release of chlorine amounted to 500 lbs/yr. Is this the total releases to the air (ie. stack + fugitive) or was this a misprint and should have read 500 Tons/yr?
2. It has been stated that in the 150 year operation of four plants in Canada there has been "no adverse effect or impact on any of our neighbours or their property". How do you reconcile this with the view that the risks imposed by these plants substantially limits the full potential land use of adjacent properties?
3. The risk calculations were unable to provide margins of error because as it states in reply to question 24(b) of the Sep 23/97 public information meeting "There are too many unknowns in a risk assessment and too many variables...". Similarly, on page 30 of the July 4/97 Bover report it states "The uncertainties in estimating the chance of rare events, and in projecting the effects on human populations, are considerable." Wouldn't it then be more prudent (for staff to recommend to council) that there be an additional safety margin based on the best guess as to what those uncertainties are?
4. The comparison of the assumptions for the 1994 model predictions and the 1997 ones were not clear. For the corresponding years, and for the "big spill", what assumed fraction of the total spill eventually went into the cloud?
5. For low wind velocities how long will the cloud from a major spill persist?
6. The Occupational Safety and Health Administration (OSHA) defines an immediately dangerous to life or health concentration (IDLH) emergency response regulation as "An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere". For Chlorine the IDLH was apparently recently revised from 30ppm down to 10ppm. How does this impact the risk calculations?

7. The hazard posed for the same volume release is much greater for night-time and cloudy conditions than for sunny day-time conditions. In the modelling, did the appropriate weighting take into account the number of total hours of sunshine at the plant location or was a more conservative assumption, that the release would always occur at night, taken?

8. In various places you use the phrase "typical daytime weather conditions" Did this include cloud cover or only atmospheric stability ratings?

9. It was stated that there has been only one recent major spill of chlorine. This was the case of the 84,000lb spill at the Henderson facility in Nevada in 1991. Have there not been a number of others?

10. What is the total amount of chlorine produced at this plant per year? (A good guess would be 1735 rail cars of 90 tons each for a total of 156,000 tons?) Is the volume of chlorine stored near the site still the same, despite the statement that on-site inventories have been reduced from 1780 tons to 550 tons?

11. On average how many deaths can we expect if 300 tons of chlorine is released into the air?

12. Why is there no data which give the likely consequences of each event described? (ie. number of fatalities).

13. For the review conducted by A.D. Little was the modelling done with independent programs, or was the same proprietary model supplied by BOVAR used?

14. It states in response to Q3 of the Oct 30/97 Public meeting that "people would be exposed for less than 1 hour". How do you reconcile this with published reports (eg UCRL-53685 - Emergency Response Planning for Potential Accidental Liquid Chlorine Releases - Lawrence Livermore National Laboratory - May/86) which states "these concentrations persist over periods of approximately two to three hours".

Yours truly,

Corrie Kost

cc: Dennis Back

SUMMARY OF ATTACHMENTS

- UCRL-53685 - Emergency Response Planning for Potential Accidental Liquid Chlorine Releases
- Abstract 97-TA33.03 of Air & Waste Management Association's 90th Annual Meeting held June 1997 in Toronto
- Curves of 10% and 50% fatalities for various chlorine concentrations and exposure times (taken from data provided)
- Document showing revision/rational for IDHL reduction from 30ppm to 10ppm
- October/97 EH&S News release on new NAC/AEGL committee to review acute exposure guidelines for chlorine
- Some of the significant incident reports on chlorine spills from Right-To-Know Network
- List of the 40 chlorine plants in US with trend prediction of future chlorine demand
- US map illustrating 10 sites selected for detailed review
- Comparison of 10 US Chlorine Plants to CXY
- EPA report 749-F-94-010a : Chemical Summary for Chlorine
- Detailed maps & statistics of the 10 US Chlorine Plants

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- Document showing revision/rational for IDHL reduction from 30ppm to 10ppm
- October/97 EH&S News release on new NAC/AEGL committee to review acute exposure guidelines for chlorine
- Some of the significant incident reports on chlorine spills from Right-To-Know Network
- List of the 40 chlorine plants in US with trend prediction of future chlorine demand
- US map illustrating 10 sites selected for detailed review
- Comparison of 10 US Chlorine Plants to CXY
- EPA report 749-F-94-010a : Chemical Summary for Chlorine
- Detailed maps & statistics of the 10 US Chlorine Plants

March 29/98

To: Irwin Torry
District of North Vancouver

From: Corrie Kost
[REDACTED]
[REDACTED]
[REDACTED]

As a result of a conversation with Mayor Don Bell I attach a number of questions about the QRA's I hope you can find some of the answers by the time of Tuesday's public hearing.

Outstanding Risk Question:

1. It has been stated that the atmospheric release of chlorine amounted to 500 lbs/yr. Is this the total releases to the air (ie. stack + fugitive) or was this a misprint and should have read 500 Tons/yr?
2. It has been stated that in the 150 year operation of four plants in Canada there has been "no adverse effect or impact on any of our neighbours or their property". How do you reconcile this with the view that the risks imposed by these plants substantially limits the full potential land use of adjacent properties?
3. The risk calculations were unable to provide margins of error because as it states in reply to question 24(b) of the Sep 23/97 public information meeting "There are too many unknowns in a risk assessment and too many variables...". Similarly, on page 30 of the July 4/97 Bover report it states "The uncertainties in estimating the chance of rare events, and in projecting the effects on human populations, are considerable." Wouldn't it then be more prudent (for staff to recommend to council) that there be an additional safety margin based on the best guess as to what those uncertainties are?
4. The comparison of the assumptions for the 1994 model predictions and the 1997 ones were not clear. For the corresponding years, and for the "big spill", what assumed fraction of the total spill eventually went into the cloud?
5. For low wind velocities how long will the cloud from a major spill persist?
6. The Occupational Safety and Health Administration (OSHA) defines an immediately dangerous to life or health concentration (IDLH) emergency response regulation as "An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere". For Chlorine the IDLH was apparently recently revised from 30ppm down to 10ppm. How does this impact the risk calculations?

7. The hazard posed for the same volume release is much greater for night-time and cloudy conditions than for sunny day-time conditions. In the modelling, did the appropriate weighting take into account the number of total hours of sunshine at the plant location or was a more conservative assumption, that the release would always occur at night, taken?

8. In various places you use the phrase "typical daytime weather conditions" Did this include cloud cover or only atmospheric stability ratings?

9. It was stated that there has been only one recent major spill of chlorine. This was the case of the 84,000lb spill at the Henderson facility in Nevada in 1991. Have there not been a number of others?

10. What is the total amount of chlorine produced at this plant per year? (A good guess would be 1735 rail cars of 90 tons each for a total of 156,000 tons?) Is the volume of chlorine stored near the site still the same, despite the statement that on-site inventories have been reduced from 1780 tons to 550 tons?

11. On average how many deaths can we expect if 300 tons of chlorine is released into the air?

12. Why is there no data which give the likely consequences of each event described? (ie. number of fatalities).

13. For the review conducted by A.D. Little was the modelling done with independent programs, or was the same proprietary model supplied by BOVAR used?

14. It states in response to Q3 of the Oct 30/97 Public meeting that "people would be exposed for less than 1 hour". How do you reconcile this with published reports (eg UCRL-53685 - Emergency Response Planning for Potential Accidental Liquid Chlorine Releases - Lawrence Livermore National Laboratory - May/86) which states "these concentrations persist over periods of approximately two to three hours".

Yours truly,

A solid black rectangular box used to redact the signature of Corrie Kost.

Corrie Kost

Irwin Torry

From: Jennifer Paton
Sent: March 25, 1998 8:47 AM
To: Irwin Torry
Subject: The Magic Number(s)

Within one mile of canoxy I can estimate the following number of units:

532 single family
379 townhouse
386 apartment

1297 total

This does not include secondary suites

I have the map if you need a copy of it.

Jen

0405

Chlorine; CASRN 7782-50-5 (04/01/97)

Health assessment information on a chemical substance is included in IRIS only after a comprehensive review of chronic toxicity data by U.S. EPA health scientists from several Program Offices and the Office of Research and Development. The summaries presented in Sections I and II represent a consensus reached in the review process. Background information and explanations of the methods used to derive the values given in IRIS are provided in the Background Documents.

STATUS OF DATA FOR Chlorine

File On-Line 06/01/94

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	06/01/94
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	01/01/93

I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)

Substance Name -- Chlorine
CASRN -- 7782-50-5
Last Revised -- 06/01/94

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. ORAL RfD SUMMARY

Critical Effect	Experimental Doses*	UF	MF	RfD
No observed adverse effects	NOAEL: 14.4 mg/kg-day	100	1	1E-1 mg/kg-day
	LOAEL: None			
Rat Chronic Drinking Water Study				
NTP, 1992				

*Conversion Factors and Assumptions: Doses determined based on body weight and water consumption values from the study.

I.A.2. PRINCIPAL AND SUPPORTING STUDIES (ORAL RfD)

NTP (National Toxicology Program). 1992. NTP Technical Report on the Toxicology and Carcinogenesis Studies of Chlorinated and Chloraminated Water in F344/N Rats and B6C3F1 Mice (drinking water studies). U.S. Dept. of Health and Human Services. NTP TR 392.

In a 2-year study (NTP, 1992) Fischer 344/N rats and B6C3F1 mice (70/sex/group) were administered chlorinated drinking water containing 0, 70, 140 or 275 ppm of available chlorine (based on IR measurements of available atomic chlorine) for up to 104 weeks. Based on body weights and water consumption values reported in the study, these doses correspond to doses of 4.2, 7.3 and 13.6 mg/kg-day for male rats; 4.2, 7.8 and 14.4 mg/kg-day for female rats; 7.4, 14.0 and 24 mg/kg-day for male mice; and 7.6, 14.2 and 24.2 mg/kg-day for female mice. Interim sacrifices of 10 animals/sex/dose were performed at 15 and 46 weeks. A complete necropsy and hematologic examination was performed on all animals at these times; additionally, a complete histopathologic examination was conducted for all animals in the control and high-dose groups. Results from these evaluations were unremarkable for both rats and mice. All animals were subjected to complete necropsy and a histopathologic examination at completion of the study. Survival among treated rats and mice was similar to controls. A decrease in water consumption noted in both rats and mice apparently was dose-related. Mean body weights of all dosed male rat groups, high-dose female rats, high-dose male mice and all dosed female mice groups appeared decreased compared with controls; these decreases never exceeded 10%.

In rats, water consumption was decreased 21% for males and 23% for females at the highest dose from weeks 53-104. No decreases were reported in food consumption and survival rates were similar for all groups of animals (treated and controls). At interim sacrifices (14 and 46 weeks) no significant differences in body weight, organ weights or body-to-organ weight ratios were reported. No differences were reported in blood chemistry or gross or microscopic histologic parameters. In the second year of the study, body weights were slightly reduced; however, the reduction in body weights was <10%. No other nonneoplastic lesions or effects were seen at 104 weeks in any treated animals.

In mice, body weights were decreased 3-8% for males and 5-7% for females, and water consumption was reduced 31% for males and 26% for females. Survival rates were similar for all groups. Significant decreases were noted in brain weights at 15 weeks and liver weights at 46 weeks for the high-dose males. These effects were not reported at 104 weeks and may be attributed to lower body weights and reduced water consumption. No alterations were reported in hematologic or histologic parameters.

The NOAEL of 275 ppm (13.6 or 14.4 mg/kg-day for male and female rats, respectively) is chosen as the basis for the chronic oral RfD. Mice received a higher dose on a weight basis (24 mg/kg) but effects, although equivocal, were observed. Doses between 14.0 and 24.0 mg/kg were not tested in rats. In addition, this NOAEL is supported by NOAELs from other chronic and subchronic rat studies. Therefore the 14.4 mg chlorine/kg in females is selected as the basis of the RfD.

I.A.3. UNCERTAINTY AND MODIFYING FACTORS (ORAL RfD)

UF -- The uncertainty factor of 100 reflects 10 for interspecies extrapolation

T.A.4. ADDITIONAL STUDIES / COMMENTS (ORAL WED)

F344 rats (50/sex) received sodium hypochlorite in drinking water for 104 weeks at doses of 0, 500 or 1000 ppm in males and 0, 1000 or 2000 ppm in females (Kurokawa et al., 1986). These doses correspond to 0, 70 and 140 mg/kg-day for males and 0, 95 and 190 mg/kg-day for females based on reference body weight and water consumption values (U.S. EPA, 1984). Following exposure, survival, clinical signs, water consumption and body weights were monitored. Hematologic parameters and serum biochemical analyses were evaluated, and gross necropsy and histopathologic examinations were performed. In female rats a dose-related decrease in body weight relative to controls.

Parental animals began treatment at 100 days of age. Rats were repeatedly mated and remained on treatment during pregnancy and lactation. Selected progeny were separated from their dams at 30-40 days and were designated the subsequent generation. Animals of the F3 and F4 generations consumed chlorinated water only until the birth of progeny. Subsequent generations remained on chlorinated water for their entire life span. Two groups of animals served as controls at the beginning and ending of the experimental

period.

Weight gain among neonates was somewhat depressed during the first few days of life. By maturity the average body weight for all generations of test animals was about 5-10% greater than that of the untreated rats. Of 236 rats observed, no treatment-related effects were noted on the life span, fertility, growth, hematologic measurements or histology of liver, spleen, kidney and other organs. The incidence of malignant tumors in the treated rats was not found to differ from that of control group rats. A NOAEL of 10 mg chlorine/kg could be identified from this study.

In a reproductive study by Carlton et al. (1986), chlorine was administered by gavage in deionized water at doses of 1.0, 2.0 and 5.0 mg chlorine/kg-day to male (12/dose group) and female (24/dose group) Long Evans rats for 66-76 days. Males were treated for 56 days and females for 14 days prior to mating. Dosing continued during the 10-day mating period and afterwards females were dosed with chlorine daily during gestation and lactation. Males were necropsied at the end of the mating period. Dams and some offspring were necropsied at 21 days after birth. Other offspring were dosed with chlorine after weaning until they were 28-40 days old. No statistical differences were observed between the control and dose group in litter survival, litter size and pup weight. Developmental landmarks such as the mean day of eye opening and the average day of observed vaginal patency also were comparable across groups. Adult male rats exposed up to 5.0 mg/kg-day showed no adverse reproductive effects. A NOAEL of 5 mg/kg-day for maternal, fetal and neonatal effects can be defined from this study.

C3H/HEJ and C57BL/6J mice were administered drinking water that had been treated with sodium hypochlorite and hydrochloric acid (10-13 ppm) to maintain the water at pH 2.5 over a 6-month trial period (Lee, 1968). Control animals received tap water, which varied in pH from 9.2-9.8, but was usually 9.6. In the treated animals, the number of mice born and the number weaned/dam were greater than in the control ($p < 0.01$). The authors concluded that the treatment of C3H/HEJ and C57BL/6J mice with chlorine and hydrochloric acid had no adverse effects on their reproductive performance.

McKinney et al. (1976) noted a periodic increase in reproductive failure among CD-1 mice. Mating, number of embryos per fertile female and embryonic development were affected. The effect was seasonal and was most severe in the winter. In the absence of any other observed variations in the animal husbandry, the authors attributed the reproductive deficiencies to the heavily chlorinated Durham, NC, city water consumed by the mice.

Two attempts were made to repeat the observations reported by McKinney et al. (1976). Chernoff et al. (1979) found no significant difference in the reproductive parameters of CD-1 mice consuming Durham, NC, drinking water as compared with the control group maintained on distilled water. The animals were maintained on the test or control water for a 2-week period after which mating was begun. Dams were sacrificed on day 18 of gestation. Exposure was continued throughout the course of the study (December-September). Dams were analyzed for differences in numbers inseminated, number pregnant, weight gain during gestation, organ weight and percent resorption. Fetuses were examined for skeletal and visceral anomalies as well as mortality and body weight. No statistically significant maternal or fetal effects were noted, except for a 28.1% incidence of supernumerary ribs in the group consuming tap water compared with 21.1% in the control group consuming distilled water ($p < 0.05$).

In a second study, Staples et al. (1979) reported no significant overall influence on the incidence of malformed fetuses (skeletal or visceral malformations) that could be attributed to the chlorination of drinking water. The incidence of malformations in the controls was 8.1% compared with 7.8% in treated animals. Differences pointed in the opposite direction of the finding of McKinney et al. (1976). Two significant effects occurred in the month of January, and one occurred in the month of February. In January, a lower number of mated females CD-1 became pregnant, and the average number of

implants/pregnant females was lower in the group consuming purified water. In February, the average fetal weight was lower in the purified-water group than in the tap-water group. Indeed, the presence of chlorine in the water seemed to confer a beneficial effect. The authors concluded that the results of their study did not support the findings of McKinney et al. (1976), although there were complicating factors in the Staples et al. (1979) study. There appears to be no evidence that would link chlorination at levels consistent with current practice to any adverse reproductive effects in the species so far examined.

Balan and Proudfoot (1982) studied the effects of sodium hypochlorite in drinking water on Shaver broiler chickens. Sodium hypochlorite was added to the drinking water of chicks (240/sex) at doses of 0, 300, 600 and 1200 ppm. A significant ($p < 0.01$) reduction was found in the weight of chick, testes at dose levels of 600 and 1200 ppm of available chlorine. At these higher concentrations, however, there was also a decrease in total body weight, food and water consumption and an increase in mortality.

Meier et al. (1985) demonstrated that oral administration of a sodium hypochlorite solution, but not hypochlorous acid, resulted in dose-related increases in the amount of sperm-head abnormalities in male B6C3F1 mice. Ten animals/group were given 1 mL of a residual chlorine solution daily for 5 days. Test solutions were prepared by bubbling Cl_2 into a 1M solution of NaOH and adjusting the pH to either pH 8.5 (predominant species OCl^-) or pH 6.5 (predominant species $HOCl$). The solutions were diluted with distilled water to 200 mg/L, 100 mg/L and 40 mg/L chlorine equivalents (8.0, 4.0 or 1.6 mg/kg-day, respectively). The mice were then sacrificed at 1, 3 or 5 weeks after the last dose was administered. In mice given OCl^- , significant increases in sperm-head abnormalities were observed only at the 3-week interval at doses of 1.6 and 4.0 mg/kg-day. These results were reproduced in retrievals of the experiment. $HOCl$ administration at any dose was not associated with increases in sperm-head abnormalities.

Six virgin Sprague-Dawley rats were administered 0, 1, 10 or 100 mg $HOCl/L$ in drinking water for 2.5 months prior to mating. Animals were maintained on the treated water after pregnancy was confirmed (day 0) and killed on day 20. Maternal weight at time of death was not reported. The incidence of fetal anomalies associated with exposure to hypochlorous acid solutions was not found to be statistically significant. Mean fetal weights from the 10 and 100 mg/L groups were less than the control, but this decrease was not statistically significant. Neither was there a significant difference in numbers of resorptions between control and treated groups. Examination of general trends in the study indicated an increase (not significant) in skeletal anomalies in animals treated with 10 mg $HOCl/L$. Soft tissue anomalies for the 100 mg $HOCl/L$ treatment group were increased significantly by comparison with the control. The findings of these experiments were limited by the small number of study animals. Some of the calculations of anomaly percentages reported in the paper were incorrect. Furthermore, the rate of both skeletal and soft tissue anomalies appeared to be higher in the control group than in the low-dose treatment groups (Abdel-Rahman et al., 1982).

Exon et al. (1987) reported immunotoxic effects when sodium hypochlorite (5, 15 and 30 ppm) was administered in drinking water to Sprague-Dawley rats (12/sex/dose group) from weaning to 12 weeks of age. Based on reference body weight and water consumption values for subchronic exposure (U.S. EPA, 1986) the corresponding intake of chlorine was 0.7, 2.1 and 4.2 mg/kg-day. Parameters monitored were body weight, spleen and thymus weight, antibody production, delayed-type hypersensitivity (DTH) reactions, natural killer cell (NKC) cytotoxicity, oxidative metabolism response, phagocytosis by macrophages and production of interleukin 2 (IL2). The effects attributed to sodium hypochlorite treatment (at only the high dose) were reductions of spleen weight, DTH reactions, oxidative metabolism by macrophages and elevated prostaglandin E_2 production. The toxicological significance of these effects is not clear. A NOAEL and/or LOAEL were not defined in this study.

I.A.5. CONFIDENCE IN THE ORAL RFD

Study -- High
Data Base -- Medium
RFD -- Medium

Confidence in the principal study (WTF, 1992) is high to medium. Relevant endpoints in two animal species were examined after prolonged exposure by an appropriate route. An effect level was not achieved in the study, however, and higher levels may not be practicable due to taste aversion (and therefore reduced water consumption). Confidence in the data base is medium. Information is available for mice and rats on the noncarcinogenic toxicity of oral exposure to chlorine for subchronic periods. Developmental and reproductive toxicity of chlorine have been examined in mice and rats, but

with suboptimal studies. Due to the chemical relationship between chlorine and monochloramine, reproductive and developmental studies for monochloramine may be used to satisfy data gaps for chlorine. Confidence in the RFD is medium.

I.A.6. EPA DOCUMENTATION AND REVIEW OF THE ORAL RFD

Source Document -- U.S. EPA, 1992

The Drinking Water Criteria Document for Chlorine/Hypochlorous Acid/Hypochlorite Ion has undergone limited Agency review.

Other EPA Documentation -- None

Agency Work Group Review -- 07/20/93, 10/14/93, 12/15/93

Verification Date -- 12/15/93

I.A.7. EPA CONTACTS (ORAL RFD)

Please contact the Risk Information Hotline for all questions concerning this assessment or IRIS, in general, at (513)569-7254 (phone), (513)569-7159 (FAX) or RIM.IRIS@EPA.MAIL.EPA.GOV (Internet address).

I.B. REFERENCE CONCENTRATION FOR CHRONIC INHALATION EXPOSURE (RfC)

Substance Name -- Chlorine
CASRN -- 7782-50-5

Not available at this time.

II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- Chlorine
CASRN -- 7782-50-5

Not available at this time.

VI. BIBLIOGRAPHY

Substance Name -- Chlorine
CASRN -- 7782-50-5
Last Revised -- 06/01/94

VI.A. ORAL RFD REFERENCES

Abdel-Rahman, M.S., M.R. Bernardi and R.J. Bull. 1982. Effect of chlorine and monochloramine in drinking water in the developing rat fetus. *J. Appl. Toxicol.* 2(3): 156-159.

Abdel-Rahman, M.S., D.N. Suh and R.J. Bull. 1984. Pharmacodynamics and toxicity of chlorine in drinking water in the rat. *J. Appl. Toxicol.* 4(2): 82-86.

Carlton, B.D., P. Bartlett, A. Basaran, K. Colling, I. Osis and M.K. Smith. 1986. Reproductive effects of alternative disinfectants. *Environ. Health Perspect.* 69: 237-241.

Chernoff, N., E. Rogers, B. Carver, B. Kavlock and E. Gray. 1979. The fetotoxic potential of municipal drinking water in the mouse. *Teratology.* 19: 165-169.

Daniel, F.B., L.W. Coodie, M. Robinson et al. 1990. Comparative subchronic toxicity studies of three disinfectants. *J. Am. Water Works Assoc.* 82: 61-69.

Daniel, F.B., H.P. Ringhand, M. Robinson, J.A. Stober, G.R. Olson and K.P. Page. 1991. Comparative subchronic toxicity of chlorine and monochloramine in the B6C3F1 mouse. *J. Am. Water Works Assoc.* 83(11): 68-75.

Druckrey, H. 1968. Chlorinated drinking water toxicity tests involving seven generations of rats. *Food Cosmet. Toxicol.* 6: 147-154.

Exon, J.H., L.D. Koller, C.A. O'Reilly and J.P. Berce. 1987. Immunotoxicologic evaluation of chlorine-based drinking water disinfectants, sodium hypochlorite and monochloramine. *Toxicology.* 44: 257-269.

Hasegawa, K., M. Takahashi, T. Kokubo et al. 1984. Carcinogenicity study of sodium hypochlorite in F344 rats. *Food Chem. Toxicol.* 24(12): 1295-1303.

Hulan, H.W. and F.G. Froudfoot. 1982. Effect of sodium hypochlorite (Javox) on the performance of broiler chickens. *Am. J. Vet. Res.* 43(10): 1804-1806.

Kurokawa, Y., S. Takayama, Y. Konishi et al. 1986. Long-term in vivo carcinogenicity test of potassium bromate, sodium hypochlorite and sodium chlorite conducted in Japan. *Environ. Health Perspect.* 69: 221-235.

Lee, E.P. 1968. Effect of acidified - chlorinated water on reproduction in C3H/HEJ and C57BL/6J mice. *Lab. Anim. Care.* 18(2): 210-213.

McKinney, J.D., R.R. Maurer, J.R. Nass and R.O. Thomas. 1974. Possible factors in the drinking water of laboratory animals causing reproductive failure. In: Identification and Analysis of Organic Pollutants in Water, L.H. Keith, Ed. Ann Arbor Science Publishers, Inc., Ann Arbor, MI. p. 417-432.

Meier, J.R., R.J. Bull, J.A. Stober and M.C. Cimono. 1985. Evaluation of chemicals used for drinking water disinfection for production of chromosomal damage and sperm-head abnormalities in mice. Environ. Mutagen. 7: 201-211.

NTP (National Toxicology Program). 1992. NTP Technical Report on the Toxicology and Carcinogenesis Studies of Chlorinated and Chloraminated Water in F344/N Rats and B6C3F1 Mice (drinking water studies). NTP TR 392, National Institutes of Health.

Staples, R.E., M.C. Worthy and T.A. Marks. 1979. Influence of drinking water: Tap versus purified on embryo development in mice. Teratology. 19: 237-244.

U.S. EPA. 1986. Reference Values for Risk Assessment. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste, Washington, DC.

U.S. EPA. 1992. Drinking Water Criteria Document for Chlorine, Hypochlorous Acid and Hypochlorite Ion. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water, Washington, DC. (External review draft)

__VI.B. INHALATION RfC REFERENCES

None

__VI.C. CARCINOGENICITY ASSESSMENT REFERENCES

None

__VII. REVISION HISTORY

Substance Name -- Chlorine
CASRN -- 7782-50-5

Date	Section	Description
06/01/91	I.B.	Inhalation RfC now under review
01/01/93	II.	Carcinogenicity assessment now under review
06/01/93	I.A.	Oral RfD now under review
12/01/93	I.A.	Work group review date added
01/01/94	I.A.	Work group review date added
06/01/94	I.A.	Oral RfD on-line

06/01/94 VI.A. Oral RfD references on-line
06/01/94 SYN Synonyms revised

SYNONYMS

Substance Name -- Chlorine
CASRN -- 7782-50-5
Last Revised -- 06/01/94

7782-50-5
7681-52-9
7790-92-3
Bartholite
Caswell No. 179
Chloor [Dutch]
Chlore [French]
CHLOR [German]
Chlorine
CLORO [Italian]
Cloro [Spanish]
EPA Pesticide Chemical Code 020501
MSDB 206
Hypochlorite (sodium)
Hypochlorous acid
MOLECULAR CHLORINE
UN 1817

EH&S News

Regs News highlights hot topics and trends in regulatory compliance and legislation.

Committee Develops Acute Exposure Guidelines

The National Advisory Committee for Acute Exposure Guideline Levels for Hazardous Substances (NAC/AEGL Committee) has developed its first set of acute exposure guideline levels (AEGLs) for 12 chemicals. The "Proposed AEGLs" are:

- 1,1-Dimethylhydrazine
- Methylhydrazine
- Aniline
- Ethylene Oxide
- Hydrazine
- 1,2-Dichloroethene
- Nitric Acid
- Fluorine
- Chlorine
- Arsine
- Phosphine

The AEGLs (Acute Exposure Guideline Levels) are threshold or ceiling values for short-term exposure to hazardous substances. The guidelines are designed to protect the general public, including persons who may be sensitive, but not hypersensitive to exposure. Three AEGL values representing three "biological endpoints" for four exposure periods (30 minutes, 1 hour, 4 hours, 8 hours) will be established for each chemical. AEGL-1 is the airborne concentration at which the general population could experience "notable discomfort." AEGL-2 is the airborne concentration at which the general population could "experience irreversible or other serious, long-lasting effects or impaired ability to escape." Finally, AEGL-3 represents the concentration at which the general public is predicted to "experience life-threatening effects or death."

Formed by the EPA, the mission of the NAC/AEGL Committee has been to study and develop guidelines for short-term hazardous chemical exposure. The NAC/AEGL Committee intends to develop AEGL values for 30-40 chemicals during each of its quarterly meetings for the next eight to ten years. After public comment, the Committee will review and revise proposed guideline values to establish "Interim AEGL" values. The Interim AEGLs may be used as biological reference values by agencies, but the values will be further reviewed and finalized by the National Academy of Science. Once these guideline levels have been established, they may be adopted by government agencies and private sector organizations for chemical

emergency programs. The EPA then intends to adopt the finalized guideline levels as toxicity references for short-term threshold or ceiling exposure values.

Federal Register
October 30, 1997

EPA Announces Changes in Ambient Air Quality Surveillance for Lead

The Environmental Protection Agency (EPA), recognizing that automobiles account for less than 1% of lead emissions, has changed its surveillance focus to stationary source lead emissions. Effective December 22, 1997, as many as 70 of the 85 National Air Monitoring Stations (NAMS) and several of the State and Local Air Monitoring Stations (SLAMS) will be discontinued. The EPA will now close those NAMS consistently reporting peak levels less than 1.5 mg/m³. This change will allow state and local agencies to focus monitoring efforts on lead stationary sources that are causing, or could potentially cause, exceedances of the quarterly National Ambient Air Quality Standards (NAAQS).

Federal Register
November 5, 1997

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Emergency Response Planning Committee

David P. Kelly, Chair
Finis L. Cavender, Ph.D., CIH, DABT, V-Chair
Dean J. Hansen, Ph.D. MPH, CIH, Secretary
Larry Gephart, DABT, P-Chair
Dennis R. Anderson, Ph.D., CIH
Jonathan Borak, MD, FACOEM
Patricia A. Brogan, Ph.D., CIH, ROH
Keith H. Jacobson, Ph.D., CIH(ret)
Frank M. Renshaw, Ph.D., CIH
Susan D. Ripple, CIH
Marc M. Ruijten, Ph.D.
George M. Rusch, Ph.D.
Richard B. Schlesinger, Ph.D.
John W. Spencer, CIH, CSP
Allan S. Susten, Ph.D.
Richard D. Thomas, Ph.D., DABT

Board Coordinator: Lindsay Booher, CIH, CSP

Mission Statement: To develop guidelines for responding to potential releases of airborne substances for use in community emergency planning.

Goal: Publish brief summaries and estimates of tolerable-effect thresholds, not intended as exposure recommendations, to assist in the planning for accidental, episodic chemical releases.

Objective: Review the health and safety data on the chemicals of greatest concern in the United States.

Strategies:

- Assign evaluators to review and revise toxicology summaries on chemicals of concern.
- Meet as a full committee four times a year to review summary documents and to develop estimates of tolerable exposure levels.
- Prepare emergency response guidelines for publication and distribution by the AIHA national office.
- Prepare and maintain documentation supporting the guidelines.

Below is a "snapshot" of major activities of the AIHA Emergency Response Planning committee. If you are interested in further information about this committee's activities, or are an AIHA member and wish to join this technical committee, please contact the chair (above on this committee page) or refer back to the main Webpage menu to the AIHA Committee brochure.

Summary of Current Committee Activities

Publications in Progress:

- The AIHA 1997 ERPGs and WEELs Handbook. To be published 1/98.
- 1997 ERPG Update Set. To be published 1/98.
- 12-15 new ERPG are expected to be developed for chemical substances in the 1997-98 year.

Other Activities:

- Support for AIHA Public Relations efforts.
- Support for EPA Federal Advisory Committee Act (FACA) Acute Exposure Guideline Levels (AEGLE) committee.
- AIHA ERPG's recommended as values in the latest EPA Risk Management Plan under the Clean Air act.
- Liaison with scientists in the Netherlands and Germany on ERP issues.

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United States
Environmental Protection
Agency

Office of Pollution Prevention
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Chemicals in the Environment: Public Access Information

TRI Toxics Release Inventory

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The History of TRI

Susan Hazen, Director
Office of Pollution Prevention and Toxics (OPPT)
Environmental Assistance Division

In 1986, the Superfund legislation was amended to add Emergency Planning and Community Right-to-Know (EPCRA) provisions. Following closely on the fatal chemical release accident in Bhopal, India and since far though less drastic incidents in the U.S., these new provisions were intended to assure citizens that the presence, management, and routine releases of toxic chemicals in the U.S. were well understood. It was evident that the Bhopal incident could happen in the U.S. In fact, there were facilities in the U.S. where the same chemicals were manufactured, used, and stored although information about them was generally not disclosed. Emergency response teams, state and local governments, and perhaps, most importantly, the citizens who lived and shared common neighborhoods with these facilities were unaware of chemicals used and stored there.

The history of TRI has been a turbulent one. It was hard fought through Congress and the implementing rules were scrutinized heavily as they moved their way through the regulatory process. At the core of the debate was the provision that would create a facility-specific, chemical-based inventory.

The inventory, termed the Toxics Release Inventory (TRI), would create a national database identifying facilities, chemicals manufactured and used at those facilities, and the annual accidental and routine releases of these toxic substances. This information, though commonly known by individual plant owners and operators, was not made readily available to government officials nor to the general public. Also, this information usually did not become available until after serious accidents occurred or until major impacts on human health and the environment were evident. This after-the-fact disclosure of information did little to help plan for or prevent serious health and environmental incidents.

From 1987 to 1990, TRI data focused on release and transfer data for approximately 300 chemicals and 28,000 facilities. With the passage of the Pollution Prevention Act of 1990 (PPA), information on the amount of toxic materials leaving a facility in waste was added. As with the original implementation rules, the rules implementing the PPA were subjected to rigorous review and EPA was unable to finalize working definitions that would assure consistency in the data. This remains a weakness of the TRI and a challenge for EPA, the regulated community, and all users of the data.

It is fair to say, that turbulent or not, the history of TRI is one which has dramatically changed the last decade of environmental policies. TRI has enabled the public to participate on an equal footing in environmental debates. It has allowed the public to question the decisions of lawmakers and industry alike. It has alerted U.S. industry to the impact they have on their local environments and has pointed out the significant losses of raw material encountered each year as a result of releases and transfers.

TRI has forever changed the relationship between EPA, industry and the public; a change which created the need for transparency, openness and honesty. As changes go, this is one of the best!

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Expanding the Public's Right to Know



Marka Doa, (Acting) Chief
OPPT Environmental Assistance Division (EAD) - TRI Branch

Few would disagree that the 1987 Emergency Planning and Community Right-to-Know Act (EPCRA) provisions proved to be among the most successful stimuli for reducing the amount of toxic materials that enter the environment. The Toxics Release Inventory (TRI) Program under EPCRA focused public and industrial attention on billions of pounds of toxic materials released directly into our air, land, water, and underground injection wells, as well as managed through waste recycling, combustion for energy recovery, and treatment for destruction.

TRI has forced us all to take a hard look at our approach to toxic chemicals. Between 1988 (the accepted baseline year for TRI) and 1994, industrial releases covered by TRI decreased by 44%, from 3.54 billion pounds to 1.56 billion pounds. This reduction reflects the hard work of manufacturing facilities; facilities that have refined processes, looked for source reduction opportunities, assessed outstanding housekeeping practices, and worked to minimize the footprint they leave on the surrounding environment. TRI has provided the clues for all to use when seeking areas for environmental improvement.

One valid criticism of the program has been its limited breadth and depth of the chemical, facility, and data coverage. When Congress passed EPCRA, EPA named over 300 chemicals and chemical categories on the "TRI Chemical List." This list was a combination of two existing lists, the New Jersey Environmental Hazardous Substance List and the Maryland Chemical Inventory Report List. The original industries subject to TRI were all manufacturers, and required data was confined to releases and certain transfers off-site for waste management.

Because TRI spurred significant reduction in releases, the next logical step was to expand coverage to other industrial sectors and chemicals imposing similar impacts on our environment. To that end, the Agency has aggressively pursued an expansion strategy to enlarge the boundaries of TRI in all directions.

Chemical Expansion

EPA has expanded the chemical list in two parts, following the statutory criteria for listing found in EPCRA (acute or chronic human health effects, or environmental effects). In 1993, EPA added ozone-depleting hydrochlorofluorocarbons (HCFCs) and 22 other chemicals that cause chronic health effects. In 1994, EPA added 286 new chemicals that can cause a variety of effects, some connected to cancer or other chronic human health effects; others to acute human health effects; and others to adverse environmental effects. These actions almost doubled the size of the TRI chemical list. EPA is currently considering whether to add certain persistent bioaccumulators to TRI and to lower the reporting thresholds for all persistent bioaccumulators on TRI. EPA expects to propose a rule on this topic in 1998.

Chemical Petitions

EPCRA contains provision for the public to petition the Agency to add chemicals to or delete chemicals from the TRI list. EPA has added and deleted chemicals through this process. EPA added stratospheric ozone-depleting chlorofluorocarbons (CFCs) in response to a petition from four governors. EPA has deleted various chemicals, 16 in all, that do not meet the statutory listing criteria.

Facilities Expansion

Recognizing that the manufacturing sector only contributes a fraction of releases to the environment, in 1991, EPA undertook a thorough review of all other U.S. industrial sectors. This multi-year effort focused particular attention on sectors linked to manufacturing — those providing energy or raw materials to, or removing materials from the manufacturing sector. EPA assessed: (1) the industries that manufacture, process, or use TRI chemicals and (2) whether including these facilities in TRI could reasonably be anticipated to increase public information.

The first facility expansion came as a result of a Presidential Executive Order, which required reporting for Federal Facilities starting in 1994. In May of 1997, as a result of its assessment, EPA added seven industry sectors to TRI: metal mining, coal mining, electric utilities that combust coal and/or oil, solvent recyclers, hazardous waste treatment and disposal facilities, chemical distributors and petroleum bulk terminals. The first reports from these facilities are due July 1, 1999. (See *Industry Expansion*, page 6). EPA will pursue an additional facility expansion activity addressing the oil and gas industry early in 1998.

Data Expansion

In 1990, Congress passed the Pollution Prevention Act. Among its requirements is a mandate to expand TRI to include



information on toxic chemicals in waste and source reduction methods. Beginning in 1991, covered facilities are required to report on toxic chemicals in waste, that is, how much is combusted for energy recovery, recycled, treated, and released.

A newer data expansion effort, often referred to as "TRI Phase III," considers using materials accounting data in a right-to-know context. Many community, environmental, and labor organizations believe that TRI would be greatly enhanced by the collection of facility-specific use information. Data elements could include the amount produced on-site, the number of employees potentially exposed, and the amount of the toxic chemical leaving the facility as or in a product. EPA issued a notice requesting public comment on the addition of materials accounting information to TRI, and is currently evaluating those comments.

The TRI Program has indeed proven to be an effective tool for bringing both industrial and public attention to the release of toxic chemicals. The concern generated by this program has resulted in efforts to minimize the use of these toxics and/or their release into the environment. EPA believes that by expanding the scope of TRI information, in terms of the chemicals and facilities covered as well as the kinds of data required, the Agency can further improve TRI's value for us all.

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Chemical Fact Sheets

Dick Wormel, OPPT

OPPT chemical fact sheets provide the public with information about chemicals released in the environment. They describe what each chemical is and list several of its more important commercial uses. They describe in a non-technical manner what happens to the chemical once it is released into the environment and how the chemical may affect human health and the environment. They also provide the reader with a contact list for additional chemical information. Each fact sheet is accompanied by a more detailed summary that gives the technical basis for each statement that it contains. Both the fact sheet and its technical support document can be found on the Internet at <http://www.epa.gov/chemfact>. Also, both are available in printed form and can be requested from the Toxic Substances Control Act (TSCA) hotline at (202) 554-1404. Currently, there are thirty-one chemical fact sheets available to the public.



OPPT chemical fact sheets originate from the group of scientists responsible for assessing risks for industrial chemicals covered under the Toxic Release Inventory (TRI) and TSCA. The group has been assessing chemicals for more than twenty years. They collected and processed volumes of assessment information on thousands of chemicals. The chemical fact sheet initiative is the group's attempt to share some of its information with the public. The standing goal of this group is to provide the public with fact sheets for forty or more additional chemicals each year.

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Industry Expansion Training for the Newly-Added Industries

Tim Crawford, OPPT

What is Industry Expansion?

On May 1, 1997, a final rule was published to add certain industry sectors to the current list of facilities required to report TRI information under Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). Known as TRI I Industry Expansion, the addition of these industry sectors will greatly strengthen community right-to-know by providing information on toxic chemical releases and waste management from a broader facility base.

This final action also amends the interpretation of the term "otherwise used," which is one of the activity thresholds that triggers TRI reporting. EPA amended this definition to include the treatment, stabilization, and disposal of toxic chemicals received from off-site for waste management purposes or generated during the waste management of materials received from off-site. This amendment provides additional information on waste management activities (beyond the amounts managed by commercial hazardous waste treatment and disposal facilities) at facilities that currently report to TRI.

The addition of the new industries and the revised interpretation of "otherwise used" will be effective for activities conducted during the 1998 calendar year with reports due on or before July 1, 1999.

Industry Training

Since the final rule was published, EPA developed guidance documents to assist each of the newly added industries to understand and comply with EPCRA section 313 requirements. These documents were circulated for industry review and comment and are now final and being made available.

EPA, along with contracted assistance, is in the process of conducting training sessions in each of EPA's regional locations prior to the effective date. The training sessions last two days and consist of an overview of EPCRA Section 313 reporting requirements and modules which provide exercises in interpreting and completing reports for each of the new industries.

For more information on TRI industry expansion and industry training, please contact Tim Crawford at (202) 260-1715.

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Industry	SIC Code
Metal Mining	10
Coal Mining	12
Electric Utilities	4911, 4921, 4931
Commercial Hazardous Waste Treatment	4962
Chemicals & Allied Products - Wholesale	5168
Petroleum Bulk Terminals and Plants	5171
Solvent Recovery Services	7299



Using TRI to Measure Progress: A Regional Perspective

Dwight G. Peavey, Ph.D., Environmental Scientist
EPA Region 1 - New England

James M. Phillips, Senior Environmental Engineer
The National Council on the Aging, Inc.

Over the past ten years, the Toxics Release Inventory (TRI) data has given everyone an opportunity to access chemical specific information at the facility, local, state, regional and national levels. One can query the TRI data by media specific emission, waste generation and transfers, on and off-site treatment activities for 650 toxic chemicals, and chemical categories. The Pollution Prevention Act (PPA) of 1990 required industries to report additional data about waste management activities and pollution prevention or source reduction information on their TRI Form Rs. This additional information allows an individual to query TRI about the total waste generated by a facility. The total waste generated includes toxics that are released, recycled, burned for energy recovery, treated and disposed both on and off site.

The public's initial and continued interest has been focused on the total environmental releases of these toxics to the air, water and land including underground injection. Which facilities, states or parent companies are in the "Top Ten" has dominated the press coverage of the yearly TRI public data release. Our national, regional, state and facility successes have been measured by relative decreases in total environmental releases. Federal and state agencies often have targeted the facilities with the "biggest/largest" total environmental releases for attention.

Region 1's Approach

In New England, three of our six states have Toxics Use Reduction (TUR) or Pollution Prevention laws which have created a focus on preventing waste, also called source reduction. EPA - New England and state agencies are now focusing on the "biggest/largest" waste generating facilities. Due to the Pollution Prevention Act of 1990, everyone has had the ability to query, sort, and rank total waste generation for TRI data since 1991. Progress in terms of the rate of reduction for total waste generation has not paralleled the continued decreasing rate for total environmental releases. Although some have questioned and openly debate the success of pollution prevention and the affects of the states TUR laws, no one debates that, if given the opportunity, preventing waste and pollution is preferable to managing waste and pollution. Several corporations and facilities, which joined the 33/50 Program (an EPA program in which industries voluntarily committed to reduce the release of chemical waste), have shown the environmental and economic advantages of pollution prevention. The Pollution Prevention Act established a national policy that states pollution should be prevented at the source whenever feasible.

With the recent challenges posed by Congress and our Agency, we have looked to the TRI data (specifically, waste generation data) to find opportunities to better direct our assistance efforts and measure the resulting progress. In the past, these sectors (Fig. 1) accounting for the largest releases would be targeted. When the TRI waste generated data (Fig. 2) is analyzed, however, another picture is found. For example, the chemical and fabricated metals industries rank #1 and #2 for waste generated but the paper industry, traditionally ranked #1 for environmental releases. A multi-year analysis shows a significant decrease in total waste for the fabricated metals industry, which is neither explained by decreased reporting or decreased production. That is, the production process itself has become less polluting. This decrease in total waste production may be the results of our New England Environmental Assistance Team (NEEAT) work with this sector as well as EPA's Common Sense Initiative. The paper industry, on the other hand, shows little or no reduction in the first three years and an actual increase in waste generation in the last two years. While the chemical industry profile showed a continued reduction in environmental releases, Figure 3 shows initial decreases and then increased waste production. Further analysis of waste generation data shows a forecasted increase in waste production in 1996 and 1997 for this sector.

Ranking our six states by total environmental releases always has Connecticut and Massachusetts, the two largest manufacturing states in New England, as #1 and #2. In all the TRI reporting years (1987-1995), each of our six New England states had overall decreases in environmental releases which exceeded the national average decreases; cumulative decreases also exceeded the national average. Another way to analyze how well states are doing is to consider the number of facilities compared to total emissions (total environmental releases). Figure 4 clearly demonstrates that both Maine and Connecticut facilities rank on an emissions per facility basis as #1 and #2, respectively, with Massachusetts #6. Does this show an effect of the Massachusetts Toxics Use Reduction law? Further analysis of the 1991-1995 TRI waste generation data (Fig. 5) clearly demonstrates that average waste production of facilities in Maine and Connecticut are more than double those of the four other states. The comparisons of states with P2 and TUR laws mandating prevention activities with those states which do not, therefore, pose many more questions than answers as to why certain industries prevent pollution while others choose to manage pollution.

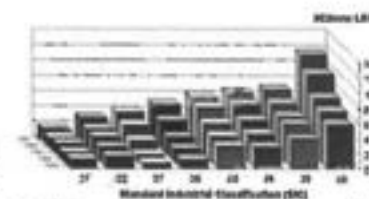


Fig 1

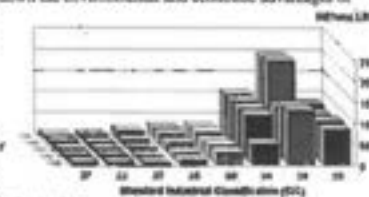


Fig 2

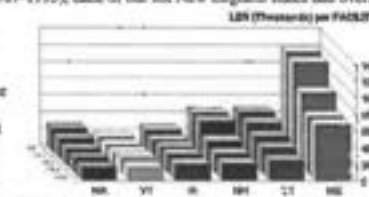


Fig 3

Region 1's Office of Assistance and Pollution Prevention now provides trend analysis of TRI data on total environmental releases and total waste generated. In New England, progress will be measured both by the individual success stories and reduction of the TRI bottom line: total waste generation. Progress may be measured by the pounds of toxics prevented from reaching the waste stream. This gives a better indication in the relative efficiency of the process and facility. Ultimately, the success of TRI and Pollution Prevention is measured at each individual facility.

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Toxics Release Inventory User Support (TRI-US) Services

Lisa Fleming, OPPT

Under the Emergency Planning and Community Right To Know Act (EPCRA) Section 313, Congress mandated that the TRI data collected by EPA be made publicly available "by electronic and other means." Hence, the Office of Pollution Prevention & Toxics (OPPT) established the Toxic Release Inventory User Support (TRI-US) service to support TRI products and facilitate public access to the TRI data.

TRI-US provides access and user support to citizens, industry, environmental and public interest groups, libraries, the international community, media, academia, federal, state and local agencies. Since the TRI data are available in a variety of formats, TRI-US staff can help a patron determine the TRI data product best suited for their needs.

TRI-US provides comprehensive search assistance for the TRI on-line and CD-ROM databases. Search assistance includes access to a product, installation or search instructions, product troubleshooting, and search strategies. On a limited basis, TRI-US can help individuals perform searches.

In addition to access, user support and search assistance, TRI-US conducts training and demonstrations for both the TRI CD-ROM and the National Library of Medicine/TOXNET, which includes the TRI data, through individual sessions and workshops. Staff attend conferences and exhibits to promote TRI awareness, access available products, and increase usage of data. TRI-US also distributes documents that present and explain the TRI program such as the Public Data Release book, the TRI Information Kit, and the TRI List of Chemicals.

TRI-US maintains up-to-date information about the TRI program. However, a patron may be referred to a more appropriate person or service (inside or outside EPA) if a question cannot be answered by the TRI-US staff and/or requires additional information outside the TRI program.

The TRI program also maintains a website on the Internet where patrons can send TRI questions. TRI-US staff will answer these questions and/or refer patrons to the appropriate Internet address for more information. TRI-US can be contacted by phone, fax, email, the Internet or mail.

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TRI/Right-to-Know Conference

Geraldine Nowak, OPPT

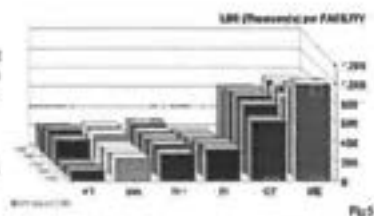


Fig 5



The Toxics Release Inventory and Right-to-Know Conference convened in Washington, D.C. on September 8-10, 1997, amidst the largest group of participants in its conference history. What was once the TRI Data Use Conference was expanded to integrate other RTK issues and information. Some participants embraced the concept with enthusiasm; others met it with caution, skepticism, or somewhere in between. The conference identified how the stakeholders could use the Toxics Release Inventory (TRI) and Right-to-Know (RTK) information. Dialogues were held among stakeholders and sessions aimed toward finding mutually beneficial goals which will improve TRI and RTK information.



The conference featured many distinguished speakers committed to promoting Toxics Release Inventory (TRI) and Right-to-Know (RTK) issues and programs. EPA Region III Administrator, Michael McCabe, opened the conference focusing on the fact that before TRI there was no way for citizens to know about toxics in their community. TRI has had a positive effect on both communities and industries because it enables communities to interact with industries in the neighborhood. Also, industry utilizes the TRI to capitalize on source reduction opportunities. As the keynote speaker, Dr. Lynn Goldman, EPA Assistant Administrator for Prevention, Pesticides, and Toxic Substances, reminded everyone of the history behind the legislation, highlighted TRI and RTK accomplishments, and mentioned the program's expansion. She further emphasized that the power of information provides real time tools to help families protect themselves and their communities.

Twenty-four panels of distinguished speakers shared their expertise, knowledge, and ideas for the future of TRI and RTK by addressing six broad questions:

- What are the key TRI data issues?
- How can TRI be used for Pollution Prevention?
- What are the TRI use success stories?
- What information do communities need?
- How can we integrate RTK information?
- How can the various stakeholders work better together, including the local and international perspective?

The Union Institute, the conference sponsor, successfully planned each panel to reflect views from a variety of stakeholders, representing the 600 participants from federal, state and local government, industry, advocates, academia, citizen groups, media, and international organizations. Speakers discussed their ideas and vision, and also showed practical experience on data use and analytic approaches.

The Right-to-Know Village housed forty-five exhibits which featured various information access tools developed by federal and state government, the commercial sector, and citizen and consumer advocacy groups. The village offered an opportunity to talk directly with RTK proponents on local environmental matters. The conference offered several demonstrations and training courses to teach participants how to use various information access systems and tools.

The three plenaries covered stakeholder views on the legislative history and net effect of TRI and RTK, and provided insights into the future. Comments from the audience flowed freely after the plenaries and panels; participants shared their concerns, frustrations, and hopes with the panelists.

During the closing plenary, EPA Administrator Carol Browner thanked stakeholders for working together with a sense of common purpose to improve the use of environmental RTK information and for making RTK initiatives work for everyone — communities, state and local government, and the reporting industries. She reiterated this Administration's goal of right-to-know as a vital part of the presidential agenda for protecting public health and the environment. EPA is making this goal a reality as a means to solving environmental problems.

Author Note: Thanks to all those who gave their precious time and vast talents to make the conference a source of inspiration, common purpose, and renewed dedication to environmental protection.

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Stakeholder Dialogue on TRI Reporting Forms and Reporting Practices

Michelle Price, OPPT

On April 22, 1997, EPA completed a rule under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) Section 313 to add seven new industry sectors to the Toxics Release Inventory (TRI) program. (For a list of sectors, see *Industry Expansion*, page 5.) These newly added industry groups will provide significant information on TRI chemicals and engage in activities directly related to the support of manufacturing activities already covered under TRI. Certain facilities within these industry groups will begin submitting activity reports by July 1, 1999, containing data collected during the 1998 calendar year. (See *Expanding the Public's Right to Know*, page 3.)

Announcing the industry expansion rule, the Vice President said that EPA would initiate a comprehensive stakeholder process to evaluate the current reporting forms and reporting practices relating to the TRI program. The goals of this process will be to improve the type of right-to-know information available to communities and to help streamline right-to-know reporting to ease the paperwork burden for businesses affected by the requirements. EPA is using the Toxics Data Reporting Committee (TDR) of the National Advisory Council for Environmental Policy and Technology (NACEPT) and additional stakeholder meetings to obtain input from interested parties on these issues.

Under the Federal Advisory Committee Act, NACEPT provides advice and recommendations to the Administrator of EPA on a broad range of environmental policy issues. TDR is a committee created under the auspices of NACEPT. The committee currently consists of twenty-three members from industry, academia, government agencies, environmental groups, environmental justice groups, labor organizations, and public interest groups.

Over the next year, TDR will identify improvements and burden reduction measures (i.e., industry must undertake to report TRI data) in the TRI program. EPA will review the recommendations received from NACEPT and use them to make decisions about changes to TRI Form R and Form A. Administrative changes to the reporting forms can be made expeditiously; however, substantive changes require a formal notice and comment rulemaking. Some examples of issues that will be discussed by the group include: format and nomenclature used in the Form R; additional clarification of the elements in the Form R; opportunities for burden reduction in both the Form R and Form A; and EPA's presentation of the data in public information documents.

The public as well as other interested parties may attend the TDR Committee meetings. The first TDR Committee meeting was held on September 29 and 30, 1997 in Washington, DC. An additional six meetings are planned over the next year. The next meeting is planned for early December, 1997. EPA will publish Federal Register notices of meetings to announce the date, time and location of the meetings.

In addition to the NACEPT process, EPA plans to obtain views and information from stakeholders through a number of smaller meetings for interested parties. EPA will hold approximately nine public meetings over the next year regarding the issues outlined above. The first three meetings are scheduled for October 30, 1997 in San Francisco, CA; November 13, 1997 in Washington, DC; and November 20 in Chicago, IL. These efforts are aimed at not only at reducing the burden to industry but improving the quality and practical utility of the information in the TRI program.

For more information about the TDR Committee or other public meetings on these issues, please contact Michelle Price at (202) 260-3372 or price.michelle@epamail.epa.gov.

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TRI and the CD-ROM: Present and Future

John Nowlin, OPPT

Beginning in 1989 and every year thereafter, EPA has published a CD-ROM containing the Toxics Release Inventory (TRI). The Office of Pollution Prevention and Toxics (OPPT) publishes the entire TRI database from 1987 through the current reporting year. This year the TRI data is available through reporting year 1995 on two compact disks in a format that

allows for easy searches of the data.

The TRI CD-ROM contains software that is meant to be flexible and powerful, with the ability to search over 200 fields (e.g., by chemical, company, kind of release, or zip code, and across multiple years of data). The CD-ROM also allows users to conduct multiple and complex queries, which is especially useful to those individuals or groups who wish to analyze trends or perform statistical analysis. Aside from the TRI data, the CD-ROM provides a wealth of other TRI information. It contains a tutorial, the annual TRI Data Release Book, the State Fact Sheets, TRI's reporting form (Form R), and Chemical Fact Sheets on selected chemicals.

Each year, the TRI CD-ROM reaches new audiences and increases its distribution. Currently, the CD-ROM circulation is over 4,000, including libraries and public interest groups. Future plans to appeal to a wider audience include distribution in conjunction with educational materials. Through a grant with the National Science Teachers Association (NSTA), the TRI CD-ROM will be the centerpiece in a cross-disciplinary set of classroom materials and activities. These materials should be available for 1998 school year.

OPPT plans to release a user-friendly Windows version later in 1998 (containing 1987-1996 data) that will be faster and easier to use than the DOS format of past years. The Office is also aggressively pursuing the integration of additional tools into future releases such as statistical packages complete with tables and charts, mapping packages, multi-media, and Internet connectivity.

How to Get Your Copy of the TRI CD-ROM:

To make TRI information widely available for public use, the CDs are distributed free of charge to all non-profit organizations, schools and government agencies who request a copy. Free copies may be obtained by calling the National Center for Environmental Publications and Information (NCEPI) at (800) 490-9199.

The general public can purchase the CDs from the National Technical Information Service (NTIS) by calling (800) 553-6847 and asking for PB97-502-587 or by calling the U.S. Government Printing Office (GPO) at (202) 512-1800 and requesting stock #055-00 0-0582-6.

The CD-ROM is one of the many ways in which OPPT disseminates TRI information to the public. Other sources of TRI Data include a new diskette containing Standard Industrial Classification (SIC) codes, and diskettes containing TRI Data for each State, both of which may be obtained from NCEPI, NTIS, or GPO. Another easy way to access TRI data is through the Internet at: <http://www.epa.gov/opptintr/tri/>.

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EPA Software Streamlines TRI Reporting by Facilities

Jan Erickson, OPPT

Since inception of the TRI program, one of EPA's goals has been to simplify the reporting required under the Emergency Planning and Community Right-to-Know Act (EPCRA) and the Pollution Prevention Act. Hotline, training, and publication of industry-specific guidelines are just a few examples of the many efforts undertaken to help meet that goal. To further simplify the reporting process, EPA developed the Automated Form R (AFR) reporting software.

Several years ago, the AFR software allowed facilities the option of creating TRI reports on their own computers and sending EPA electronic copies on a floppy disk, instead of filling out the printed forms manually. Not only did it make reporting much easier for the facility, it eliminated re-keying of the data by EPA. The results were faster processing, fewer data entry errors, and improved data quality. Since then, use of the AFR has increased in popularity. A growing number of facilities using the software—accounting for nearly 60% of all TRI submissions. In addition, all but ten states (which also receive TRI data) are accepting floppy disks created by AFR software, instead of printed forms.

In 1997, in response to a growing demand by AFR users, the Office of Pollution Prevention and Toxics (OPPT) distributed a Windows 3.1 version for the first time. The new AFR software included many features germane to the Windows environment, for example, menu and tool bars, buttons, etc. EPA distributed the Windows AFR software and printed instructions automatically to all TRI facilities; a DOS version was available on request.

In addition, both Windows 3.1 and DOS versions of the AFR software were available for downloading from the TRI Home Page on the Internet (www.epa.gov/opptintr/form.htm). This allowed facilities that preferred DOS software to obtain it immediately, without waiting for EPA to send them a floppy disk in that format. The website was especially helpful in communicating with TRI facilities during the reporting period. It enabled EPA to post improved versions of the software, more detailed instructions, and answers to frequently-asked questions. Facilities were also able to comment on their questions directly to the EPCRA Reporting Center using e-mail over the Internet.

EPA's goal is to reach 80% electronic submittal in the 1997 reporting year and 90% in the following year. This is a very ambitious goal, but with industry's support and cooperation, it can be reached!

EPA is presently updating the AFR software for reporting 1997 TRI submissions due to EPA on July 1, 1998. We are developing an additional version of AFR optimized for use with Windows 95 and Windows NT. As of this writing, an independent software testing firm, as well as volunteers from the reporting community, are conducting rigorous beta testing to ensure that the software performs correctly. For more information about AFR software, please call Jan Erickson at 202-260-3801.

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Chemical Use

Matt Gillen, OPPT

The Toxics Release Inventory (TRI) is the public's primary source of information on the toxics in our environment. To broaden its scope, two Agency actions have recently expanded the chemicals and industries covered under TRI. (See *Industry Expansion*, p. 3)

EPA's Phase 3 project is another expansion project: it looks at adding chemical use information to TRI. EPA has been actively exploring chemical use information in order to improve the public's ability to evaluate a range of important environmental issues that exist in communities. By chemical use, EPA is referring to what is known as materials accounting information: amounts of listed chemicals coming into a facility, amounts manufactured or consumed on site, and amounts leaving the facility in products and wastes.

EPA believes that chemical use data could improve the public's understanding of environmental issues that arise from the use of chemicals at a facility. Materials accounting information:

- Improves the ability to evaluate facility source reduction and pollution prevention performance.
- Focuses emergency planning efforts related to the transportation of chemicals through communities.
- Provides a handle on the amounts of toxic chemicals going into products, and
- Improves the ability to address worker safety and health issues.

The importance of this initiative was illustrated in August 1995, when President Clinton sent a memorandum to the EPA Administrator to facilitate TRI expansion. The memorandum directed EPA to develop "an expedited, open, and transparent process for consideration of reporting under EPCRA on information on the use of toxic chemicals at facilities, including information on mass balance, materials accounting, or other chemical use data."

EPA has held several public meetings on Phase 3 and issued an Advance Notice of Proposed Rulemaking (ANPR) to take comment on chemical use issues. Over 40,000 comments were received, with strong opinions expressed on all sides. Environmental groups generally supported chemical use reporting, stating that it fills in some important gaps in TRI. Industry groups generally opposed materials accounting, questioning its value for communities and expressing concerns about the potential loss of sensitive business data to foreign competitors.

EPA has reviewed the comments and issues as well as reviewed the two state programs (Massachusetts and New Jersey) that already collect chemical use information, and is continuing to evaluate a number of other issues. EPA is currently considering its options and anticipates a decision by early 1998 on how best to proceed with chemical use reporting.

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State Perspective: Ohio's TRI Program

Cindy DeWalt, Ohio EPA

Ohio EPA's Division of Air Pollution Control (DAPC) coordinates the Toxics Release Inventory (TRI) program in Ohio. The Ohio Right-to-Know Act of 1988 gave Ohio EPA authority to administer and enforce Section 313 of the federal Emergency Planning and Community Right-to-Know Act (EPCRA) and establish filing fees for covered facilities to support the TRI program.



Today, Ohio EPA is focusing its efforts on compliance assistance and outreach. Ohio EPA will be working with facilities to help them understand recent changes to the chemical list and addition of new industrial sectors. Ohio EPA will continue its ongoing outreach efforts that include informing all new facilities building within Ohio of the EPCRA reporting requirements. Through the release of Ohio EPA's annual TRI report, the impact of any changes to the reporting requirements also will be explained to communities.

The TRI data has become a significant tool for Ohio EPA to improve environmental quality as demonstrated by the following actions:

- DAPC uses TRI data to help identify facilities which are subject to new regulations, such as Section 112(r) of the Emergency Preparedness and Response Program required by the Clean Air Act. TRI data is used to evaluate industry compliance with recently adopted rules concerning toxic releases. TRI data is also used to focus efforts in ambient air monitoring evaluations, and to determine county-wide levels of toxics for air pollution studies.
- Ohio EPA's Office of Pollution Prevention used TRI data to identify the top 100 facilities that report the most releases of toxic chemicals to the environment. These facilities were invited to join Ohio Prevention First, a program in which facilities voluntarily develop comprehensive pollution prevention plans.
- Ohio EPA's Division of Surface Water (DSW) uses TRI data to develop water quality based effluent limits for National Pollutant Discharge Elimination System (NPDES) permits. DSW's pretreatment program also uses TRI data when developing indirect discharge permits. The state screens the data to determine if additional pollutants need to be evaluated for possible inclusion in the permit.
- TRI data was used to fill information requests from private citizens, legislators, journalists, schools, consulting firms, attorneys, business and trade associations, environmental groups, industry, and various state and federal agencies.
- The public uses TRI data to raise awareness regarding the toxic chemicals released from manufacturing industries within their communities.

Ohio EPA continues to work with US EPA on TRI implementation. Through the Forum of State and Tribal Toxics Action (FOSTTA), US EPA meets with states to discuss the implementation and administration of the TRI program. FOSTTA conducts the annual survey of state TRI programs which is included in the national TRI data release. Through FOSTTA, states and US EPA have become more aware of each other's needs. Ohio EPA chairs the FOSTTA TRI workgroup.

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A Non-Profit Organization's Perspective on TRI

Terry Greene, JSI Center for Environmental Health Studies

The JSI Center for Environmental Health Studies is a non-profit public health organization. It provides scientific, technical, and organizational assistance to community, labor, and environmental organizations which address health problems arising from exposure to toxic chemicals. The Center helps citizens' groups investigate and respond to suspected environmental hazards by providing technical information, as well as assistance in conducting and reviewing health studies and in developing strategies to reduce the risk of exposure to toxic materials. Through training activities and educational materials and programs, the Center strives to empower these groups to play an informed and effective role in solving environmental problems.

ISI found that the right to know about toxic hazards in workplaces and communities is key to the public's ability to protect themselves, their families, and the environment. The EPA's Toxics Release Inventory (TRI) is a valuable tool for community right-to-know. However, there remains a need to promote awareness of TRI (and complementary environmental and health information from federal, state, and local databases, registries, and reference materials) and to assist citizens in using it. For many people, the only sources of environmental information are media reports on toxic hazards which too often leave citizens feeling confused and powerless. The ability to locate, understand, and use various forms of information on the environment and health is vital to citizens in taking their rightful place as equal partners with government and industry to make decisions that affect their communities, health, and children's future.

Making sense of pages of information, presented in different formats and measurement units, can challenge even citizens with technical backgrounds. To truly benefit from public access to information, citizens need details on how to obtain and interpret environmental quality indicators and health status information specific to their communities. They should have an understanding of basic principles for evaluating health risks, along with adequate technical assistance and analytical tools that can help in risk screening. Citizens also need to be familiar with various strategies for pollution prevention in homes, communities, and workplaces and enhanced opportunities to participate and take action in each of these arenas, such as funding to compensate citizens for their service on advisory committees and support for organizational development for community-based organizations.

ISI is working with EPA Region 1 and the Office of Pollution Prevention and Toxics (OPPT) on outreach and education efforts to communities. These include a Massachusetts pilot which trained librarians in the use of resources such as the TRI, and subsequently sponsored workshops within libraries for their respective communities. The project was designed to encourage community-wide use of publicly available information by:

- Building the capacity of libraries to serve as local environmental information centers available to their communities;
- Introducing broad sectors of the community (including local officials, members of environmental, citizen, and labor groups, and representatives from health agencies, schools, and industry) to information on local health and the environment; and
- Creating a forum that fosters collaboration among these sectors to use these information resources to identify and prevent pollution at the local level.



Most important among the lessons learned is that TRI outreach is not simply a matter of introducing EPCRA and the TRI and then demonstrating various search engines. Community outreach must start with the concerns and needs of the community, and TRI data must be presented within the context of what is of interest to the community and its various sectors. The term outreach itself is misleading in that it implies "experts" going out to spread their knowledge. Successful outreach is actually a dialogue in which an outside advisor has just as much to learn from residents, area businesses, and local government as they do from the advisor.

Additionally, ISI combines TRI and Massachusetts data on toxic chemical use reporting. This is especially timely given the current policy debate on Phase III expansion of TRI to include chemical use data. Contrary to fears expressed by some people opposed to TRI Phase III expansion, the Massachusetts experiment shows that information on total chemical use and industrial processes encourages the public to take a more reasonable look at facility data. The additional data allows for a more precise identification of potential exposure scenarios and opportunities for pollution prevention. It also highlights when certain reductions in chemical use would be difficult to attain and not produce much benefit.

ISI has developed training materials on conducting outreach efforts on community-based environmental data used in national workshops for health professionals, environmentalists, academics, and community advocates. Included in these materials is ISI's tutorial, *Environment and Health: How to Investigate Community Environmental Health Problems*, which provides an introduction to TRI and various complementary sources of environmental and health information. A workshop was recently held at the American Public Health Association Conference in Indianapolis. Contact Terry Greene at (617) 482-9485 for more information about these sessions or materials.

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Putting Environmental Information in the Classroom

Odelia Funke, Chief

OPPT Information Management Division - Information Access Branch

The Toxics Release Inventory Program taught EPA the value and power of bringing environmental information to the public. As a result of the experience with TRI, OPPT has redoubled its effort to provide information from all of its programs to various kinds of audiences. Making the information truly useful requires that OPPT presents it in a number of different formats and contexts.

In 1995, OPPT developed a strategy to tailor environmental information products for educational purposes. During this process, the Office decided to embark on a partnership with the National Science Teachers Association to develop an information product for high school students. NSTA already had experience in creating a set of cross-disciplinary classroom materials, with related student activities, focused on environmental subjects. This kind of educational package is designed for presentation by teachers in different subject areas, with different perspectives; the teachers coordinate their efforts to present the topic across disciplines.

NSTA was particularly interested in building this kind of educational package using a large database. OPPT and NSTA agreed on a cross-disciplinary classroom product based on the TRI database. NSTA worked closely with teachers and writers to develop the materials, which are currently in draft. Once reviews and revisions are completed, NSTA will introduce this new tool to its members and science teachers across the country.

For OPPT, this collaborative effort is providing a new way to present TRI information to an audience that generally would not be aware of it. Students and teachers will learn how TRI data, and other environmental information, can be relevant to their communities. This project also might provide a model for ways in which OPPT can make other programmatic information more relevant and available to students. Working with environmental data in this way highlights some of the complex issues and unanswerable questions posed when we analyze environmental data. Through these kinds of products, OPPT hopes to engender a better appreciation and understanding of environmental issues and goals.

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TRI Relative Risk-Based Environmental Indicators

Nick Bouwer, OPPT
Steven Hunter, OPPT

In order to provide a risk-related perspective for assessing the relative impacts of TRI chemicals on the U.S. population, OPPT developed an environmental indicators model as a Microsoft Windows-based computer application. The TRI Relative Risk-Based Chronic Human Health Indicator takes into account the relative potency of individual chemicals, the quantity of these chemicals to which the general, non-worker population is exposed, and the size of this population. This screening-level tool allows for a broad spectrum of users to examine a multitude of environmental issues.

The TRI Indicators model incorporates eight years of TRI reporting data on most of the significant chemical releases reported by more than 27,000 facilities. Indicator values are relative ranking numbers. The data elements computed by the indicators can be viewed at a national level or disaggregated in a wide variety of ways, e.g., by medium, chemical, geographic area (EPA Region, state, county, city, zipcode), industry sector, reporting facility, year or a combination of these and other variables. Besides risk-related assessments, the model enables users to examine TRI reported emissions from a pounds-only perspective, as well as investigate the influence of toxicity weights and population on the final values. The TRI indicators model not only allows the analyst to examine trends, but to rank and prioritize chemicals for strategic planning, risk-related targeting, and community-based environmental protection purposes as well. This will potentially allow communities to direct scarce public resources to ward the most pressing environmental needs and provide a basis for establishing a dialogue with local TRI reporting facilities.

OPPT is developing the Environmental Justice (EJ) Module which will provide a unique capability for examining, in a comparative manner, estimates of the aggregate risk-related impacts on user-selected geographic locations from all TRI on-site releases and off-site transfers. Combined with demographic information on affected populations (such as race, income or age), the indicators are used to investigate EJ issues related to the distribution of risk-related impacts.

There is no correlation between the toxicity criteria and methodology used to make listing/delisting decisions under EPCRA section 313 and the methodology used to rank chemicals for the indicators. EPCRA sets out statutory criteria for listing



chemicals on the basis of acute human, chronic human and/or environmental toxicity which each chemical on the TRI list meets. To investigate the relative risk-based impacts associated with emissions of these chemicals, the indicators must differentiate their relative toxicity and rank them in a consistent manner. The ranking of each chemical reflects its single, most sensitive chronic human health toxicity endpoint for inhalation and oral exposure pathways. Note that this ranking is only relative to other chemicals which are included in the indicators, not to some benchmark or absolute value.

Working relationships were established with other EPA Offices, e.g., the Office of Enforcement and Compliance Assurance's Sector Facility Indexing Project (providing information to communities on hazard-weighted TRI releases within five industrial sectors) and the Federal Facilities Office's Environmental Justice Enforcement Initiative (a national report based in part on risk-related analyses provided by the Indicators). The EPA Science Advisory Board (SAB) recently conducted reviews of: (1) the indicators' toxicity weights, (2) overall methodology, and (3) a consultation on the development of the chronic ecological indicator. The SAB expects to issue its final reports by year's end. An OPPT Internet home page will make available news about the model, documents, toxicity weights, and results.

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International Perspective: Pollutant Release and Transfer Registers

John Harman, OPPT

The Toxics Release Inventory (TRI) is an environmental management system that countries around the globe are implementing. It is expected that within the next few years, over 30 nations will be operating TRI-like systems, known internationally as Pollutant Release and Transfer Registers (PRTRs). This global movement is offering new opportunities, not only at the international level, but at the national level as well.

Compiling and Comparing PRTR Data

An example is the work already underway in North America. An organization called the Commission for Economic Cooperation (CEC), created by a side-agreement to the North American Free Trade Association (NAFTA), has prepared a document that compares the PRTR data between Canada and the United States. Another CEC report builds on this study by actually compiling the common data. The result is a picture of releases and transfers of toxic chemicals across both countries. PRTR data from Mexico is to be included starting with the 1997 report.

There are benefits to this process of compiling and comparing PRTR data between nations. As pollutants do not respect political boundaries and releases in one country can affect the environment of a neighbor, the public should know about these chemical releases. Therefore, the public could benefit from PRTR data because they are able to obtain release and transfer data across a much larger area—in this case, the North American continent.

Another benefit is the ability to compare release and transfer data between the countries. It can be advantageous, for instance, to contrast the reporting patterns of an industrial sector in one country to that sector in another country regardless of the reason for the differences. Looking at individual chemicals or groups of chemicals can lead to fruitful investigation of one country's environmental regulations as a model for other countries.

Meeting International Obligations

PRTRs also play a role in the work undertaken by the Organisation for Economic Co-operation and Development (OECD). The OECD is an organization comprised of the 29 most industrialized democracies, which last year issued a Council Recommendation calling on its member states to implement PRTR systems.

As part of its commitment to PRTRs, the OECD has integrated its PRTR work into its larger Chemicals Program. Among the objectives of this approach is to use the PRTR data as a tool for tracking progress toward meeting the many international agreements and conventions of which the OECD is a part. For instance, the OECD is working within the frameworks of the Persistent Organic Pollutants, the Climate Change Convention, and the Basel Convention. PRTR data can be used to track and monitor the progress at meeting the goals of these agreements both by individual nations and for the OECD community as a whole. Regional organizations, such as North America's CEC and European organizations (Convention on Long-Range



Transboundary Air Pollution), have proposed similar steps.

Analyzing PRTRs

An additional project that the OECD is presently undertaking is another example of the benefits of the internationalization of PRTR systems. This study is a look at the reporting patterns, plus the resulting benefits of reporting, by industries in countries with PRTR systems. By conducting this analysis, the OECD can highlight how the various PRTR systems affect the environmental activities and the environmental cultures at the reporting facilities.

Cooperation Between Nations

The results of the OECD study will be one of the subjects at an international workshop on PRTRs. Japan, which is moving swiftly to develop its own PRTR system, will host this workshop in 1998. The workshop will be an opportunity for countries already operating PRTR systems, countries with PRTRs under development, and other interested nations, industry, and non-governmental organizations to meet and discuss the rapidly evolving status of PRTRs around the globe. As in every step of the PRTR process, the United States is an active participant.

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TRI-US Services: A Look at Customer Service, Satisfaction, and Assessment

Georgianne McDonald, OPPT

Before a product is developed or a service is provided, there are many things to consider in assessing the needs of the audience.

Traditional program evaluations address the objective outcomes of a program, but products and services should also be evaluated, in terms of qualities such as accuracy, timeliness, usefulness and ease of access. Over the past several years, the Office of Pollution Prevention and Toxics (OPPT) has been conducting customer satisfaction surveys to help assess information products and services. Based on customer feedback, OPPT can modify its products and services to better meet the public's needs.

OPPT's TRI User Support (TRI-US) team provides a variety of products and services to a wide range of customers—individuals, communities, local and state governments, private businesses, non-profit organizations, Native American tribes, and others. To meet the needs and preferences of TRI-US customers, and to solicit feedback on the products and services currently provided, OPPT initiated a customer service review.

Methods of gathering customer feedback include focus groups, mail-out surveys, telephone surveys, hands-on labs, or just plain, old-fashioned postcards. To determine the customers' level of satisfaction, OPPT chose to use a telephone survey for TRI-US services. This method would allow OPPT to:

- Gain insight into the identification of TRI-US service qualities of greatest importance to the public;
- Examine the gap between customer expectations and their perception of actual service performance; and
- Identify customers attitudes, opinions, and expectations, regarding the service.

For the TRI-US project, OPPT analyzed the TRI-US Caller Log Sheets to identify a sample set of existing customers for the survey, identifying the target audiences for a product or service can be directed towards those who are personally interested in TRI, those who use it professionally for themselves, or those who use it to gather the information for others. The most likely and primary target for TRI-US services and information is the educated, non-technical information provider (e.g., county/state public health official, public interest representative, teacher, and community-based organizer, etc.) who has access to a network of people interested in TRI or environmental issues.

With the help of survey experts, OPPT designed the TRI-US telephone survey questionnaire; the experts are conducting the survey by making calls to customers. A final report on survey results is due to OPPT in mid-January 1998. OPPT expects that the survey will help target the kinds of TRI information services, and quality of service, that are most important to our customers.

Conducting surveys, assessments and focus groups serves as a valuable tool for recognizing and addressing the public's information needs. With customer feedback, OPPT seeks to find out whether TRI-US products and services are reaching the



intended and hence, are providing the kind of information people seek, and satisfying the public in terms of quality and timeliness.

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TRI: An Academic Perspective

John C. Pine, Ed.D., Associate Professor - Research
Institute for Environmental Studies, Louisiana State University

The publication of the Toxics Release Inventory (TRI) in 1989 provided a means for examining environmental policies and strategies, and clarifying risks associated with toxic chemicals at the state and local level. For the academic community, the data submitted by manufacturing facilities at the state and federal levels meet rigorous standards and can be used to examine public policy and program strategies.

Quality of TRI Data

Students and faculty in the academic community have been drawn to the TRI data because it provides a national perspective for collecting data at the national, state, and local level. The data do not focus on one area of the environment but include information from a broad perspective including air emissions, water releases, and land discharges. The data are collected nationally in a consistent manner under the guidance and support of the U.S. Environmental Protection Agency and the states. Users from the academic community believe that the collection procedures are valid and consistent. TRI data facilitate long-term assessments of national and state policies, and industry efforts to reduce emissions.

Applications of TRI Data

TRI data provide a foundation for examining environmental programs and risk assessments. Three studies completed by faculty at the Institute for Environmental Studies at Louisiana State University demonstrate the wide use of the data by the academic community. The first was an objective examination of state environmental programs using the emissions-to-jobs (EJ) ratio which compares TRI data to employment. This ratio is determined by the number of pounds of emissions per year per job in a given industry and location.

There seem to be few objective standards available for evaluating state environmental programs and policies. A state may use the EJ ratio to examine total emissions by industry based on their standard industrial classification (SIC) code, as well as the total emissions by employment within the SIC code. The EJ ratio is also one way to see how state property tax exemptions affect new industries or the expansion of current industry operations.

In the second study, TRI was used to estimate total TRI emissions given the size and composition of a state's manufacturing sector as compared to the Green Index, a national listing which uses 256 indicators to categorize each state's environmental health. For example, TRI data from 1988, 1989, and 1990 may be used to estimate the difference between a state's expected level of total emissions and the reported value. States were ranked based on these estimated emissions and compared to the Green Index's "green conditions" and "policy conditions."

For the third study, TRI data were used to identify and assess areas in a state and the risks associated with accidental releases of hazardous chemicals. The study identified 12 to 15 parishes (counties) with the greatest risk of accidental releases from hazardous chemicals. These "high risk" parishes would be targeted for intensive hazards analysis efforts. In the study, TRI air emissions data were summed by parish along with pollution prevention (P2) reports submitted to the state Right-to-Know Office.

At the time of this analysis, Louisiana was one of only a few states that had an electronic database of the P2 chemical inventories of hazardous chemicals. In addition to the P2 chemical inventories, researchers selected a subset of the P2 data, including Extremely Hazardous Substances (EHS). A relative ranking of the parishes was established using the TRI air emissions, P2 chemicals and facilities, and EHS chemicals and facilities. A comparison of these rankings showed that the TRI air emissions was an excellent predictor of both the P2 chemicals and facilities rankings, and the EHS chemicals and facilities.

The three applications of the TRI data in research projects illustrate that the academic community is looking well beyond relative reductions in emissions by chemical or by media. In contrast to state TRI program officials or facility managers, the academic community combines the TRI with other data to examine public policy issues, environmental initiatives, and the



relative risk of geographic areas with hazardous chemicals.

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Proof Positive: TRI Success Stories

Maria Hendriksson, OPPT

Now in its eleventh year, the TRI program continues to expand its outreach. As the Right-to-Know concept broadens its purview, more and more people are interested in learning about the TRI's successes. To meet this growing interest, EPA is creating a compendium of success stories. The purpose of this compendium is to collect and share information on the program's uses for addressing and enhancing public awareness of the potential risks posed by toxic chemicals released into the environment by industrial facilities.

Many facilities realize the environmental and societal benefits of disclosing their information. As a result of the program's influence, EPA has expanded the list of chemicals and industries covered under TRI. There has also been a doubling in the number of chemicals reported by facilities around the US. Over 31,000 facilities are now submitting reports, representing a 30% increase over the past year. To date, there are over 600 chemicals listed in the database.

The recent TRI/Right-to-Know Conference held in Washington, DC presented an opportunity for TRI to celebrate its successes. In the opening and closing plenaries as well as in a course entitled, "Success Stories of TRI Use," there were several discussions on how TRI has made a positive impact through communities, industries, state and local government, advocacy groups and other organizations. Here are some of the highlights in TRI's achievements as mentioned in the conference:

Business and Industry

In the steady increase of industry participation, several companies have stepped to the forefront in reducing chemical releases to the environment. Companies such as Rhône-Poulenc and DuPont attribute their successes, wholly or partly, to the TRI program. Since Rhône-Poulenc (the 6th largest chemical company worldwide) joined the program, their toxic emissions have decreased by 50% and they are now recycling 90% of the chemicals they use. DuPont's chemical releases have declined by over 50% and it has experienced a 70% decrease in the number of injuries, illnesses and incidents involving chemical releases.

TRI has even influenced businesses not covered under the regulation. Lucrative investments in environmentally-friendly industries are on the rise. According to Neuberger & Berman (N&B), because of the growing interest in environmentally conscientious companies, N&B is now using TRI to screen socially-responsive portfolios.

State Government

Examples of states that have recently instituted TRI-based initiatives include Tennessee and Louisiana, two states with a high population of industrial facilities. Tennessee is proud of its 2000 Initiative on air pollution. This program emphasizes industry outreach and the participation of local facilities in pollution reduction schemes. Louisiana is equally pleased with its Environmental Leadership Program. This initiative encourages partnerships with the local chemical industry and stresses voluntary reductions of emissions beyond levels of compliance.

Administrator Browner recently stated that more than 1,500 community groups use TRI data in their dealings with local government and industry. Grassroots groups and non-profit organizations, well represented at the conference, were eager to voice their successes in the legislative and legal systems. Inspired by TRI's momentum, some groups successfully lobbied for state laws such as the Toxics Use Reduction Act (Massachusetts) and a Toxics Right-to-Know charter amendment (Oregon). Other organizations, such as Don't Waste Arizona, Inc., successfully sued facilities for failure to report under EPCRA — but with a constructive twist: instead of paying hefty fines to EPA, court judgments were issued for companies to apply some fines toward facility improvements to meet compliance.



TRI is successful because there is something in it for everyone. In complying with regulations, industry benefits the environment by reducing chemical releases. In some cases, a company's stock investments increase and the bottom line improves as a result of more socially-responsible practices. As community groups learn about the hazards around them, they can coalesce to promote safer, healthier communities. Non-profit organizations serve to increase public awareness and efficacy by bridging communications with government. Finally, while serving the public at large, Federal, State and local governments become stewards of environmental protection by operating programs and initiatives that further awareness of potential chemical hazards.

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Revisiting Carrying Capacity: Area-Based Indicators of Sustainability

by William E. Rees, The University of British Columbia

Conventional wisdom suggests that because of technology and trade, human carrying capacity is infinitely expandable and therefore virtually irrelevant to demography and development planning. By contrast, this article argues that ecological carrying capacity remains the fundamental basis for demographic accounting. A fundamental question for ecological economists is whether remaining stocks of natural capital are adequate to sustain the anticipated load of the human economy into the next century. Since mainstream (neoclassical) models are blind to ecological structure and function, they cannot even properly address this question. The present article therefore assesses the capital stocks, physical flows, and corresponding ecosystems areas required to support the economy using "ecological footprint" analysis. This approach shows that most so-called "advanced" countries are running massive unaccounted ecological deficits with the rest of the planet. Since not all countries can be net importers of carrying capacity, the material standards of the wealthy cannot be extended sustainably to even the present world population using prevailing technology. In this light, sustainability may well depend on such measures as greater emphasis on equity in international relationships, significant adjustments to prevailing terms of trade, increasing regional self-reliance, and policies to stimulate a massive increase in the material and energy efficiency of economic activity.

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WHY CARRYING CAPACITY?

According to Garrett Hardin (1991), "carrying capacity is the fundamental basis for demographic accounting." On the other hand, conventional economists and planners generally ignore or dismiss the concept when applied to human beings. Their vision of the human economy is one in which "the factors of production are infinitely substitutable for one another" and in which "using any resource more intensely guarantees an increase in output" (Kirchner *et al.*, 1985). As Daly (1986) observes, this vision assumes a world "in which carrying capacity is infinitely expandable" (and therefore irrelevant). Clearly there is great division over the value of carrying capacity concepts in the sustainability debate.

This article sides solidly with Hardin. I start from the premise that despite our increasing technological sophistication, humankind remains in a state of "obligate dependence" on the productivity and life support services of the ecosphere (Rees, 1990). Thus, from an ecological perspective, adequate land and associated productive natural capital are fundamental to the prospects for continued civilized existence on Earth. However, at present, both the human population and average consumption are increasing while the total area of productive land and stocks of natural capital are fixed or in decline. These opposing trends demand a revival of carrying capacity analysis in sustainable development planning. The complete rationale is as follows:

Definitions: Carrying Capacity and Human Load

An environment's carrying capacity is its maximum persistently supportable load (Catton 1986).

For purposes of game and range management, carrying capacity is usually defined as the maximum population of a given species that can be supported indefinitely in a defined habitat without permanently impairing the productivity of that habitat. However, because of our seeming ability to increase our own carrying capacity by eliminating competing species, by importing locally scarce resources, and through technology, this definition seems irrelevant to humans. Indeed, trade and technology are often cited as reasons for rejecting the concept of human carrying capacity out of hand. [According to orthodox theory, free trade is invariably good, resulting in improved living standards and increased aggregate productivity and efficiency — increased carrying capacity — through comparative advantage.]

This is an ironic error — shrinking carrying capacity may soon become the single most important issue confronting humanity. The reason for this becomes clearer if we define carrying capacity not as a maximum population but rather as the maximum "load" that can safely be imposed on the environment by people. Human load is a function not only of population but also of *per capita* consumption and the latter is increasing even more rapidly than the former due (ironically) to expanding trade and technology. As Catton (1986) observes: "The world is being required to accommodate not just more people, but effectively 'larger' people..." For example, in 1790 the estimated average daily energy consumption by Americans was 11,000 kcal. By 1980, this had increased almost twenty-fold to 210,000 kcal/day (Catton 1986). As a result of such trends, load pressure relative to carrying capacity is rising much faster than is implied by mere population increases.

The Ecological Argument

Despite our technological, economic, and cultural achievements, achieving sustainability requires that we understand human beings as ecological entities. Indeed, from a functional perspective, the relationship of humankind to the rest of the ecosphere is similar to those of millions of other species with which we share the planet. We depend for both basic needs and the production of artifacts on energy and material resources extracted from nature and all this energy/matter is eventually returned in degraded form to the ecosphere as waste. The major material difference between humans and other species is that in addition to our biological metabolism, the human enterprise is characterized by an industrial metabolism. In ecological terms, all our toys and tools (the "capital" of economists) are "the exosomatic equivalent of organs" (Stenner, 1993) and, like bodily organs, require continuous flows of energy and material to and from "the environment" for their production and operation. It follows that in a finite world:

* Economic assessments of the human condition should be based on, or at least informed by, ecological and biophysical analyses.

* The appropriate ecological analyses focus on the flows of available energy/matter (essergy) particularly from primary producers—green plants and other photosynthesizers—to sequential levels of consumer organisms in ecosystems (specifically, humans and their economies) and on the return flows of degraded energy and material (wastes) back to the ecosystem.

This approach shows that humankind, through the industrial economy, has become the dominant consumer in most of the Earth's major ecosystems. We currently "appropriate" 40% of the net product of terrestrial photosynthesis (Vitousek *et al.*, 1986) and 25-35% of coastal shelf primary production (Pauly & Christensen, 1995), and these may be unsustainable proportions. [Global fisheries yields have fallen since

1989.] At the same time some global waste sinks seem full to overflowing.

A fundamental question for ecological economics, therefore, is whether the physical output of remaining species populations, ecosystems, and related biophysical processes (i.e., critical self-producing natural capital stocks -- see Box 1), and the waste assimilation capacity of the ecosphere, are adequate to sustain the anticipated load of the human economy into the next century while simultaneously maintaining the general life support functions of the ecosphere. This "fundamental question" is at the heart of ecological carrying capacity but is virtually ignored by mainstream analyses.

Box 1: On Natural Capital

Natural capital refers to "a stock [of natural assets] that yields a flow of valuable goods and services into the future." For example, a forest or a fish stock can provide a flow or harvest that is potentially sustainable year after year. The stock that produces this flow is "natural capital" and the sustainable flow is "natural income." Natural capital also provides such services as waste assimilation, erosion and flood control, and protection from ultra-violet radiation (the ozone layer is a form of natural capital). These life support services are also counted as natural income. Since the flow of services from ecosystems often requires that they function as intact systems, the structure and diversity of the system may be an important component of natural capital.

There are three broad classes of natural capital: *Renewable* natural capital, such as living species and ecosystems, is self-producing and self-maintaining using solar energy and photosynthesis. These forms can yield marketable goods such as wood fiber, but may also provide unaccounted essential services when left in place (e.g., climate regulation). *Replenishable* natural capital, such as groundwater and the ozone layer, is non-living but is also often dependent on the solar "engine" for renewal. Finally, non-renewable natural capital such as fossil fuel and minerals, are analogous to inventories - any use implies liquidating part of the stock.

This article takes the position that since adequate stocks of self-producing and replenishable natural capital are essential for life support (and are generally non-substitutable), these forms are more important to sustainability than are non-renewable forms.

Source: Rees (1995), liberally adapted from Costanza and Daly (1992).

Second Law Arguments

A related rationale for revisiting carrying capacity flows from consideration of the Second Law of Thermodynamics. In particular, modern formulations of the second law suggest that all highly-ordered systems develop and grow (increase their internal order) "at the expense of increasing disorder at higher levels in the systems hierarchy" (Schneider & Kay, 1992). In other words, complex dynamic systems remain in a nonequilibrium state through the continuous dissipation of available energy and material (essergy) extracted from their host environments. They require a constant input of energy/matter to maintain their internal order in the face of spontaneous entropic decay. Such self-organising nonequilibrium systems are therefore called "dissipative structures."

This extension of the second law is critical to human carrying capacity. Consider that:

* The human economy is one such highly-ordered, dynamic, far-from equilibrium dissipative structure. At the same time . . .

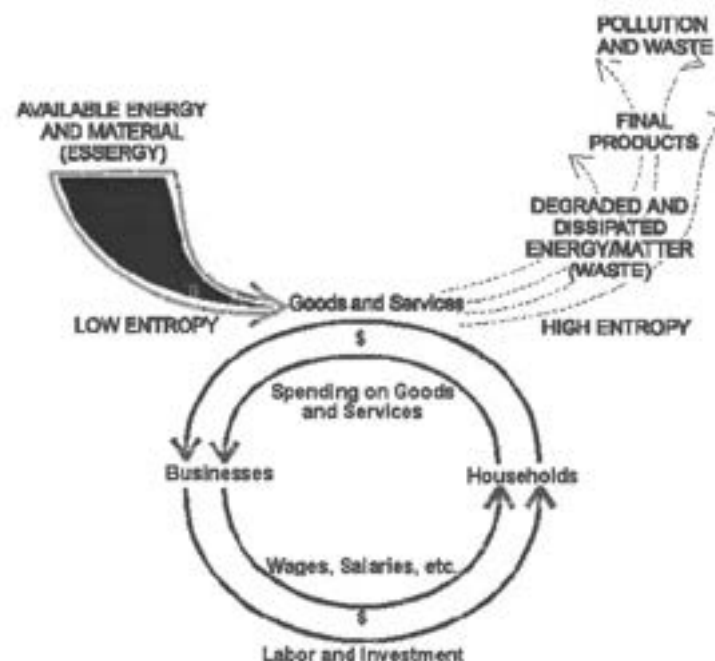
* The economy is an open, growing, subsystem of a materially closed, nongrowing ecosphere (Daly, 1992), and is therefore dependent on the formation of essergy in the ecosphere for its growth and developments. [This input to the economy from nature is the "natural income" referred to in Box 1]

This relationship implies that beyond a certain point, the continuous growth of the economy can be purchased only at the expense of increasing disorder or entropy in the ecosphere. This is the point at which consumption by the economy exceeds natural income and would be manifested through the continuous depletion of natural capital -- reduced biodiversity, air/water/land pollution, deforestation, atmospheric change, etc. In other words, the empirical evidence suggests that the aggregate human load already exceeds, and is steadily eroding, the very carrying capacity upon which the continued humane existence depends. Ultimately this poses the threat of unpredictable ecosystems restructuring (e.g., erratic climate change) leading to resource shortages, increased local strife, and the heightened threat of ecologically induced geopolitical instability.

In this light, the behavior of complex systems and the role of the economy in the global thermodynamic hierarchy should be seen as fundamental to sustainability, yet both concepts are alien to the dominant development-oriented institutions in the world today.

Why Economics Cannot Cope

FIGURE 1. The linear throughput of energy/matter



The linear throughput of low-entropy energy and matter (upper part of diagram) sustains the economy and drives the circular flow of exchange value (lower part of diagram), yet is invisible to conventional economic analysts.

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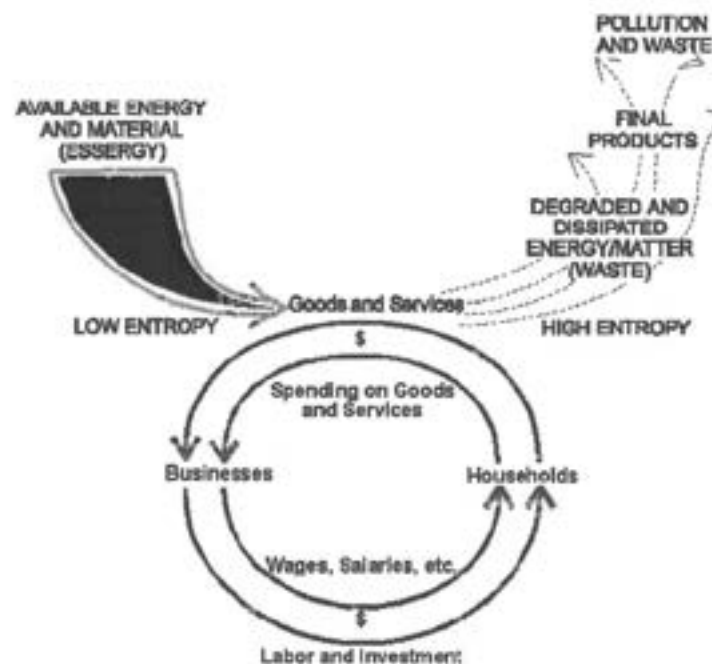
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Box 2: The Blind Spot in Conventional Analysis

Mainstream economics approaches the issue of adequate capital stocks through monetary analysis. However, money and prices are excessively abstracted from the material wealth they are supposed to represent. For example:

Where there are markets for ecologically significant "goods and services," prices do not reflect the size of the corresponding natural capital stocks, whether there are critical minimal levels below which stocks can no longer replenish themselves (the real measure of biophysical scarcity), the functional roles of such stocks in relevant ecosystems, or their ultimate value in sustaining life. Meanwhile...

Many ecological goods and most life-support services remain unpriced and therefore not subject to market signals or related behavioral change of any kind. (The ozone layer is a case in point.)

Unfortunately, current efforts to "internalise the externalities," "get the prices right" and otherwise commodify the environment suffer from major data gaps, the functional transparency of natural processes (we don't know they're valuable until they're gone), and other theoretical problems that often render futile attempts to quantify, let alone price, many critical ecological goods and services (Vain and Bromley 1993). In short...

Standard monetary analyses are blind to ecological structure and function and are therefore incapable of indicating either ecologically meaningful scarcity of incipient systems destabilisation.

Part of the reason for this perceptual gap is that many of the questions raised by ecological and thermodynamic considerations are invisible to mainstream approaches. Economic analysis is based on the circular flow of exchange value (money flows) through the economy, not on physical flows and transformations. Prevailing economic models of growth and sustainability thus "lack any representation of the materials, energy sources, physical structures, and time-dependent processes basic to an ecological approach" (Christensen, 1991). Thus while, the second law is arguably the ultimate governor of economic activity, standard models do not recognize the unidirectional and thermodynamically irreversible flux of available energy and matter upon which the economy depends (Figure 1). Similarly, conventional approaches to conservation and sustainability focus mainly on the money values of marketable resource commodities (e.g., timber) and are insensitive to the intangible (but ultimately more valuable) nonmarket ecological functions of the natural capital that produces them (e.g., the forest ecosystem). Box 2 summarizes this problem.

In this light, economists' lack of concern about carrying capacity would seem to derive, in large part, from conceptual weaknesses in their analytic models. The necessary conditions for ecological sustainability can better be defined through the analysis of physical stocks and flows interpreted in light of appropriate ecological and complex systems theory.

Technology and Trade: No Boon to Carrying Capacity

As previously noted, conventional analysts often argue that trade and technology expand ecological carrying capacity. This is a misconception. Even in the best of circumstances, technological innovation does not increase carrying capacity *per se* but only the efficiency of resource use. In theory, shifting to more energy- and material-efficient technologies should enable a defined environment to support a given population at a higher material standard, or a higher population at the same material standard, thereby seeming to increase carrying capacity. However, in either case, the best we could hope for in an increasingly open global economy would be to maintain total human load constant in the vicinity of carrying capacity – the latter would still ultimately be limiting.

In practice, we have not done even this well – the steady gains in efficiency throughout the post-war

period have been accompanied by steadily increasing *per capita* and aggregate consumption. It seems that efficiency gains may actually work *against* conservation through the price and income effects of technological savings.

As Saunders (1992) notes, this counter intuitive hypothesis has been the focus of considerable controversy. He tested it using neoclassical growth theory and found that energy efficiency gains might well increase aggregate energy consumption by making energy cheaper and by stimulating economic growth, which further "pulls up" energy use. How might this work? If a firm saves money by switching to more energy- and material efficient manufacturing processes, it will be able to raise wages, increase dividends, or lower prices, which can lead to increased net consumption by workers, shareholders, or consumers respectively. These behavioral responses to changes in prices and income are referred to as the "rebound effects" by economists (Jaccard, 1991). Similarly, technology-induced money savings by individuals are usually redirected to alternative forms of consumption, canceling some or all of the initial potential benefit to the environment (Hannon, 1975). To the extent that such mechanisms contribute to increased aggregate material consumption and accelerated stock depletion, they indirectly *reduce* carrying capacity.

(Rebound effects can be avoided if adequate stock depletion taxes or marketable resource quotas are imposed. (Such incentives should be used to stimulate conservation in the first place.) "Ecological taxation" would raise unit resource prices, effectively capturing any efficiency savings and preventing their further circulation in the economy. However, because of reduced material and energy intensity, consumer prices for goods and services would increase less rapidly than resource prices (Rees, 1994a).]

More generally, however, technology can directly reduce carrying capacity while creating the illusion of increasing it! We often use technology to increase the short-term energy and material flux through exploited ecosystems. This seems to enhance systems productivity while actually permanently eroding the resource base. For example, the effectiveness of electronic fish-finding devices and high-tech catching technology has overwhelmed the reproductive capacity of fish stocks; energy-subsidized intensive agriculture may be more productive than low-input practices in the short term, but it also increases the rate of soil and water depletion. The net effect is to create unsustainable dependencies on enhanced material flows (the technologies involved are often based on nonrenewable resources) while reducing longterm carrying capacity.

The carrying capacity gains from trade are also illusory. While commodity trade may release a local population from carrying capacity constraints in its own home territory, this merely displaces some fraction of that population's environmental load to distant export regions. In effect, local populations import others' "surplus" carrying capacity. The resultant increase in population and resource use in import regions increases the aggregate load of humanity on the ecosphere but there is *no net gain* in carrying capacity since trade reduces the load-bearing capacity of the export regions. Indeed, like technology, trade may even result in reduced global carrying capacity if access to cheap imports (e.g., food) lowers the incentive for people to conserve their own local natural capital stocks (e.g., agricultural land) and leads to the accelerated depletion of natural capital in distant export regions.

These comments are not to be taken as arguments against technology or trade *per se*. Rather the point is to emphasize that conventional assumptions about both should be carefully reexamined in light of carrying capacity considerations and that certain conditions must be satisfied before either can contribute to ecological sustainability.

APPROPRIATED CARRYING CAPACITY AND ECOLOGICAL FOOTPRINTS

We can now redefine human carrying capacity as the maximum rates of resource harvesting and waste generation (the maximum load) that can be sustained indefinitely without progressively impairing the productivity and functional integrity of relevant ecosystems wherever the latter may be located. The size of the corresponding population would be a function of technological sophistication and mean *per capita* material standards (Rees, 1988). This definition reminds us that regardless of the state of technology, humankind depends on a variety of ecological goods and services provided by nature and that for sustainability, these must be available in increasing quantities from somewhere on the planet as population and mean *per capita* resource consumption increase (see also Overby, 1985).

Now, as noted earlier, a fundamental question for ecological economics is whether supplies of natural capital will be adequate to meet anticipated demand into the next century. Inverting the standard carrying capacity ratio suggests a powerful way to address this critical issue. Rather than asking what population a particular region can support sustainably, the carrying capacity question becomes: *How large an area of productive land is needed to sustain a defined population indefinitely, wherever on Earth that land is located?* (Rees, 1992; Rees & Wackernagel, 1994; Wackernagel & Rees, 1995). Since many forms of natural income (resource and service flows) are produced by terrestrial ecosystems and associated water bodies, it should be possible to estimate the area of land/water required to produce sustainably the quantity of any resource or ecological service used by a defined population at a given level of technology. The sum of such calculations for all significant categories of consumption would give us a conservative area-based estimate of the natural capital requirements for that population.

A simple mental exercise serves to illustrate the ecological reality behind this approach. Imagine what would happen to any modern human settlement or urban region, as defined by its political boundaries or the area of built-up land, if it were enclosed in a glass or plastic hemisphere completely closed to material flows. Clearly the city would cease to function and its inhabitants would perish within a few days. The population and economy contained by the capsule would have been cut off from both vital resources and essential waste sinks leaving it to starve and suffocate at the same time. In other words, the ecosystems contained within our imaginary human terrarium would have insufficient carrying capacity to service the ecological load imposed by the contained population.

This mental model illustrates the simple fact is that as a result of high population densities, the enormous increase in *per capita* energy and material consumption made possible by (and required by) technology, and universally increasing dependencies on trade, the *ecological locations of human settlements no longer coincide with their geographic locations*. Twentieth century cities and industrial regions are dependent for survival and growth on a vast and increasingly global hinterland of ecologically productive landscapes. It seems that in purely ecological terms, modern settlements have become the human equivalent of cattle feedlots!

Cities necessarily appropriate the ecological output and life support functions of distant regions all over the world through commercial trade and the natural biogeochemical cycles of energy and material. Indeed, the annual flows of natural income required by any defined population can be called its "appropriated carrying capacity." Since for every material flow there must be a corresponding land/ecosystem source or sink, the total area of land/water required to sustain these flows on a continuous basis is the true "ecological footprint" of the referent population on the Earth. (See Box 3 for definitions of these and related indicators.) Calculating its ecological footprint provides a rough measure of the natural capital requirements of any subject population for comparison with available supply.

"Footprinting" the Human Economy

Box 3: A Family of Area-based Sustainability Indicators

Appropriated Carrying Capacity - The biophysical resource flows and waste assimilation capacity appropriated per unit time from global totals by a defined economy or population.

Ecological Footprint - The corresponding area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a defined population at a specified material standard of living, wherever on Earth that land may be located.

Personal planetoid - The *per capita* ecological footprint (EF_p/N).

Fair Earthshare - the amount of ecologically productive land "available" *per capita* on Earth, currently about 1.5 hectares (1995). A fair seashare (ecologically productive ocean - coastal shelves upwellings and estuaries - divided by total population) is just over .5 ha.

Ecological Deficit - The level of resource consumption and waste discharge by a defined economy or population in excess of locally/regionally sustainable natural production and assimilative capacity (also, in spatial terms, the difference between that economy/population's ecological footprint and the geographic area it actually occupies).

Sustainability Gap - A measure of the decrease in consumption (or the increase in material and economic efficiency) required to eliminate the ecological deficit. (Can be applied on a regional or global scale.)

The first step in calculating the ecological footprint of a study population is to estimate the *per capita* land area appropriated (aa) for the production of each major consumption item i . We do this by dividing average annual consumption of that item [c_i in kg/capital] by its average annual productivity or yield [p_i in kg/ha] per hectare:

$$aa_i = c_i/p_i$$

In practice, it is often only possible to estimate average *per capita* consumption by dividing aggregate consumption by the referent population size. Of course, many consumption items (e.g., clothing and furniture) embody several inputs and we have found it useful to estimate the areas appropriated by each significant input separately. Ecological footprint calculations are therefore both more complicated and more interesting than appears from the basic concept. So far we have estimated the land requirements to produce 23 categories of consumer goods and services (Wackernagel & Rees, 1995).

We then compute the total *per capita* ecological footprint (ef) by summing all the ecosystem areas appropriated by individual items in the annual shopping basket of consumption goods and services:

$$ef = \sum_{i=1}^{i=n} aa_i$$

Thus, the ecological footprint (EF_p) of a study population is the *per capita* footprint multiplied by population size (N): $EF_p = N(ef)$

We account for direct fossil energy consumption and the energy content of consumption items by estimating the area of carbon-sink forest that would be required to sequester the carbon dioxide emissions associated with burning fossil fuels ([carbon emissions/capital]/[assimilation rate/hectare]), on the

assumption that atmospheric stability is central to sustainability. (An alternative is to estimate the area of land required to produce the biomass energy equivalent [ethanol] of fossil energy consumption. This produces a larger energy footprint than the carbon assimilation method.)

Every effort is made to avoid double-counting in the case of multiple land uses and where there are data problems or significant uncertainty we err on the side of caution. Also, while we define the footprint comprehensively to include the land/water areas required for waste assimilation, our calculations to date do not account for waste emissions other than carbon dioxide. Accounting fully for this ecological function would add considerably to the ecosystem area appropriated by economic activity. Together these factors suggest that our ecological footprint calculations to date are more likely to be under-estimates than over-estimates.

Data from my home city, Vancouver, British Columbia, Canada, serve to illustrate application of the concept. Vancouver proper has a population (1991) of 472,000 and an area of 114 km² (11,400 hectares). However, the average Canadian requires over a hectare (ha) of crop and grazing land under current land management practices to produce his/her high meat protein diet and about .6 ha for wood and paper associated with various other consumption items. In addition, each "occupies" about .2 ha of ecologically degraded and built-over (e.g., urban) land. Canadians are also among the world's highest fossil energy consumers with an annual carbon emission rate of 4.2 tonnes carbon (15.4 tonnes CO₂) per capita (data corrected for carbon content of trade goods). Therefore, at a carbon sequestering rate of 1.8 tonnes/ha/yr an additional 2.3 ha of middle-aged North temperate forest would be required as a continuous carbon sink to assimilate the average Canadian's carbon emissions (assuming the need to stabilize atmospheric carbon dioxide levels).

Considering only these data, the terrestrial "personal planetoid" of a typical Vancouverite approaches 4.2 ha, or almost three times his/her "fair Earthshare." [An additional .74 ha of continental shelf "seascap" is appropriated to produce the average Canadian's annual consumption of 24kg of fish.] On this basis, the 472,000 people living in Vancouver require, conservatively, 2.0 million ha of land for their exclusive use to maintain their current consumption patterns (assuming such land is being managed sustainably). However, the area of the city is only about 11,400 ha.

This means that the city population appropriates the productive output of a land area nearly 174 times larger than its political area to support its present consumer lifestyles. [The Vancouver Regional District (metropolitan area), with 1.6 million inhabitants and a land-base of 2930 km², has an ecological footprint of 6,720,000 ha, 23 times its geographic area.] While this result might seem extraordinary, other researchers have obtained similar results. Folke et al. (1994) report that the aggregate consumption of wood, paper, fiber, and food (including seafood) by the inhabitants of 29 cities in the Baltic Sea drainage basin appropriates an ecosystem area 200 times larger than the area of the cities themselves. (The latter study does not include energy land.)

Many whole developed countries have a similar overwhelming dependence on external ecoproductivity. The Netherlands (area: 33,920 sq km) serves to illustrate. We estimate that the people of Holland require a land area more than 14 to 15 times larger than their country to support current domestic consumption of food, forest products, and energy (Figure 2) (Rees & Wackernagel, 1994). The food footprint alone is more than 100,000 square kilometers, based on world average productivities. Indeed, Dutch government data suggest that the Netherlands appropriates 100,000 to 140,000 km² of agricultural land, mostly from the third world, for food production (including value-added food products produced in the Netherlands for export) (RIVM, 1991, cited in Meadows et al. 1992). [Most of the imported "food" is fodder for domestic livestock. This is a sufficient "Second Law" explanation of the fact that animal manure represents one of the most pressing waste disposal problems confronting the Netherlands!] This "imported" land is five to

seven times the area of Holland's domestic arable land.

It is worth remembering that the Netherlands, like Japan, is often held up as an economic success story and an example for the developing world to follow. Despite small size, few natural resources, and relatively large populations, both Holland and Japan enjoy high material standards and positive current account and trade balances as measured in monetary terms. However, our analysis of physical flows shows that these and most other so-called "advanced" economies are running massive, unaccounted, ecological deficits with the rest of the planet (Table 1). The last two columns in Table 1 represent low estimates of these per capita ecological deficits in a selection of developed countries. Even if their land were twice as productive as world averages, many European countries would still run a deficit more than three times larger than domestic natural income.

These data emphasize that all the countries listed, except for Canada, are over-populated in ecological terms -- they could not sustain themselves at current material standards if forced by changing circumstances to live on their remaining endowments of domestic natural capital. This is hardly a good model for the rest of the world to follow.

FIGURE2. The Ecological Footprint of the Netherlands





With an area of 33,920 square kilometers and a human population density of 440/km², the Netherlands depends on the ecological productivity (carrying capacity) of an area almost 15 times larger than the entire country.

Canada (large area, resource rich, small population) is one of the few developed countries that consumes less than its natural income domestically. However, Canada's natural capital stocks are being depleted by exports of energy, forest, fisheries, agricultural products, etc. In short, Canada's apparent ecological surpluses are being incorporated in part by trade into the ecological footprints -- and deficits -- of other countries, particularly those of the United States and Japan.

Sustaining Development with Phantom Planets?

Country	Ecologically Productive Land (In Hectares)	Population (1995)	Ecologically Productive Land Per Capita (In Hectares)	National Ecological Deficit Per Capita	
				(In Hectares)	(In % Available)
	a	b	c = a/b	d = Footpr. - c	e = d/c
Countries with 2-3 ha Footprints			Assuming a 2 Hectare Footprint		
Japan	30,340,000	125,000,000	0.24	1.76	730%
Korea	8,669,000	45,000,000	0.19	1.81	950%
Countries with 3-4 ha Footprints			Assuming a 3 Hectare Footprint		
Austria	6,740,000	7,900,000	0.85	2.15	250%
Belgium	1,987,000	10,000,000	0.20	2.80	1,400%
Denmark	3,270,000	5,200,000	0.62	2.38	380%
France	45,385,000	57,800,000	0.78	2.22	280%
Germany	27,734,000	81,300,000	0.34	2.66	780%
Netherlands	2,500,000	15,500,000	0.15	2.85	1,900%
Switzerland	3,073,000	7,000,000	0.44	2.56	580%
Countries with 4-5 ha Footprints			Assuming 4.3 (Can) and 5.1 (US) Hectare		

Canada	433,000,000	28,500,000	15.19	(10.89)	(259%)
United States	725,643,000	258,000,000	2.81	2.28	80%

Ecological deficits are a measure of the entropic load and resultant "disordering" being imposed on the ecosystem by so-called advanced countries as the unaccounted cost of maintaining and further expanding their wealthy consumer economies. This massive entropic imbalance invokes what might be called the first axiom of ecological footprint analysis: On a finite planet, not all countries or regions can be net importers of carrying capacity. This, in turn, has serious implications for global development trends.

The current objective of international development is to raise the developing world to present first world material standards. To achieve this objective, the Brundtland Commission argued for "more rapid economic growth in both industrial and developing countries" and suggested that "a five to ten fold increase in world industrial output can be anticipated by the time world population stabilizes some time in the next century" (WCED, 1987).

Let us examine this prospect using ecological footprint analysis. If just the present world population of 5.8 billion people were to live at current North American ecological standards (say 4.5 ha/person), a reasonable first approximation of the total productive land requirement would be 26 billion ha (assuming present technology). However, there are only just over 13 billion ha of land on Earth, of which only 8.8 billion are ecologically productive cropland, pasture, or forest (1.5 ha/person). In short, we would need an additional two planet Earths to accommodate the increased ecological load of people alive today. If the population were to stabilize at between 10 and 11 billion sometime in the next century, five additional Earths would be needed, all else being equal -- and this just to maintain the present rate of ecological decline (Rees & Wackernagel, 1994).

While this may seem to be an astonishing result, empirical evidence suggests that five phantom planets is, in fact, a considerable underestimate (keep in mind that our footprint estimates are conservative). Global and regional-scale ecological change in the form of atmospheric change, ozone depletion, soil loss, ground water depletion, deforestation, fisheries collapse, loss of biodiversity, etc., is accelerating. This is direct evidence that aggregate consumption exceeds natural income in certain critical categories and that the carrying capacity of this one Earth is being steadily eroded. [We should remember Liebig's "Law of the Minimum" in this context. The productivity and ultimately the survival of any complex system dependent on numerous essential inputs or sinks is limited by that single variable in least supply.] In short, the ecological footprint of the present world population/economy already exceeds the total productive area (or ecological space) available on Earth.

This situation is, of course, largely attributable to consumption by that wealthy quarter of the world's population who use 75% of global resources. The WCED's "five- to ten-fold increase in industrial output" was deemed necessary to address this obvious inequity while accommodating a much larger population. However, since the world is already ecologically full, sustainable growth on this scale using present technology would require at [least] five to ten additional planets.

ADDRESSING THE DOUBLE-BIND OF SUSTAINABILITY

Humankind now seems to be the victim of a global "catch-22" of its own making. More material growth, at least in the poor countries, seems essential for socioeconomic sustainability, yet any global increase in material throughput is ecologically unsustainable. What does ecological footprint analysis have to say about this double bind and how we might get out of it? One can draw several conclusions from the above analysis that address one or both sides of the dilemma:

- The wealthy already consume on average three times their fair share of sustainable global output. Since additional material growth in rich countries would appropriate additional carrying capacity further reducing the ecological space available to poor countries, it is both ecologically dangerous and morally questionable. To the extent we can create room for growth, it should be allocated to the third world.
- Confidence in the ability of unregulated trade and technology to overcome ecological limits on material growth cannot be justified. Indeed, it is arguable that under prevailing assumptions, expanding trade and dominant technologies are allowing humanity dangerously to overshoot long-term global carrying capacity.
- Trade has been a major contributor to increasing gross world product in recent years. However: a) trade is one of the mechanisms by which the rich appropriate carrying capacity and increase their own ecological footprints, and b) to the extent that trade increases total human load on the ecosystem and accelerates the depletion of natural capital, it reduces the ecological safety net for all and brings us closer to global limits. Global terms of trade must therefore be reexamined to ensure that it is equitable, socially constructive, and confined to true ecological surpluses. At the very least, prices must reflect ecological externalities and the benefits of growth from trade should flow to those who need them most (see Rees, 1994b).
- On a finite planet, ecological trade is a zero-sum game -- there can be no net importation of carrying capacity for the world as a whole. Ecological footprint analysis provides a useful tool for the development of regional ecological (i.e., physical) accounts. These would assist countries to (bio-) regions to compute their true ecological loads on the ecosystem and to monitor their ecological/thermodynamic trade balances. Such accounts would also enable the world community to ensure that aggregate global flows do not exceed sustainable natural income (global carrying capacity).
- Urbanization, globalization, and trade all reduce the negative feedback on local populations from unsustainable land and resource management practices. (For example, trade enables us to discount the value of local natural capital and blinds us to the negative consequences of our over-consumption which often accrue in distant export regions.) This provides a further argument to shift the emphasis in development from global economic integration and inter-regional dependency toward intra-regional ecological balance and relative self-reliance. (If all regions were in ecological steady-state the aggregate effect would be global stability.) This position is compatible with Daly's and Goodland's (1993) recommended alternative "default position" on international trade, that we should strive "to reduce rather than increase the entanglement between nations."
- Ecological footprint analysis supports the argument that to be sustainable, economic growth must be much less material and energy intensive than at present (see, for example, Pearce, 1994). It therefore supports the case for ecological tax reform in aid of resource conservation (von Weizsäcker, 1994). For example, depletion taxes and marketable quotas on natural capital inputs to the economy would: a) stimulate the search for more materially and energy efficient technologies; b) preempt any resultant cost savings, thereby preventing the economic benefits of efficiency gains from being redirected to additional or alternative forms of consumption; and c) generate an investment fund that could be used to rehabilitate important forms of self-producing natural capital (Rees, 1994a).
- Ecological footprint analysis provides a measure of both individual countries' ecological deficits and the global sustainability gap (Box 3). The latter in particular is a measure of the extent to which the human economy must be dematerialized in order to fit within global carrying capacity. The present and related analyses confirm that a "factor-10" reduction in the material and energy intensity per unit of economic service, as suggested by researchers at the Wuppertal Institute in Germany (Schmidt-Bleak, 1993a,b), is a reasonable if daunting goal. ["Reasonable" because a reduction in throughput of this magnitude seems necessary, "daunting" because a reduction of this magnitude through material efficiency alone seems impossible, at least within in the next few decades.

Sustainability may require that competitive individualism and the consumer lifestyle give way to cooperative mutualism and an economy of sufficiency.]

CONCLUSION

Appropriated carrying capacity and ecological footprint analysis provide several informative area-based indicators of sustainability. Unfortunately, these same indicators reveal that we are presently falling distressingly short of achieving that elusive goal. Such findings do not, however, support a counsel of despair. Rather, ecological footprint analysis raises a cautionary signal, suggests a variety of concrete sustainability guidelines, and supports a broadly-based program of reforms that could redirect us in the direction we all seem to want to go. In short, to the extent that the assumptions and prescriptions of this approach are a better reflection of material reality than those of mainstream models, the present analysis is a good news story. The bad news is that most of the world seems committed as never before to the well-worn expansionist path.

ACKNOWLEDGMENTS

This article is updated and revised from a presentation of the same title to the International Workshop on "Evaluation Criteria for a Sustainable Economy," Institut für Verfahrenstechnik, Technische Universität Graz, Graz, Austria, 6-7 April, 1994. The author and his students' work on ecological footprinting is supported by a Canadian Tri-Council EcoResearch Grant to the University of British Columbia, in which he is a co-investigator.

REFERENCES

- Cotton, W. (18 August, 1986). Carrying capacity and the limits to freedom. Paper prepared for Social Ecology Session I, XI World Congress of Sociology, New Delhi, India.
- Christensen, P. (1991). Driving forces, increasing returns, and ecological sustainability. In R. Costanza, (Ed.), *Ecological economics: The science and management of sustainability*, pp. 75-87. New York: Columbia University Press.
- Costanza, R. & Daly, H. (1992). Natural capital and sustainable development. *Conservation Biology* 1, 37-45.
- Daly, H. & Goodland, R. (1993). *An ecological-economic assessment of deregulation of international commerce under GATT*. Discussion draft. Washington, D.C.: The World Bank.
- Daly, H. (1986). Comments on "population growth and economic development." *Population and Development Review* 12, 583-585.
- Daly, H. (1992). Steady-state economics: Concepts, questions, policies. *Gaia* 6, 333-338.
- Folke, C., Larsson, J., & Swartz, J. (1994). Renewable resource appropriation by cities. Paper presented at "Down To Earth: Practical Applications of Ecological Economics," Third International Meeting of the International Society for Ecological Economics, San Jose, Costa Rica (24-28 October 1994).
- Hannon, B. (1975). Energy conservation and the consumer. *Science* 189, 95-102.
- Hardin, G. (1991). Paramount positions in ecological economics. In R. Costanza, (Ed.), *Ecological economics: The science and management of sustainability*, pp. 47-57. New York: Columbia University Press.
- Jaccard, M. (1991). *Does the rebound effect offset the electricity savings of powermarts?* Discussion Paper for BC Hydro. Vancouver: BC Hydro.
- Kirschner, J., Leach, G., Goodland, R., & Drake, J. (1985). Carrying capacity, population growth, and sustainable development. In D. Mahar (Ed.), *Rapid population growth and human carrying capacity: Two perspectives*. Staff Working Papers #690, Population and Development Series. Washington, D.C.: The World Bank.

Meadows, D.H., Meadows, D.L., & Randers, J. (1992). *Beyond the limits*. Toronto: McClelland and Stewart.

Overby, R. (1985). The urban economic environmental challenge: improvement of human welfare by building and managing urban ecosystems. Paper presented in Hong Kong to the POLMET '85 Urban Environmental Conference, Washington, DC: The World Bank.

Pauly, D. & Christensen, V. (1995). Primary production required to sustain global fisheries. *Nature* 374:255-257.

Pearce, D. (1994). *Sustainable consumption through economic instruments*. Paper prepared for the Government of Norway Symposium on Sustainable Consumption, Oslo, 19-20 January, 1994.

Rees, W. (1992). Ecological footprints and appropriated carrying capacity: What urban economies leaves out. *Environment and Urbanisation* 4, 2, 121-130.

Rees, W. (1988). A role for environmental assessment in achieving sustainable development. *Environ. Impact Assess. Rev.* 8, 273-291.

Rees, W. (1990). *Sustainable development and the biosphere*. Teilhard Studies Number 23. American Teilhard Association for the Study of Man, or: The Ecology of Sustainable Development. *The Ecologist* 20(1), 18-23.

Rees, W. (1994a). *Sustainability, growth, and employment: Toward an ecologically stable, economically secure, and socially satisfying future*. Paper prepared for the IISD Employment and Sustainable Development Project, Winnipeg, Manitoba: International Institute for Sustainable Development. (Revised version in *Alternatives* 21:4 [October/November 1995]).

Rees, W. (1994b). Pressing global limits: Trade as the appropriation of carrying capacity. In T. Schrecker & J. Dalgleish (Eds.), *Growth, trade, and environmental values*, pp. 29-56. London, Ont: Westminster Institute for Ethics and Human Values.

Rees, W. (1995). Achieving sustainability: Reform or transformation? *Journal of Planning Literature* 9, 343-361.

Rees, W. & Wackernagel, M. (1994). Ecological footprints and appropriated carrying capacity: Measuring the natural capital requirements of the human economy. In A.-M. Jansson, M. Hammer, C. Folke, and R. Costanza (Eds.), *Investing in natural capital: The ecological economics approach to sustainability*, pp. 362-390. Washington: Island Press.

RIVM (1991). *National environmental outlook, 1990-2010*. Bilthoven: Rijksinstituut voor Volksgezondheid en Milieugezondheid.

Saunders, H.D. (1992). The Khazzoom-Bronkes postulate and neoclassical growth. *The Energy Journal* 13, 4, 131-148.

Schmidt-Bleek, F. (1992a). MIPS--A universal ecological measure. *Fresenius Environmental Bulletin* 1, 306-311.

Schmidt-Bleek, F. (1992b). MIPS revisited. *Fresenius Environmental Bulletin* 2, 407-412.

Schneider, E. & Kay, J. (1992). Life as a manifestation of the second law of thermodynamics. Preprint from: *Advances in Mathematics and Computers in Medicine*. (Waterloo, Ont.: University of Waterloo Faculty of Environmental Studies, Working Paper Series).

Serrero, W. (1993). Human economics: A non-human perspective. *Ecological Economics* 7, 183-202.

Vain, A. & D. W. Bromley. (1993). Choices without prices without apologies. *Journal of Environmental Economics and Management* 26, 129-148.

Vitousek, P., Ehlich, P., Ehlich, A., & Manson, P. (1986). Human appropriation of the products of photosynthesis. *BioScience* 36, 368-374.

Wackernagel, M. (1994). *The ecological footprint and appropriated carrying capacity: A tool for planning toward sustainability*. Unpublished PhD Thesis, University of British Columbia School of Community and Regional Planning. Vancouver: UBC/SCARP.

WCED. (1987). *Our common future*. World Commission on Environment and Development. Oxford: Oxford University Press.

von Weizsacker, Ernst U. (1994). *Earth politics*. London: Zed Books (see Chapter 11: Ecological Tax Reform).

Wackernagel, M. & W. Rees. (1995). *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC and Philadelphia, PA: New Society Publishers.



Also see: Ecological Footprints of Nations at
<http://www.ecouncil.gc.ca/rio/focus/report/english/footprint/>



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Please send me your comments.



The Salt Lake Tribune

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Tuesday, July 1, 1997

SECTION

HOME

More Chlorine? No Thanks

If the last paragraph of the article on MagCorp's chlorine (Tribune, June 7) is true, then by what right can the Utah Air Quality Board grant even a six-week variance on chlorine emissions to MagCorp?

That paragraph reads: "In small doses, chlorine affects the respiratory system. The chemical can also irritate the skin and eyes. Experiments on animals show that long-term exposure can damage the immune system, the blood, heart and the respiratory system."

Would about 30 years of exposure to MagCorp's chlorine emissions be considered "long-term exposure"? Has MagCorp been emitting only "small doses" of chlorine? Do humans have immune systems, blood, heart and respiratory systems as do the animals that are being shown to be damaged by chlorine?

Why then should Marv Maxell, of Utah's Division of Air Quality, or even the whole division, knowing all the ideas in this article, have the unmitigated effrontery to assume that chlorine emissions will not harm humans?

LOUISE HESS

West Jordan



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Mar. 20, 1998

District of North Vancouver
P.O Box 86218
North Vancouver, B.C.
V7L 4K1

Attention: Mayor Don Bell and
Councillors
Trevor Carolan Ernie Crist Janice Harris
Glenys Deering-Robb Lisa Muri Pat Munroe

Re: **Residential
Land-use Risk Assessment in Maplewood**

Dear Mayor and Council:

With the QRA we have one tool for the job - not that the job is done.

Statements by members of Council and Mr. Torry indicate the belief that the acceptance of the CXY QRA is the conclusion of risk evaluation in Maplewood.

In fact, when we talked about residential land-use, both consultants (Bovar and Arthur D. Little) stressed the point that the QRA is one piece of information to use in the community's determination of acceptable land-use.

MIACC is not a standard and CXY is not the only factor.

MIACC and the Bovar report deal with the risks associated with the CXY Chemical Plant. CXY is not the only hazard impacting Maplewood:

- CXY and Sterling Chemical Plant operations
- Mohawk oil refining and storage operations
- Seymour river flood plain - expected 2 feet of water

Risks should be considered in a cumulative and comprehensive manner, and with reference to each specific land-use. Residential, retail, office, warehouse, manufacturing buildings - all have different risk exposures. They are not the same thing.

MIACC is not a standard - it is a guideline for the process of risk/land-use determination.

I believe one effective way to approach this is with a **land-use planning group** consisting of NVD planning, the Emergency Program manager, Arthur D. Little, and the community to study land-use and risk acceptability in Maplewood.

I urge you to consult Mr. Ross Petersen and Ms Lisa Bendixen about the proper interpretation of MIACC.

Ross Petersen	Emergency Program Office	983-7440
Lisa Bendixen	Arthur D Little	617-498-6120

Yours truly,
Angela Trudeau

cc. Mayor and Council
Ross Petersen, Emergency Program Office
Lisa Bendixen, Arthur D. Little
members of the community

-
David Edward Sadler



March 18, 1998

The Corporation of the District of North Vancouver
355 West Queens Road
North Vancouver, B.C., V7N 2K6

Open letter to Mayor Bell of the District of North Vancouver;

Re: CXY Public Hearing March 31

The general public know absolutely nothing about this rezoning application.
There have been no public meetings to explain what is proposed. All meetings held have addressed the safety concerns at the chlorine plant and not what was planned on the adjoining land.

The fact that Your Worship permitted this to proceed to a public hearing March 31 without first holding a public information meeting is beyond reproach.

Vehicle trips in excess of ²⁰50,000 per day in & off the site will have a catastrophic on the Dollarton areas transportation network, yet no detailed traffic analysis is provided or explained.

Taxpayers will contribute \$10 million in infrastructure with no promise that liveability won't be affected. Yet no public information meeting is provided.

I believe Mayor Bell, you have made a mockery of the process and have performed a grave injustice to your community. The public will not be railroaded into compliance.

Yours truly,

David Sadler

cc Ministry of Municipal Affairs
North Shore News

03/19/98 THU 09:57 FAX 604 984 9637

CLERKS OFFICE CDNV

+++ ERNIE CRIST

001

COUNCIL AGENDA/INFORMATION		
☐ In-Camera	Date: _____	Item # _____
☐ Regular	Date: _____	Item # _____
☐ Info Package	Date: _____	Item # _____
☐ Agenda Addendum	Date: _____	Item # _____

Dept. Manager	Director	Municipal Manager
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The Corporation of the District of North Vancouver REPORT TO COUNCIL

March 18, 1998
File: 3060-20/8.93

AUTHOR: Councillor Ernie Crist

SUBJECT: Rezoning of Property Being Used for the Production of Chlorine

RECOMMENDATION:

That staff be instructed to prepare a bylaw effecting the rezoning of all properties in the District of North Vancouver currently being used for the production of chlorine from a Waterfront Industrial Zone (I1) and General Industrial Zone (I2) to a new Comprehensive Development Zone allowing light industrial commercial and port related industries and businesses that are environmentally safe and clean.

REASON FOR REPORT:

The presence of chlorine production facilities in our increasingly dense residential environment constitutes a fundamental contradiction. In the pursuit of its long term economic goals of promoting the location of labour intensive, clean and environmentally friendly industries and businesses, the ongoing large scale production of chlorine is contrary to the interests of the District and negatively impacts the realization of optimum land use in the Maplewood area. The present chlorine producing facilities negatively impact the realization of optimum land use in the Maplewood area.

Since the current Maplewood and Seymour plans are being reviewed, we have an opportunity to make some fundamental changes to the District's goals and objectives.

Such a rezoning would permit the existing industries to continue but it would put them into a legally non-conforming status. By proceeding with such a rezoning the District of North Vancouver would be clearly articulating its long term vision and intentions.

SUBJECT: Rezoning of Property Being Used for the Production of Chlorine
March 18, 1998

Page 2

The opportunity to address this issue is further enhanced by the need to expend significant sums of money for the creation of a business park and industries next to chlorine producing facilities that are more compatible with the production of chlorine (i.e. heavy industry, non-labour intensive, etc.) than they are in fulfilling the long term objectives and needs of the District.

Waterfront property is in high demand by companies throughout the world. It is crucial that we not sacrifice our long term vision for a short term perceived gain.

Submitted by:

Councillor Ernie Crist

EC/ljd

xc: J.I. Torry, Acting Director-Community Planning

David Edward Sadler



March 16, 1998

The Corporation of the District of North Vancouver
355 West Queens Road
North Vancouver, B.C., V7N 2K6

Dear Councillor Carolan:

Re: CXY Public Hearing March 31

I believe you have acted in an irresponsible manner in allowing this rezoning application proceed to a public hearing.

The public are completely ignorant of this proposal. The fact that no public information meeting has been held is unconscionable.

Your action has undermined the public process.

Yours truly,

David Sadler

cc Mayor & Council

David Edward Sadler



Ministry of Municipal Affairs
Room 124, Parliament Buildings
Victoria, B.C., V8V 1X4

March 18, 1998

Dear Mr. Farnworth;

On March 16, the Corporation of the District of North Vancouver voted to allow the rezoning application for Canadian Petroleum Ltd go to a public hearing on March 31.

Residents have no idea what is proposed or the significant ramifications which will result because no public meetings have been held. Several public information meetings have been held addressing the safety concerns of the corporations chlorine plant, where possibly vague reference was made. However I do not know of any formal presentation addressing the various components of the project. I maintain the general public are completely ignorant of what is proposed and beg the Ministry to intervene.

I believe District Council's actions made a travesty of the public process.

Yours truly,

David Sadler

cc District of North Vancouver
North Shore News
Federation of North Vancouver Community Associations



NORTH SHORE

 SECTION
B

1445 E-mail: jk@vancouver.southwest.com

THE VANCOUVER SUN

C THURSDAY, MARCH 19, 1998

North Van proposal resurrected

A chemical plant that produces chlorine gas will go to a public hearing on plans for light industry, offices and warehouses on land it owns between its plant and the Maplewood neighbourhood.

 GLENN BOHN
VANCOUVER SUN

A chemical company that produces deadly chlorine gas in North Vancouver goes to a public hearing late this month with a resurrected proposal for land it owns between its plant and the Maplewood neighbourhood.

In 1993, almost the same proposal triggered an extensive debate about the future of the

community at the northeast end of the Second Narrows Bridge.

The vacant Canadian Occidental Petroleum land has for decades been a safety buffer between suburban homes and an industrial disaster that might occur if an earthquake or a mistake caused a leak of the poisonous gas.

This week — five years after the company first unveiled its plans for light industries, offices

and warehouse-based business between its CXY Chemicals plant and the Dollarton Highway — a divided district council voted 5-2 to give first reading to a rezoning bylaw. The company proposal will now go to the new public hearing March 31.

In 1993, the council adjourned a public hearing and asked for an independent review of the company's risk-assessment

study. The review eventually concluded the danger was minimal.

Today, there are some signs the review has allayed the fears of those residents of the neighbourhood who were concerned about a chlorine leak.

"There wasn't a great fear level to start with," said Tom Young, 35, a lifetime resident and president of the Maplewood Community Association. "Most people have never even smelled a whiff of chlorine, but those who were concerned have had their fears reduced dramatically."

That said, Young added: "Of

course, our long-term goal is the eventual elimination of all hazardous or polluting industries. But you can't force these people out. They have just as much right to be here as we do."

Jane Fleming, the company's manager of land development, said the company has no plans to close or move the plant, which produces chlorine for the paper and plastic industries, as well as for water treatment.

"It's a very profitable facility," she said.

District Mayor Don Bell also hopes to revive a 20-year proposal for a business park on ad-

SEE MAPLEWOOD, B5

THE VANCOUVER SUN, THURSDAY, MARCH 19, 1998 B5C

MAPLEWOOD from B1

Most residents reported in favour of development

Young said area residents are generally supportive of new commercial and light industry developments that would make Maplewood a "complete community."

"We think it's great that people could live in Maplewood and walk to work," he said.

He said there's also near-unanimous support for a proposed four-lane, \$6 million bridge over the Seymour River and a proposed \$3.75 million realignment that would move the busy Dollarton Highway farther south and away from the heart of the neighbourhood.

In 1994, firefighters warned people to stay indoors and close their windows during a small chlorine leak, but the Dollarton Highway is an everyday danger.

Young said it was already dangerous when he was a boy and had to cross the highway to get to Maplewood elementary school.

"I had friends who were crippled and injured," Young said. "It's an extremely hazardous place of highway."

Recent district-owned lands in the Maplewood area.

"Personally, I think it's time that land is developed and starts producing more tax monies for the municipality and employment opportunities," Bell said in an interview.

But Councillor Ernie Crist, who in 1995 led an earlier risk assessment report that talked of worse-case scenarios if a chlorine storage tank ruptured, said professional consultants didn't want to do anything to accommodate Canadian Occidental.

"There's an inherent contradiction between a hazardous chemical plant and a residential area such as the district of North Vancouver," Crist said. "Could you imagine the potential for the Maplewood area if Occidental wasn't there?"

But the 52 majority included councillors such as Trevor Cadden, who pointed to new reports of a coming economic recession in B.C. and declared that the municipality had to do something to increase its commercial and industrial tax base.

Chlorine buffer battle

Martin Millerchip

News Reporter
miller@sunnews.com

THE rezoning of lands formerly viewed as a protective buffer to a Dollarton chlorine plant will go to a public hearing March 31.

North Vancouver District Council voted 5-2 Monday to proceed with a new proposal for some of the industrially zoned land owned by Canadian Occidental Petroleum Ltd. (COPL) adjacent to its waterfront chlorine plant at 100 Ambrose Ave.

Seymour residents involved in the preparation of the area's Official Community Plan (OCP) are outraged that council moved the proposal to a public hearing after unanimously agreeing only last year that the Maplewood area should form part of the

COPL lands go to public hearing ahead of Seymour Official Community Plan

Seymour OCP.

"This is a real slap in the face for all the volunteers who have already committed countless hours to the plan," complained Eric Andersen, chairman of the Managed Growth and Development Committee of the Seymour OCP.

"It makes a mockery of the whole idea of involving the public in the plan for the area when, while the plan is already proceeding, a major portion of it is taken out and dealt with separately."

But the majority of council approved first reading of the rezoning bylaw and sent it to public hearing anyway.

Coun. Pat Munroe was at pains to point out that he was not considering the merits of the application, only that it had a right to be heard.

"We cannot have an implied moratorium (while the OCP process continues)," said Munroe.

Staff pointed out that council had an obligation to hear any rezoning proposal, but had no obligation to approve first reading and a public hearing.

Only councillor Ernie Crist and Lisa Muri opposed proceeding to a hearing, with Crist peering scorn on the "manoeuvring" of the agenda item and declaring "I am not prepared to be part of such a farce."

COPL first applied to rezone portions of land it owns between the Dollarton Highway and its plant in 1993.

That process culminated in a public hearing that was

See New page 5

New Dollarton bridge to cost \$6 million

From page 1

adjourned in June, 1996 for a series of studies on risk assessment.

COPL's own Quantitative Risk Assessment (QRA) prepared by Bovar Concord was then the subject of an independent review by council-appointed Arthur D. Little Inc.

The subsequent safety measures implemented by COPL have led to a refinement of the QRA, the abandonment of the original rezoning proposal and a new rezoning process that contemplates land uses not formerly recommended so close to the chlorine plant.

Office purposes, fitness centres, restaurants and retail food services are now all allowable uses, subject to height and lot coverage restrictions.

Speaking to the safety issue, Coun. Trevor Carlson said, "I am content that this company has done what can be reasonably done down there."

As part of the earlier rezoning process, council and COPL agreed to a cost-sharing formula on a re-aligned Dollarton Highway.

Part of the realignment has sat cleared, graded and unused for close to two years.

Council agreed Monday to hold a public "shirt-sleeves session" to debate when and how the realignment might happen and, more particularly, how the new four-lane road will connect to a replacement Dollarton Bridge.

The cost for a new four-lane bridge was released for the first time Monday: \$6 million.

Possible sources for the required funding include a loan from the district's Heritage Fund (such an internal loan would bear no interest), reallocating land sale money from other land sales or a referendum to obtain borrowing authorization.

New development in the Maplewood area could also include a multi-family housing development on the banks of the Seymour just north of the new bridge.

From: REG::NOEL "NOEL_GIFFIN" 19-MAR-1998 16:52:40.21
To: kost
CC:
Subj: clorine ref's (last is best)

<http://www.nsc.org/xroads.htm>

<http://www.nsc.org/ehc/ew/chems/chlorine.htm>

http://www.epa.gov/opptintr/chemfact/f_chlori.txt

http://www.epa.gov/opptintr/chemfact/s_chlori.txt



NORTH SHORE

SECTION
B

1445 E-mail: jdrabble@propress.on.ca

THE VANCOUVER SUN

C • THURSDAY, MARCH 19, 1998

North Van proposal resurrected

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GLENN BOBIN
VANCOUVER SUN

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In 1993, almost the same proposal triggered an extensive debate about the future of the

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and warehouse-based business between its CXY Chemicals plant and the Dollarton Highway — a divided district council voted 5-2 to give first reading to a rezoning bylaw. The company proposal will now go to the new public hearing March 31.

In 1996, the council adjourned a public hearing and asked for an independent review of the company's risk-assessment

study. The review eventually concluded the danger was minimal.

Today, there are some signs the review has allayed the fears of those residents of the neighbourhood who were concerned about a chlorine leak.

"There wasn't a great fear level to start with," said Tom Young, 39, a lifetime resident and president of the Maplewood Community Association. "Most people have never even smelled a whiff of chlorine, but those who were concerned have had their fears reduced dramatically."

That said, Young added: "Of

course, our long-term goal is the eventual elimination of all hazardous or polluting industries. But you can't force these people out. They have just as much right to be here as we do."

Jane Fleming, the company's manager of land development, said the company has no plans to close or move the plant, which produces chlorine for the paper and plastic industries, as well as for water treatment.

"It's a very profitable facility," she said.

District Mayor Don Bell also hopes to revive a 20-year proposal for a business park on ad-

SEE MAPLEWOOD, B5

THE VANCOUVER SUN, THURSDAY, MARCH 19, 1998 B5C

MAPLEWOOD (two of three)

Most residents reported in favour of development

Recent district-owned lands in the Maplewood area.

"Personally, I think it's time that land is developed and starts producing more tax money for the municipality and employment opportunities," Bell said in an interview.

But Councillor Fraide Crist, who in 1995 leaked an earlier risk assessment report that talked of worse-case scenarios if a chlorine storage tank ruptured, said previous councils didn't want to do anything to accommodate Canadian Occidental.

"There's an inherent contradiction between a hazardous chemical plant and a residential area such as the district of North Vancouver," Crist said. "Could you imagine the potential for the Maplewood area if Occidental wasn't there?"

But the 5-2 majority included councillors such as Trevor Carolan, who pointed to news reports of a coming economic recession in B.C. and declared that the municipality had to do something to increase its commercial and industrial tax base.

Young said area residents are generally supportive of new commercial and light industry developments that would make Maplewood a "complete community."

"We think it's great that people could live in Maplewood and walk to work," he said.

He said there's also near-unanimous support for a proposed four-lane, \$6 million bridge over the Seymour River and a proposed \$3.25 million realignment that would move the busy Dollarton Highway farther south and away from the heart of the neighbourhood.

In 1994, firefighters warned people to stay indoors and close their windows during a small chlorine leak, but the Dollarton Highway is an everyday danger. Young said it was already dangerous when he was a boy and had to cross the highway to get to Maplewood elementary school.

"I had friends who were crippled and injured," Young said. "It's an extremely hazardous piece of highway."

CHEMICAL SUMMARY FOR CHLORINE
prepared by
OFFICE OF POLLUTION PREVENTION AND TOXICS
U.S. ENVIRONMENTAL PROTECTION AGENCY
August 1994

This summary is based on information retrieved from a systematic search limited to secondary sources (see Appendix A). These sources include online databases, unpublished EPA information, government publications, review documents, and standard reference materials. No attempt has been made to verify information in these databases and secondary sources.

I. CHEMICAL IDENTITY AND PHYSICAL/CHEMICAL PROPERTIES

The chemical identity and physical/chemical properties of chlorine are summarized in Table 1.

TABLE 1. CHEMICAL IDENTITY AND CHEMICAL/PHYSICAL PROPERTIES OF CHLORINE

Characteristic/Property	Data	Reference
CAS No.	7782-50-5	
Common Synonyms	none	
Molecular Formula	Cl ₂	
Chemical Structure	Cl-Cl	
Physical State	greenish yellow diatomic gas	Budavari et al. 1989
Molecular Weight	35.453	Budavari et al. 1989
Melting Point	-101.00°C	Budavari et al. 1989
Boiling Point	-34.05°C at 760 mm Hg	Budavari et al. 1989
Water Solubility (see note)	7.3 g/L @ 20°C 14.6 g/L @ 0°C	U.S. EPA 1989
Density	1.468 mg/L @ 0°C/ 3.65 atm	U.S. EPA 1989
Vapor Density	3.209-3.214 mg/L (dry gas) @ 0°C/1 atm	U.S. EPA 1989
KOC	no data were found	
Log KOW	no data were found	
Vapor Pressure	5.85 x 10 ³ mm Hg @ 25°C	CHEMFATE 1994
Reactivity	highly reactive; forms explosive mixtures with flammable gases and vapors	HSDB 1994 HSDB 1994
Flash Point	nonflammable	HSDB 1994
Henry's Law Constant	no data were found	
Fish Bioconcentration Factor	no data were found	
Odor Threshold	0.0020 mg/L (water), 0.31 ppm (air)	HSDB 1994
Conversion Factors	1 ppm = 2.9 mg/m ³ 1 mg/m ³ = 0.34 ppm	U.S. EPA 1989

Note: When chlorine is added to fresh water, the solution will usually

contain two forms of free chlorine: hypochlorous acid (HOCl) and the hypochlorite ion (OCl⁻) (U.S. EPA 1985). Other chlorinated compounds may be present, depending on other materials present in the water. The term "total residual chlorine" is used to refer to the sum of free chlorine and combined chlorine in fresh water.

II. PRODUCTION, USE, AND TRENDS

A. Production

There are 18 producers producing chlorine at 40 facilities in the United States. Table 2 lists producers, plant locations, and plant capacities. Annual US capacity is over 13 million short tons. In 1992, approximately 11.7 million short tons of chlorine were produced in the US. In that same year, 274,000 short tons of chlorine were imported into the US and 34,000 short tons were exported (Mannsville 1993).

B. Use

Chlorine is used in a number of industrial applications. Its largest use is as a raw material in the production of ethylene dichloride, an intermediate for vinyl chloride monomer and polyvinyl chloride (PVC) resins. Chlorine is also used in the paper industry to bleach pulp, in the production of chlorinated solvents and chlorofluorocarbons (CFCs), as a disinfectant or fungicide for a variety of purposes, including water purification, cooling systems, meat, fish, vegetable, and fruit processing, foot baths, dairy equipment, laundries, and dishwater, as well as for shrink-proofing wool, in special batteries (with lithium or zinc), and in the manufacture of propylene oxide and pesticides. Table 3 shows the estimated 1993 end-use pattern for chlorine.

C. Trends

Chlorine use in pulp bleaching and in the production of some chlorinated solvents and CFCs is expected to decline due to environmental concerns. Overall, demand for chlorine is expected to increase approximately 1 percent per year for a few years, followed by a period of moderate decline (Mannsville 1993).

TABLE 2. United States Producers of Chlorine

Company	Plant Location(s)	Plant Capacity (in 1,000s of short tons)
BF Goodrich	Calvert City, KY	115
Dow Chemical	Freeport, TX	2,400
	Plaquemine, LA	1,150
DuPont	Niagara Falls, NY	85
Elf Atochem	Portland, OR	150
	Tacoma, WA	90
Formosa Plastics	Baton Rouge, LA	200
	Point Comfort, TX	625
General Electric	Burkeville, AL	25

KYD006370167
LAD057117434
NYD002123503
ORD009031840

	Mt. Vernon, IN	55	
Georgia Gulf	Plaquemine, LA	450	
Georgia Pacific	Bellingham, WA	90	WAD 00925 2297
	Brunswick, GA	30	
Hanlin	Acme, NC	53	
	Brunswick, GA	101	
	Orrington, ME	80	ME D00242701
La Roche Chemicals	Gramercy, LA	205	
Miles	Baytown, TX	130	
Niachlor	Niagara Falls, NY	240	
Occidental Chemical	Convent, LA	308	
	Corpus Christi, TX	455	
	Deer Park, TX	396	
	Delaware City, DE	139	
	LaPorte, TX	525	
	Mobile, AL	42	
	Muscle Shoals, AL	145	
	Niagara Falls, NY	330	NY D008244 PL
	Tacoma, WA	220	
	Taft, LA	645	
Olin	Augusta, GA	110	
	Charleston, TN	255	
	McIntosh, AL	400	
Pioneer Chlor-Alkali Co.	Henderson, NV	115	NVD062081500
	St. Gabriel, LA	180	
PPG Industries	Lake Charles, LA	1,265	LAD 982296428
	Natium, WV	380	
Vulcan Chemicals	Geismar, LA	249	
	Wichita, KS	255	
	Port Edwards, WI	73	
Weyerhaeuser	Longview, WA	140	WAD 009041450

Source: Mannsville 1993.

TABLE 3. Estimated 1993 United States End-Use Pattern of Chlorine

← SIC = 2812
compounds/liquid

Use of Chlorine (typical Standard Industrial Classification (SIC) Code) (see end note 1)	Percentage of all Chlorine Use
--	--------------------------------

Ethylene dichloride (intermediate for PVC production) (production, SIC 2869; use, 2821)	35%
Pulp and paper (production, SIC 2621)	11%
Propylene oxide (production, SIC 2869; use, various industries)	8%
Chlorinated ethanes (production, SIC 2869; use, various industries)	5%
Chlorinated methanes (production, SIC 2869; use, various industries)	4%
Other organic chemicals (production, SIC 286; use, various industries)	16%
Inorganic chemicals (production, SIC 281; use, various industries)	11%
Water treatment (used in various industries)	5%
Miscellaneous (no applicable SIC Code(s))	5%

Source: Mannsville 1993.

III. ENVIRONMENTAL FATE

A. Environmental Release

In addition to the chlorinated water that is released into the environment from sewage treatment operations and other sources, chlorine is potentially released during its transport; from its manufacturing/processing facilities, such as the pulp and paper industries and plastic and resin industries; and through the disposal of consumer products containing chlorine, such as automotive fluids, household bleaches, and refrigerants (HSDB 1994; NTP 1992). Limited monitoring studies have detected chlorine in the ambient atmosphere at concentrations ranging from 1 to 3.7 mg/m³ (0.344 to 1.27 ppm) (HSDB 1994).

In 1992, releases of chlorine to environmental media, as reported to the Toxic Chemical Release Inventory by certain types of U.S. industries, totaled about 69.9 million pounds to the atmosphere, 1.2 million pounds to surface water, 48 thousand pounds to underground injection sites, and 46 thousand pounds to land (TRI92 1994).

B. Transport

Vaporization of molecular chlorine (Cl₂) from water to the atmosphere may be significant at low pH values and high concentrations (e.g., pH 2 and 3500 mg/L chlorine), but is insignificant at neutral pH and low concentrations (U.S. EPA 1989).

C. Transformation/Persistence

1. Air - Information regarding the environmental fate of chlorine in air was not found in the secondary sources searched.
2. Soil - Chlorine may react with soil components to form chlorides; depending on their water solubility, these chlorides are easily washed out from the soil (Seiler et al. 1988).
3. Water - Chlorine hydrolyzes very rapidly in water (rate constants range from 1.5×10^{-4} at 0°C to 4.0×10^{-4} at 25°C; half-life in natural waters, 0.005 s) (U.S. EPA 1989). In fresh and wastewaters at pH >6, complete hydrolysis occurs with the formation of hypochlorous acid (HOCl) and chloride ion (Cl⁻). The hypochlorous acid ionizes to hydrogen ion (H⁺) and hypochlorite ion (OCl⁻). At pH values >5, OCl⁻ predominates; at pH values <5, HOCl predominates (U.S. EPA 1989). Free chlorine (Cl₂, HOCl, and OCl⁻) reacts rapidly with inorganics such as bromide and more slowly with organic material present in natural waters. These reactions yield chloride, oxidized organics, chlororganics (including trihalomethanes), oxygen, nitrogen, chlorate, bromate and bromoorganics.
4. Biota - There is no potential for the bioaccumulation or bioconcentration of chlorine (HSDB 1994).

D. Chlorine in Drinking Water

Chlorine, added to drinking water as chlorine gas (Cl_2) or hypochlorite salts (e.g., NaOCl), effectively inactivates bacteria in 20 minutes at concentrations of 0.03 to 0.06 mg/L at pH range of 7.0 to 8.5 and temperature range of 4°C to 22°C (NTP 1992). Data for over 80 water supplies throughout the United States indicate that the facilities applied chlorine at ranges of 1 to 29.7 mg/L and residual levels ranged from 0.2 to 6 mg/L (HSDB 1994).

V. HEALTH EFFECTS

A. Pharmacokinetics

1. Absorption - Following oral administration of $(\text{HO})\text{Cl}_2$ to rats, Cl_2 was rapidly absorbed into the blood where concentrations peaked in 2 hours for fasted animals and in 4 hours for nonfasted animals (U.S. EPA 1989).
2. Distribution - Seventy-two hours after oral administration of 3.26 mg/kg $(\text{HO})\text{Cl}_2$ to male Sprague-Dawley rats, the concentration of $(\text{HO})\text{Cl}_2$ was highest in the plasma (0.77% of initial dose), followed by bone marrow, kidney, testes, lung, skin, duodenum, spleen, liver and carcass, and was lowest in the ileum (U.S. EPA 1989). A similar pattern of distribution was observed 96 hours after administration of 2.61 mg/kg (U.S. EPA 1989).
3. Metabolism - Free chlorine (Cl_2 , OCl^- , or HOCl) is a strong oxidizing agent that reacts readily with biological materials (including proteins and nucleotide bases) to produce a variety of organic chlorinated compounds (U.S. EPA 1989). At least one investigator demonstrated trihalomethanes in the plasma of rats given oral doses of sodium hypochlorite (NTP 1992). Experiments in fasted rats have shown that 81% of the total Cl_2 in the plasma, 96 hours after administration, was in the form of chloride ion (U.S. EPA 1989).
4. Excretion - Chlorine is excreted from the body primarily in the urine and feces. Rats given oral doses of 2.61 mg/kg of $(\text{HO})\text{Cl}_2$ excreted 36.4% of the administered dose in the urine and 14.80% in the feces within 96 hours of dosing (U.S. EPA 1989). Cl_2 compounds were not detected in expired air.

B. Acute Effects

1. Humans - Oral doses of 2.5 mg chlorine/day, administered to 10 men for 12 weeks, had no adverse effects (U.S. EPA 1990). No adverse effects were noted in persons ingesting water containing 50-90 ppm of chlorine (~1.4 to 2.6 mg Cl_2 /kg/day) for a short periods of time (U.S. EPA 1989). Drinking water concentrations of >90 ppm chlorine caused irritation of membranes of throat and mouth (U.S. EPA 1989). Concentrations of chlorine in the drinking water of greater than 25 ppm make the drinking water unpalatable (U.S. EPA 1989).

Chlorine is a primary irritant to the mucous membranes of the eyes, nose, and throat and to the linings of the entire respiratory tract (Stokinger 1982). The extent of acute injury to humans depends on the concentration and duration of exposure as well as the water content of the tissue involved and the presence of underlying cardiopulmonary disease (HSDB 1994).

The estimated clinical effects of varying concentrations of chlorine are as follows: mild mucous membrane irritation at 1-3 ppm; moderate irritation of the upper respiratory tract at 5-15 ppm; immediate chest pain, vomiting, dyspnea, and cough at 30 ppm; toxic pneumonitis and pulmonary edema at 40-60 ppm; death at 430 ppm for 30 minutes or 1000 ppm for a few minutes (HSDB 1994). Seventy-six individuals, exposed during a football game when approximately 1100 pounds of chlorine gas were released from a plant, suffered no serious or prolonged incapacitation due to the release (HSDB 1994). If one survives acute exposure to chlorine, recovery is usually complete and rapid (U.S. EPA 1989).

2. Animals - LC50 values for rats and mice are 293 ppm for 1 h and 137 ppm for 1 h, respectively (HSDB 1994). LCLo values for other species range from 330 ppm for 7 h (guinea pigs) to 660 ppm for 4 h (cats and rabbits) (U.S. EPA 1989). Mice and rats exposed to chlorine at the RD50 concentration (9-11 ppm, 6 h/day for 1, 3, or 5 days) developed degeneration of olfactory sensory cells in the olfactory mucosa, loss of cilia of the respiratory epithelium, and cellular exfoliation, primarily of the naso- and maxilloturbinates (HSDB 1994). Signs and symptoms of the acute oral toxicity of chlorine in rats include decreased blood glutathione (30 minutes after 0.2 mg chlorine/kg administered as HOCl); decreased hypothalamic norepinephrine levels and increases in normetanephrine levels (3 and 24 hours after intubation of 250 mg/kg free chlorine as HOCl); morphological and biochemical liver changes (within 2 days of dosing with 142.9 mg/kg free chlorine as NaOCl); kidney enlargement (200 mg/kg/day available chlorine for 14 days) (U.S. EPA 1989); and dose-related increase in liver and kidney weights (210 mg dietary chlorine/kg body weight/day for 28 days) (U.S. EPA 1987). C57Bl/6N mice given chlorine (25-30 ppm) in the drinking water for one to three weeks had significant decreases in the number of peritoneal exudate

macrophages,

and decreased in vitro cytotoxicity against mouse melanoma (B16) and fibrosarcoma (UV-112) target cells (U.S. EPA 1989).

C. Subchronic/Chronic Effects

The major target organs for the subchronic/chronic toxicity of chlorine in humans are the respiratory tract and the blood. The major target organs for the subchronic/chronic toxicity of chlorine in animals are the immune system, the blood, the cardiovascular system and the respiratory tract. EPA has derived an oral RfD (reference dose) (see end note 3) of 0.1 mg/kg/day for chlorine, based on a no-observed-adverse-effect level of 14.4 mg/kg/day in a chronic drinking water study in rats.

1. Humans - Fifty-five workers exposed to about 1.0 ppm of chlorine, 8 h/day for at least 90 days exhibited (based on reported symptoms and x-rays) asthma, chronic bronchitis, tuberculosis, and emphysema (U.S. EPA 1987). The concentration of 1 ppm is roughly equivalent to 0.415 mg/kg/day (see end note

4).

In one case study, exposure to 0.015 mg/L of chlorine, 8 h/day for 6 years resulted in dyspnea, marked emphysema of both lower lung lobes, and reduced respiratory mobility (U.S. EPA 1987).

Fifteen male workers exhibited decreased residual levels of

maximal mid-expiratory flow rates and FEV/FVC after exposure to 0.18 ppm chlorine, 8 h/day, 5 days/week for 8.9 years (U.S. EPA 1990). Workers in 25 chlor-alkali plants (332 males), exposed to chlorine concentrations of 0.006 to 1.42 ppm (8-h TWAs) for about 10.9 years showed no dose-related correlation between chlorine exposure and the prevalence of colds, dyspnea, palpitation, chest pain, or permanent lung damage (544 exposed workers had chest x-rays) (Stokinger 1982). Electrocardiograms were abnormal in 9.4% of the exposed workers, compared with 8.5% of unexposed controls, and the incidence of fatigue was increased in workers exposed to >0.5 ppm. There were small correlations between exposure to chlorine and anxiety and dizziness ($p = 0.02$), leukocytosis ($p < 0.05$) and decreased hematocrit ($p < 0.017$). A smaller study included 52 workers exposed to about 0.289 ppm chlorine for 10 years (Stokinger 1982). These workers exhibited a slightly significant, lower value for a single pulmonary function test.

2. Animals - Groups of 70 F344/N male and female rats were given drinking water containing up to 275 ppm of chlorine (14.4 mg/kg/day) for 2 years. No hematologic abnormalities were detected at interim sacrifices (14 and 66 weeks) and no non neoplastic abnormalities were observed in extensive gross and microscopic examinations at the end of the study (NTP 1992). The EPA used the no-observed-adverse-effect level, 14.4 mg/kg/day, to calculate a chronic oral RfD of 0.1 mg/kg/day for chlorine (U.S. EPA 1994).

Sprague-Dawley rats, given 5, 15, or 30 ppm chlorine in drinking water from weaning to 12 weeks of age exhibited significantly reduced spleen weights, suppressed delayed-type hypersensitivity reactions, and decreased oxidative metabolism by macrophages at the highest dose; no effects were noted for the other doses or on other parameters of immunotoxicity (NTP 1992). F344 rats given doses of chlorine up to 60 mg/kg/day for 92 days exhibited no histopathology in major organs (U.S. EPA 1989). Other species, exposed subchronically to chlorine exhibited the following: mice had no adverse effects on weight gain, food or water consumption, histological parameters (12.5 mg/kg/day for 50 days or 25 mg/kg/day for 33 days) (U.S. EPA 1989); New Zealand rabbits had increased hydroxyproline levels in heart tissue (1.6 mg chlorine/kg/day for 3 months; no effect at 0.1 mg/kg/day) (U.S. EPA 1989); Carneau pigeons exhibited cardiovascular effects (10 mg/kg/day in drinking water for 9 months) (U.S. EPA 1989).

In various studies, Sprague Dawley and F344 rats treated with chlorine orally for 12-24 months at doses ranging from 0.14 to 22 mg/kg/day exhibited one or more of the following symptoms: significant decreases in red blood cell count and hematocrit (reversed at 6 months), increased osmotic fragility, increased mean corpuscular hemoglobin, significant decreases in body and liver weights, decreased brain and heart weights ($p < 0.05$), and decreased salivary gland and kidney weights (U.S. EPA 1989), decreased spleen weight, and decreased thyroid weight (U.S. EPA 1987).

Rhesus monkeys (4/sex/dose) exposed to 62.3 ppm of chlorine 6 h/day, 5 days/week for 1 year experienced ocular irritation, conjunctival irritation, hyperplasia of the nasal mucosa, and,

chlorine/

in some females, epithelial hyperplasia of the trachea with minimal evidence of early nonkeratinizing squamous metaplasia (U.S. EPA 1990).

D. Carcinogenicity

No conclusion on the carcinogenicity of chlorine can be made based on the limited information available from human and animal studies.

1. Humans - NTP (1992) notes that some epidemiologic studies have shown an association between the consumption of chlorinated drinking water and an increased risk for the development of cancer, primarily of the urinary tract. EPA has established drinking water standards for several chlorinated by-products found in chlorinated drinking water.
2. Animals - F344/N male and female rats and B6C3F1 male and female mice (50/sex/group) received 0, 70, 140, or 275 ppm chlorine (based on atomic chlorine) in their drinking water for 2 years. (NTP 1992). The female rats had a slight increase in the incidence of mononuclear cell leukemia that was not clearly dose-related (control, 8/50; low-dose, 7/50; mid-dose, 19/51; high-dose, 16/50), but was considered by the NTP to be "equivocal evidence of carcinogenic activity". There was "no evidence of carcinogenic activity" in male rats or male and female mice at the doses tested.

In another study, chlorine administered as NaOCl to rats in drinking water at levels up to 1000 mg/L for males and 200 mg/L for females was not carcinogenic (NTP 1992). Information on the cocarcinogenicity of sodium hypochlorite are conflicting. When applied to the skin of mice, sodium hypochlorite enhanced tumor development initiated by 4-nitroquinoline-1-oxide and reduced tumor development initiated by benzo[a]pyrene (U.S. EPA 1989).

E. Genotoxicity

Chlorine was mutagenic in *Salmonella typhimurium* strains TA1530 and TA100, without metabolic activation; produced chromosome aberrations in human lymphocytes and other mammalian cells (0.20 ppm); interacted with DNA in *E. coli* polA test (as sodium hypochlorite); and was negative for the induction of erythrocyte micronuclei or chromosome aberrations of bone marrow cells of Swiss CD-1 mice (up to 8 mg/kg/day of NaOCl) for up to 5 days (U.S. EPA 1989).

F. Developmental/Reproductive Toxicity

No conclusion on the developmental/reproductive toxicity of chlorine can be made based on the limited information available from human and animal studies.

1. Humans - No information was found in the secondary sources searched to indicate that chlorine is a developmental/reproductive toxicant in humans.
2. Animals - Female Sprague-Dawley rats were given chlorine concentrations of 0, 1.0, 10, or 100 mg/L in the drinking water (as HOCl) for 2.5 months prior to conception and throughout gestation, were killed on gestation day 20, and the fetuses were examined (NTP 1992). Resorptions were not increased

at any concentration; however, fetuses in the 100 mg/L group had soft tissue defects, including improper orientation of the heart and adrenal agenesis, and a slightly increased incidence of skeletal variants, such as incompletely ossified or missing sternebrae or rudimentary ribs. Statistical analyses were not available. In other studies, chlorine administered to pregnant mice was negative for reproductive and teratogenic effects when given in drinking water as 10-13 ppm of sodium hypochlorite and hydrochloric acid (to maintain water pH of 2.5) or when given in heavily chlorinated municipal drinking water (U.S. EPA 1989).

Sperm head abnormalities were observed in B6C3F1 mice given 1.6 and 4.0 mg/kg/day of chlorine as OCl^- , but not at 8.0 mg/kg or when given as $HOCl$ (U.S. EPA 1994). BDII rats (236 total males and females) given 10 mg/kg/day of free residual chlorine in the drinking water throughout 7 generations had no adverse effects on weight gain, food consumption, water consumption, fertility, lifespan, growth pattern, hematology, histology (liver, spleen, kidney or other organs) (U.S. EPA 1989).

G. Neurotoxicity

No information was found in the secondary sources searched regarding the neurotoxicity of chlorine.

V. ENVIRONMENTAL EFFECTS

A. Toxicity to Aquatic Organisms

Chlorine has high acute toxicity to aquatic organisms; many toxicity values are less than or equal to 1 mg/L. Twenty-four-hour LC_{50} values range from 0.076 to 0.16 mg/L for *Daphnia magna* (water flea) and from 0.005 to 0.1 mg/L for *Daphnia pulex* (cladocern) (AQUIRE 1994); 48-hour LC_{50} values range from 5.3 to 12.8 mg/L for *Nitocra spinipes* (snail); and 96-hour LC_{50} values range from 0.13 to 0.29 mg/L for *Oncorhynchus mykiss* (rainbow trout), from 0.1 to 0.18 mg/L for *Salvelinus fontinalis* (brook trout), and from 0.71-0.82 mg/L for *Lepomis cyanellus* (green sunfish) (AQUIRE 1994). Papillomas of the oral cavity in fish have been associated with exposure to chlorinated water supplies (NTP 1992).

Low level chlorination (0.05 to 0.15 mg/L) results in significant shifts in the species composition of marine phytoplankton communities (HSDB 1994).

B. Toxicity to Terrestrial Organisms

Chlorine is phytotoxic but is also essential to plant growth; crops need around 5 pounds or more of chlorine per acre. Acute toxicity to plants is characterized by defoliation with no leaf symptoms and, in higher plant forms, by spotting of the leaves (at 1.5 mg/m³) and marginal and interveinal injury (at 150-300 mg/m³) (Seiler et al. 1988). No data were found in the secondary sources searched regarding the toxicity of chlorine to terrestrial animals; however, the data from experimental studies indicate that injury to animals would occur only in the presence of high concentrations of chlorine, either in drinking water or the ambient atmosphere.

C. Abiotic Effects

Information regarding the abiotic effects of chlorine was not found in the secondary sources searched.

VI. EPA/OTHER FEDERAL/OTHER GROUP ACTIVITY

The Clean Air Act Amendments of 1990 list chlorine as a hazardous air pollutant. Occupational exposure to chlorine is regulated by the Occupational Safety and Health Administration. The permissible exposure limit (PEL) is 1 part per million parts of air (ppm) or 3 mg/m³ as a ceiling value (i.e., exposures may not exceed these levels) (29 CFR 1910.1000).

Federal agency and other group activities for chlorine are summarized in Tables 4 and 5.

TABLE 4. EPA OFFICES AND CONTACT NUMBERS FOR INFORMATION ON CHLORINE

EPA OFFICE	LAW	PHONE NUMBER
Pollution Prevention & Toxics	Toxic Substances Control Act (Sec. 8A/8D/8E)	(202) 554-1404
	Emergency Planning and Community Right-to-Know Act (EPCRA)	
	Regulations (Sec. 313)	(800) 535-0202
	Toxics Release Inventory data	(202) 260-1531
Air	Clean Air Act	(919) 541-0888
Solid Waste & Emergency Response	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)/	
	Resource Conservation and Recovery Act / EPCRA (Sec. 302/304/311/312)	(800) 535-0202
Water	Clean Water Act	(202) 260-7588

TABLE 5. OTHER FEDERAL OFFICE/OTHER GROUP
CONTACT NUMBERS FOR INFORMATION ON CHLORINE

Other Agency/Department/Group	Contact Number
Agency of Toxic Substances & Disease Registry	(404) 639-6000
American Conference of Governmental Industrial Hygienists (Recommended Exposure Limit (see end note 5): 0.5 ppm) (Recommended Short Term Exposure Limit (see end note 6): 1 ppm)	(513) 742-2020
Consumer Product Safety Commission	(301) 504-0994
Food & Drug Administration	(301) 443-3170
National Institute for Environmental Health Sciences (EnviroHealth Clearinghouse)	(800) 643-4794
National Institute for Occupational Safety & Health Recommended Exposure Limit (see end note 6): 0.5 ppm)	(800) 356-4674
Occupational Safety & Health Administration (Permissible Exposure Limit (see end note 7): 1 ppm) (Check local phone book for phone number under Department of Labor)	

VII. END NOTES

1. Standard Industrial Classification code is the statistical classification standard for all Federal economic statistics. The code provides a convenient way to reference economic data on industries of interest to the researcher. SIC codes presented here are not intended to be an exhaustive listing; rather, the codes listed should provide an indication of where a chemical may be most likely to be found in commerce.

2. The RD50 concentration is that concentration that reduces respiratory rate by 50%.

3. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during the time period of concern.

4. Calculated using the factor 2.9 mg/m³ (U.S. EPA 1989) to convert 1 ppm to 2.9 mg/m³ which is multiplied by 0.143 (the occupational standard 8-hour breathing rate, 10 m³, divided by the assumed adult body weight, 70 kg, and assuming 100% absorption) to obtain the dose in mg/kg/day (U.S. EPA 1988).

5. The ACGIH exposure limit is a time-weighted average (TWA) concentration for an 8-hour workday for a 40-hour workweek.

6. This is a 15-minute short term exposure limit value that should not be exceeded at any time.

7. This is a 15-minute ceiling exposure limit value that should not be exceeded at any time.

VIII. CITED REFERENCES

AQUIRE. 1994. EPA ERL-Duluth's Aquatic Ecotoxicology Data Systems. U.S. EPA, Duluth, MN. Retrieved July 1994.

Budavari S, O'Neil MJ, Smith A, Heckelman PE (Eds.). 1989. The Merck Index, 11th ed. Merck & Co., Inc., Rahway, NJ, p. 954.

CHEMFATE. 1994. Syracuse Research Corporation's Environmental Fate Data Bases. Syracuse Research Corporation, Syracuse, NY.

HSDB. 1994. Hazardous Substances Data Bank. MEDLARS Online Information Retrieval System, National Library of Medicine. Retrieved June, 1994.

NTP. 1992. National Toxicology Program. Toxicology and Carcinogenesis Studies of Chlorinated Water (CAS NOS. 7782-50-5 and 7681-52-9) and Chloraminated Water (CAS No. 10599-90-3) (Deionized and Charcoal-Filtered) in F344/N Rats and B6C3F1 Mice (Drinking Water Studies). U.S. Dept. of Health and Human Services, National Institutes of Health, Research Triangle Park, NC. NTP TR 392.

Seiler HG, Sigel H, Sigel A. 1988. Handbook on Toxicity of Inorganic Compounds. Marcel Dekker, Inc., New York, pp. 223-237.

Stokinger HE. 1981. The halogens and the nonmetals boron and silicon. In: Clayton GD, Clayton FE, Eds. Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. 2B. New York: John Wiley & Sons, pp. 2954-2965.

TRI92. 1994. Toxic Chemical Release Inventory. National Library of Medicine, National Toxicology Program, Bethesda, MD.

U.S. EPA. 1985. U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Chlorine - 1984. Office of Water, Criteria and Standards Division, Washington, D.C. EPA 440/5-84-030.

U.S. EPA. 1987. U.S. Environmental Protection Agency. Reportable Quantity Document for Chlorine. First Draft. Office of Solid Waste and Emergency Response, U.S. EPA, Cincinnati, OH. ECAO-CIN-R387.

U.S. EPA. 1988. U.S. Environmental Protection Agency. Methodology for Evaluating Potential Carcinogenicity in Support of Reportable Quantity Adjustments Pursuant to CERCLA Section 102. Carcinogen Assessment Group, Office of Health and Environmental Assessment, U.S. EPA, Washington, D.C., pp. 21, 22. OHEA-C-073.

U.S. EPA. 1989. U.S. Environmental Protection Agency. Drinking Water Criteria Document for Chlorine, Hypochlorous Acid and Hypochlorite Ion. Prepared for the Office of Drinking Water. Prepared by Environmental Criteria and Assessment Office, U.S. EPA, Cincinnati, OH.

U.S. EPA. 1990. U.S. Environmental Protection Agency. Reportable Quantity Document for Chlorine, Draft. Prepared by Chemical Hazard Evaluation and Communication Group, Oak Ridge National Laboratory. Environmental Criteria and Assessment Office, U.S. EPA, Cincinnati, OH.

U.S. EPA. 1994. U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) Online. Coversheet for Chlorine. Office of Health and Environmental Assessment, U.S. EPA, Cincinnati, OH. Retrieved 7/94.

APPENDIX A. SOURCES SEARCHED FOR FACT SHEET PREPARATION

AQUIRE. 1994. Aquatic Information Retrieval online data base. Chemical Information Systems, Inc., a subsidiary of Fein-Marquart Assoc.

ATSDR. 1989-1994. Agency for Toxic Substances and Disease Registry. Toxicological Profiles. Chamblee, GA: ATSDR.

Budavari S, O'Neil MJ, Smith A, Heckelman PE (Eds.). 1989. The Merck Index, 11th ed. Rahway, N.J.: Merck & Co., Inc.

CHEMFATE. 1994. Syracuse Research Corporation's Environmental Fate Data Bases. Syracuse Research Corporation, Syracuse, NY.

Clayton GD, Clayton FE, Eds. 1981-1982. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley & Sons.

GENETOX. 1994. U.S. EPA GENETOX Program, computerized database.

HSDB. 1994. Hazardous Substances Data Bank. MEDLARS Online Information Retrieval System, National Library of Medicine.

IARC. 1979-1994. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man. Lyon: IARC.

NIOSH (National Institute for Occupational Safety and Health). 1992. NIOSH Recommendations for Occupational Safety and Health. Compendium of Policy Documents and Statements. Cincinnati, OH: NIOSH.

NTP. 1994. National Toxicology Program. Toxicology and Carcinogenesis

Studies. Tech Rep Ser.

NTP. 1994. National Toxicology Program. Management Status Report. Produced from NTP Chemtrack system. April 8, 1994. National Toxicology Program, Research Triangle Park, NC. OSHA. 1994. Occupational Safety and Health Administration. Table Z-2. Limits for Air Contaminants.

RTECS. 1994. Registry of Toxic Effects of Chemical Substances. MEDLARS Online Information Retrieval System, National Library of Medicine.

U.S. Air Force. 1989. The Installation Restoration Toxicology Guide, Vols. 1-5. Wright-Patterson Air Force Base, OH.

U.S. EPA (U.S. Environmental Protection Agency). 1991. Table 302.4 List of Hazardous Substances and Reportable Quantities 40 CFR, part 302.4:3-271.

U.S. EPA. Most current. Drinking Water Regulations and Health Advisories.

Office of Drinking Water, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. Most Current. Health Effects Assessment Summary Tables. Cincinnati, OH: Environmental Criteria and Assessment Office, U.S.EPA.

U.S. EPA reviews such as Health and Environmental Effects Documents, Health and Environmental Effect Profiles, and Health and Environmental Assessments.

U.S. EPA. 1994. Integrated Risk Information System (IRIS) Online. Cincinnati, OH: Office of Health and Environmental Assessment.

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* M S D S *
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* Canadian Centre for Occupational Health and Safety *
* * * * * Issue : 97-4 (November, 1997) *

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 1467163
PRODUCT NAME(S) : CHLORINE, GASEOUS H.P.
PRODUCT IDENTIFICATION : PRODUCT CODE: 16276
DATE OF MSDS : 1995-02-20

*** MANUFACTURER INFORMATION ***

MANUFACTURER : DOW CHEMICAL CANADA INC
ADDRESS : Post Office Box 1012
Sarnia Ontario
Canada N7T 7K7
Telephone: 519-339-5083
EMERGENCY TELEPHONE NO. : 403-998-8282 (Fort Saskatchewan, Alberta)
519-339-3711 (Sarnia, Ontario)
514-652-1000 (Varennnes, Quebec)

MANUFACTURER NOTE :
For French translation of this data sheet, please contact Dow Chemical Canada
Inc directly.

*** MATERIAL SAFETY DATA ***

M A T E R I A L S A F E T Y D A T A S H E E T

Dow Chemical Canada Inc. Sarnia, Ont. N7T 7K7 Phone: 519-339-3711
Product Code: 16276 Page: 1
Product Name:
CHLORINE, GASEOUS H.P.

Effective Date: 02/20/95 Date Printed: 08/08/97 MSDS:001122

1. INGREDIENTS: (% w/w, unless otherwise noted)

Chlorine CAS# 007782-50-5 99.8%

This document is prepared pursuant to the OSHA Hazard
Communication Standard (29 CFR 1910.1200). In addition, other
substances not 'Hazardous' per this OSHA Standard may be
listed. Where proprietary ingredient shows, the identity
may be made available as provided in this standard.

2. PHYSICAL DATA:

BOILING POINT: -29.3F (-34C)
VAP. PRESS: 82 psig @ 68F, 20C
VAP. DENSITY: 2.49 @ 32F, 0C
SOL. IN WATER: 0.73g/100g H2O @ 20C
SP. GRAVITY: 1.47 @ 32F, 0C; 53.2 psia
APPEARANCE: Amber color; liquified gas under pressure;
vaporizes to greenish - yellow gas.
ODOR: Pungent odor.

3. FIRE AND EXPLOSION HAZARD DATA:

FLASH POINT: None
METHOD USED: Not applicable

FLAMMABLE LIMITS

LFL: Not applicable

UFL: Not applicable

EXTINGUISHING MEDIA: Chlorine will react or cause reducing materials to burn without oxygen. Water is effective only as a cooling media to reduce the reaction rate, however, water should not be applied directly to the chlorine leak. Where

(CONTINUED ON PAGE 2)

(R) Indicates a trademark of The Dow Chemical Company

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3. FIRE AND EXPLOSION HAZARD DATA: (CONTINUED)

practical attempts should be made to reduce the available reactants through the isolation of the reaction from the chemical supply. This should be attempted only by properly trained personnel using prescribed protective equipment.

FIRE & EXPLOSION HAZARDS: May react to cause fire and/or explosion upon contact with many organic compounds, ammonia, hydrogen, or many metals, and with all metals, including steel, at elevated temperatures.

FIRE-FIGHTING EQUIPMENT: A positive pressure self-contained breathing apparatus for respiratory protection and protective clothing.

4. REACTIVITY DATA:

STABILITY: (CONDITIONS TO AVOID) Avoid proximity to flammable materials including chemicals.

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Many organic compounds, ammonia, hydrogen, moist or hot steel, and many metals. May react explosively with some organics under confinement.

HAZARDOUS DECOMPOSITION PRODUCTS: None.

HAZARDOUS POLYMERIZATION: Will not occur.

5. ENVIRONMENTAL AND DISPOSAL INFORMATION:

ACTION TO TAKE FOR SPILLS/LEAKS: Move unprotected personnel cross-wind to a clear area. Do not use water directly on a chlorine leak. A fog nozzle may be used to absorb gas. The leak should be isolated or controlled by trained personnel using prescribed protective equipment.

DISPOSAL METHOD: Prior to disposal, the active chlorine must be

(CONTINUED ON PAGE 3)

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Product Name:
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5. ENVIRONMENTAL AND DISPOSAL INFORMATION: (CONTINUED)

reduced or destroyed. Chlorine may be absorbed in dilute solutions of caustic (NaOH), soda ash (Na₂CO₃), or hydrated lime (Ca(OH)₂). For each 1 pound of chlorine, use approximately 3 pounds per gallon caustic or soda ash or 1 pound per gallon lime. Local, municipal or state authorities should be contacted for disposal of resultant product.

6. HEALTH HAZARD DATA:

EYE: May cause severe irritation with corneal injury which may result in permanent impairment of vision, even blindness.

SKIN CONTACT: Short single exposure may cause severe skin burns.

SKIN ABSORPTION: The dermal LD50 has not been determined.

INGESTION: Ingestion is unlikely due to physical state.

INHALATION: A single brief (minutes) inhalation exposure to easily attainable concentrations may cause serious adverse effects, even death. Excessive exposure may cause severe irritation to upper respiratory tract and lungs and may cause lung injury. The LC50 for mice was 137 ppm and for rats 293 ppm for 1 hour.

SYSTEMIC & OTHER EFFECTS: Excessive exposure may cause liver, lung and kidney effects. Excessive exposure may cause severe irritation to upper respiratory tract and lungs. Excessive exposure may cause lung injury. Excessive exposure to chlorine gas has been known to also cause erosion of tooth enamel.

CANCER INFORMATION: Did not cause cancer in long-term animal studies.

TERATOLOGY (BIRTH DEFECTS): Limited data suggests that chlorine is not teratogenic but may be slightly embryotoxic when administered at high doses in drinking water to pregnant rats.

(CONTINUED ON PAGE 4)

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6. HEALTH HAZARD DATA: (CONTINUED)

REPRODUCTIVE EFFECTS: In animal studies, has been shown not to interfere with reproduction.

MUTAGENICITY (EFFECTS ON GENETIC MATERIAL): Has been shown to have mutagenic activity in bacteria. Results of mutagenicity tests in animals have been negative.

7. FIRST AID:

EYES: Immediate and continuous irrigation with flowing water for at least 30 minutes is imperative. Prompt medical consultation is essential.

SKIN: Wash off in flowing water or shower.

INGESTION: No adverse effects anticipated by this route of exposure.

INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility.

NOTE TO PHYSICIAN: Excellent warning properties force rapid escape from chlorine gas; thus most inhalations are mild to moderate. If escape is not possible, exposure to high concentrations for a very short time can result in dyspnea, hemoptysis and cyanosis with later complications being tracheobronchopneumonitis and pulmonary edema. Oxygen, intermittent positive pressure breathing and aerosolized bronchodilators are of therapeutic value in the light to moderate inhalation. A severe inhalation should be hospitalized and treated as a respiratory emergency. Any chlorine inhalation in an individual with compromised pulmonary function (COPD) should be regarded as a severe inhalation and a respiratory emergency. If a burn is present, treat as any thermal burn, after decontamination.

(CONTINUED ON PAGE 5)

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Dow Chemical Canada Inc. Sarnia, Ont. N7T 7K7 Phone: 519-339-3711

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Product Name:

CHLORINE, GASEOUS H.P.

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8. HANDLING PRECAUTIONS:

EXPOSURE GUIDELINE(S): Chlorine: ACGIH TLV and OSHA PEL are 0.5 ppm TWA, 1 ppm STEL.

VENTILATION: Control airborne concentrations below the exposure guideline. Use only with adequate ventilation. Local exhaust ventilation may be necessary for some operations. Lethal concentrations may exist in areas with poor ventilation.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. When respiratory protection is required for certain operations, use an approved air-purifying respirator.

SKIN PROTECTION: Use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron, or full-body suit will depend on operation. Safety shower should be located in immediate work area. Remove contaminated clothing immediately and launder before reuse.

EYE PROTECTION: Use chemical goggles. If vapor exposure causes eye discomfort, use a full-face respirator. Eye wash fountain

should be located in immediate work area.

9. ADDITIONAL INFORMATION:

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: No attempt should be made to handle or store chlorine without a complete review of the Chlorine Manual, available from the Chlorine Institute, Inc., 2001 L Street N.W., Washington, DC 20036.

MSDS STATUS: Revised Canadian regulatory information.

For information regarding state/provincial and federal regulations see the Regulatory Information Section.

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Dow Chemical Canada Inc. Sarnia, Ont. N7T 7K7 Phone: 519-339-3711

Product Code: 16276

PAGE: R-1

Product Name:

CHLORINE, GASEOUS H.P.

Effective Date: 02/20/95 Date Printed: 08/08/97

MSDS:001122

REGULATORY INFORMATION: (Not Meant to be all-inclusive--selected regulations represented.)

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations. See MSD Sheet for health and safety information.

CANADIAN REGULATIONS

WHMIS INFORMATION: The Canadian Workplace Hazardous Materials Information System (WHMIS) Classification for this product is:

A
C
D1A
E

U.S. REGULATIONS

SARA 313 INFORMATION: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

CHEMICAL NAME	CAS NUMBER	CONCENTRATION
CHLORINE	007782-50-5	100

(CONTINUED ON PAGE R-2)

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Dow Chemical Canada Inc. Sarnia, Ont. N7T 7K7 Phone: 519-339-3711
Product Code: 16276 PAGE: R-2
Product Name:
CHLORINE, GASEOUS H.P.

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REGULATORY INFORMATION: (CONTINUED)

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard
A delayed health hazard
A sudden release of pressure hazard
A reactive hazard

U.S. DEPARTMENT OF TRANSPORTATION (D.O.T.):

Other container sizes may be regulated differently. Consult D.O.T. regulations.

Bulk: Chlorine/2.3(Poison gas)/ UN 1017/ RQ (chlorine)

OSHA HAZARD COMMUNICATION STANDARD:

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

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The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made. Consult The Dow Chemical Company For Further Information.

* An Operating Unit Of The Dow Chemical Company



CHLORINE

7783-80-5

Hazard Summary

- Acute (short-term) exposure to high levels (>30 ppm) of chlorine in humans results in chest pain, vomiting, toxic pneumonitis, pulmonary edema, and death. At lower levels, (<3 ppm), chlorine is a potent irritant to the eyes, the upper respiratory tract, and lungs.
- Limited information is available on the chronic effects of chlorine in humans. Reports from the older literature stated that chronic exposure to concentrations of chlorine of around 5 ppm caused respiratory complaints, corrosion of the teeth, inflammation of the mucous membranes of the nose, and increased susceptibility to tuberculosis.
- The Reference Concentration (RfC) and the Reference Dose (RfD) for chlorine are under review by the U.S. Environmental Protection Agency (EPA).
- No information is available on the developmental or reproductive effects of chlorine in humans or animals via inhalation exposure. A study reported no adverse effects on growth, lifespan, or fertility in rats exposed to 100 ppm chlorine in their drinking water for their entire lifespan, over seven generations.
- No information is available on the carcinogenic effects of chlorine in humans from inhalation exposure, and chlorine has not been found to be carcinogenic in oral animal studies. EPA has not classified chlorine for carcinogenicity.

Please Note: The main source of information for this fact sheet is EPA's Drinking Water Chlorine Document for Chlorine, Hypochlorous Acid and Hypochlorite Ion. Other secondary sources include the Hazardous Substances Data Bank (HSDB), a database of toxic effects that are not peer reviewed, and the Registry of Toxic Effects of Chemical Substances (RTECS), a database of toxic effects that are not peer reviewed.

Environmental/Occupational Exposure

- Workers may be exposed to chlorine in industries where it is produced or used, particularly in the food and paper industries. In addition, persons breathing air around these industries may be exposed to chlorine. (1)
- Exposure to chlorine may also occur through drinking water and swimming pool water, where it is used as a disinfectant. (2)
- Accidental releases are another potential source of chlorine exposure. (3)

Assessing Personal Exposure

- No data were located regarding detection of personal exposure to chlorine.

Health Hazard Information

Acute Effects:

- Chlorine is a potent irritant to humans to the eyes, the upper respiratory tract, and the lungs. Several studies have reported the following effects: 0.014 to 0.054 ppm: itching of the nose; 0.04 to 0.097 ppm: itching of the throat; 0.06 to 0.3 ppm: itching of the nose and cough, sneezing, or dryness of the nose and throat; 0.35 to 0.72 ppm: burning of the conjunctiva and pain after 15 minutes; above 1.0 ppm: discomfort ranging from ocular and respiratory irritation to coughing, shortness of breath, and headaches. (4)
- Higher levels of chlorine have resulted in the following effects in humans: 1 to 3 ppm: mild mucous membrane irritation; 30 ppm: chest pain, vomiting, dyspnea, cough; 46 to 60 ppm: toxic pneumonitis and pulmonary edema; 430 ppm: lethal after 30 minutes; 1,000 ppm: fatal within a few minutes. (3)
- Chlorine is extremely irritating to the skin and can cause severe burns. (5)

- Acute animal tests, such as the LC₅₀ test in rats and mice, have shown chlorine to have high acute toxicity. (6)
- EPA's Office of Air Quality Planning and Standards, for a hazard ranking under Section 112(g) of the Clean Air Act Amendments, considers chlorine to be a "high concern" pollutant based on severe acute toxicity. (6)

Chronic Effects (Noncancer):

- Several studies in the older literature reported that chronic exposure to chlorine concentrations of around 5 ppm caused respiratory complaints, corrosion of the teeth, inflammation of the mucous membranes of the nose, and increased susceptibility to tuberculosis in workers. (7)
- Animal studies have reported decreased body weight gain, eye and nose irritation, and effects on the respiratory tract, liver, and kidney from chronic inhalation exposure to chlorine. (4)
- Other studies have indicated that exposure to chlorine, via inhalation, may alter disease resistance in animals, with higher incidences of emphysema, pneumonia, and tuberculosis reported. (4)
- The RfC and the RfD for chlorine are under review by EPA. (8)

Reproductive/Developmental Effects:

- No information is available on the developmental or reproductive effects of chlorine in humans or animals via inhalation exposure.
- No adverse effects on growth, lifespan, or fertility were reported in rats exposed to 100 ppm chlorine in their drinking water for their entire lifespan, over seven generations. (4)
- Since chlorine is highly reactive, spikes at sites such as the ovaries and testes which are remote from the respiratory tract, is anticipated to be minimal. (2)

Cancer Risk:

- No information is available on the carcinogenic effects of chlorine in humans from inhalation exposure.
- Several human studies have investigated the relationship between exposure to chlorinated drinking water and cancer. These studies were not designed to assess whether chlorine itself causes cancer, but whether chlorinated water and other organic compounds occurring in drinking water as a result of chlorination are associated with an increased risk of cancer. These studies show an association between bladder and rectal cancer and chlorination byproducts in drinking water. (5)
- Chlorine has not been found to be carcinogenic in animals; no tumors were noted in a study where rats were exposed to 100 ppm chlorine in their drinking water over their lifespan, for 7 generations (see Reproductive/Developmental Effects section). (4)
- Another study evaluated the potential carcinogenicity of chlorinated drinking water in rats and mice and found no statistically significant increase in tumors that could be related to the chlorinated water. (2)
- EPA has not classified chlorine for carcinogenicity. (8)

Physical Properties

- Chlorine is a greenish-yellow gas that is slightly soluble in water. (7)
- Chlorine has a suffocating odor; the odor threshold is 0.31 ppm. (9)
- The chemical formula for chlorine is Cl₂, and its molecular weight is 70.90 g/mol. (4)

Uses

- Chlorine is used for water disinfection and for treatment of sewage effluent. It is also used to disinfect equipment and utensils in beverage and food processing plants, and as an intermediate in the manufacture of a number of organic products such as antifreeze, rubber, cleaning agents, and pharmaceuticals. (2,4)

Conversion Factors:

To convert from ppm to mg/m³: $\text{mg/m}^3 = (\text{ppm}) \times (\text{molecular weight of the compound}) / (24.45)$. For chlorine: 1 ppm = 2.9 mg/m³. Health Data from Inhalation Exposure

CHLORINE

7782-50-5

Hazard Summary

- Acute (short-term) exposure to high levels (>30 ppm) of chlorine in humans results in **chest pain, vomiting, toxic pneumonitis, pulmonary edema, and death**. At lower level, (<3 ppm), chlorine is a **potent irritant to the eyes, the upper respiratory tract, and lungs**.
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- No information is available on the developmental or reproductive effects of chlorine in humans or animals via inhalation exposure.
- No adverse effects on growth, lifespan, or fertility were reported in rats exposed to 100 ppm chlorine in their drinking water for their entire lifespan, over seven generations. (4)
- Since chlorine is highly reactive, uptake at sites such as the ovaries and testes which are remote from the respiratory tract, is anticipated to be minimal. (2)

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- Several human studies have investigated the relationship between exposure to chlorinated drinking water and cancer. These studies were not designed to assess whether chlorine itself causes cancer, but whether trihalomethanes or other organic compounds occurring in drinking water as a result of chlorination are associated with an increased risk of cancer. These studies show an association between bladder and rectal cancer and chlorination byproducts in drinking water. (5)
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Conversion Factors:

To convert from ppm to mg/m^3 : $mg/m^3 = (ppm) \times (molecular\ weight\ of\ the\ compound) / (24.45)$. For chlorine: 1 ppm = 2.9 mg/m^3 . Health Data from Inhalation Exposure

Concentration (mg/m ³)	Health numbers ^a	Regulatory, advisory numbers ^b	Reference
1,000,000.0			

100,000.0			

10,000.0			

1,000.0			
---	• LC ₅₀ (rats) (849 mg/m ³)		5
---	• LC ₅₀ (mice) (397 mg/m ³)		5
100.0			

10.0			

---		• OSHA PEL and ACGIH TLV (3 mg/m ³)	4
1.0		• OSHA PEL, ACGIH TLV, and NIOSH REL (1.5 mg/m ³)	4

ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.

LC₅₀ (Lethal Concentration₅₀)--A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

NIOSH REL--National Institute of Occupational Safety and Health's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.

OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects averaged over a normal 8-h workday or a 40-h workweek.

^a Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.

^b Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice.

References

1. U.S. Environmental Protection Agency. *Drinking Water Criteria Document for Chlorine, Hypochlorous Acid and Hypochlorite Ion*. (External Review Draft.) Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Cincinnati, OH. 1992.
2. U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS) on Chlorine*. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1993.
3. U.S. Department of Health and Human Services. Hazardous Substances Data Bank (HSDB, online database). National

Toxicology Information Program, National Library of Medicine, Bethesda, MD. 1993.

4. E.J. Calabrese and E.M. Kenyon. *Air Toxics and Risk Assessment*. Lewis Publishers, Chelsea, MI. 1991.
5. R.D. Morris, A. Audet, I.F. Angelillo, T. C. Chalmers, and F. Mosteller. Chlorination, Chlorination by-products, and cancer: A meta-analysis. *American Journal of Public Health*, 82(7):955-977. 1992.
6. U.S. Environmental Protection Agency. *Ambient Water Quality Criteria for Chlorine*. EPA 440/5-84-030. Office of Water Regulations and Standards, Washington, DC. 1985.
7. American Council of Government of Industrial Hygienists (ACGIH). *Documentation of the Threshold Limit Values*. Fourth Edition. Cincinnati, OH. 1986.
8. U.S. Department of Health and Human Services. Registry of Toxic Effects of Chemical Substances (RTECS, online database). National Toxicology Information Program, National Library of Medicine, Bethesda, MD. 1993.
9. J.E. Amoore and E. Hautala. Odor as an aid to chemical safety: Odor thresholds compared with threshold limit values and volatilities for 214 industrial chemicals in air and water dilution. *Journal of Applied Toxicology*, 3(6):272-290. 1983.

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***Note:** Due to the high demand for Maps On Demand, the server may occasionally refuse a request. If you have not received a confirmation E-mail or if your request has not reached the pickup area within eight hours, please resubmit it.*

Query Mapper

The results of Envirofacts queries can be mapped using the [Query Mapper](#) application. This tool is valuable to users who are interested in mapping facility locations and viewing the surrounding demographics, Geographic Retrieval and Analysis System (GIRAS) landuse and landcover, as well as other features. Browse the [Query Mapper Product Pickup Area](#) to view a list of maps created with this application.

SiteInfo, ZipInfo, CountyInfo, and BasinInfo

The [SiteInfo](#) application creates informative maps and reports, which include EPA-regulated facility and demographic information. Additional mapping applications developed by [EPA Region 10](#) include [ZipInfo](#), [CountyInfo](#), and [BasinInfo](#). To view maps created by these applications, click on a specific date listed in the [EPA GIS National Product Pickup Area](#).

Facility Density Mapper

The Facility Density Mapper application allows users to map and assess the concentration of EPA-regulated facilities in a given area. Facilities are identified by a valid Facility Index System (FINDS) identification number assigned by EPA. This tool is valuable to users who are interested in targeting areas of high facility concentration. Maps created using Facility Density Mapper are located in the Product Pickup Area. *This application is best viewed using browsers that support frames and JavaScript.*

- [Model](#)
- [EPA's Spatial Data Library](#)
- [LDIP Home Page](#)
- [Envirofacts Home Page](#)

For comments, questions, or suggestions, please use the [MOD Feedback Form](#).

URL: <http://www.epa.gov/enviro/html/mod/index.html>
This page was updated February 25, 1998.

Environmental Health Center



Chlorine (Cl₂) Chemical Backgrounder

Description:

Chlorine is a greenish-yellow gas with a pungent, irritating odor. It is used to bleach fabrics, to purify water, to bleach woodpulp and paper, to disinfect, to clean dairy equipment, to control biofouling in cooling systems, to shrink-proof wool, and to detin and dezinc iron. It is used for sterilization for root canals, tooth extractions, irrigations, or wounds.

It is also used in the manufacturing of pesticides, antifreeze, refrigerants, antiknock compounds, plastics, and resins.

It is used in the manufacturing of synthetic rubber and plastics, chlorinated hydrocarbons, polyvinyl chloride, ethylene dichloride hypochlorous acid, chlorobenzene, chlorinated lime, carbon tetrachloride, ethylene and propylene oxides, glycols, trichloroethylene, perchloroethylene, chloroform, vinylidene chloride, polychloropropene, hydrogen chloride, metal chlorides, chloracetic acid, chloral, synthetic glycerine, methyl chlorides, chlorinated benzenes, tetraethyl lead, fluorine compounds, titanium tetrachloride, monochloroacetic acid, phosgene, chloroisocyanuric acid, phosphorus chloride dichlorobutene, and chlorinate paraffins.

Chemical properties:

Chlorine is corrosive to some forms of plastics, rubber, and coatings. It is soluble in chlorides, alkali, and alcohols. It combines readily with all elements except the rare gases, excluding xenon, and nitrogen. It reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen, and finely divided metals. It is a noncombustible gas, and a strong oxidizer.

Chlorine is heavier than air, and less water-soluble than ammonia. Water dissolves about twice its volume of chlorine gas, forming a mixture of hydrochloric and hypochlorous acids.

Synonyms for chlorine are chlorine gas, chlorine water, molecular chlorine, javelle water, and NaOCl.

Health effects:

Chlorine exposure occurs through inhalation, or skin or eye contact. Exposure can cause burning of eyes, nose, and mouth; lacrimation and rhinorrhea; coughing, sneezing, choking, and substernal pain; nausea and

vomiting; headaches and dizziness; syncope; fatal pulmonary edema; pneumonia; conjunctivitis; keratitis; pharyngitis; burning chest pain; dyspnea; hemoptysis; hypoxemia; dermatitis; and skin blisters.

When inhaled in high concentrations, chlorine causes emphysema and damage to the pulmonary blood vessels. Chronic exposure can cause corrosion of the teeth. Cardiac arrest may occur secondary to hypoxia.

Inhalation of small amounts of chlorine causes few or no symptoms. In larger amounts, it is a powerful irritant to the mucous membranes of the eyes, nose, and throat.

Exposures of 1-3 ppm can cause mild mucous membrane irritation; 5-15 ppm, moderate irritation of upper respiratory tract; 30 ppm, immediate chest pain, vomiting, dyspnea, and cough; 40-60 ppm, toxic pneumonitis and pulmonary edema; 430 ppm, lethal over 30 minutes; and 1,000 ppm, death within a few minutes. Death is possible from asphyxia, shock, reflex spasm in the larynx, or massive pulmonary edema.

Populations at special risk from chlorine exposure are individuals with pulmonary disease, breathing problems, bronchitis, or chronic lung conditions.

Economics:

The production volume of chlorine in 1995 was 25.09 billion pounds, which ranked tenth in the production volumes of the country's top 50 chemicals. Production volume in 1994 was 24.37 billion pounds, which ranked ninth that year.

U.S. manufacturers of chlorine are Amax Inc., Rowley, UT; Dow Chemical USA, Pittsburg, CA, and Plaquemine, LA; Akzo America, Inc., Le Moyne, AL; Bayer USA Inc., Baytown, TX; E.I. DuPont de Nemours & Co., Inc., Niagara Falls, NJ; Formosa Plastics Corp. USA, Baton Rouge, LA; Fort Howard Corp., Green Bay, WI, and Muskogee, OK; General Electric Co., Burkville, AL, and Mount Vernon, IN; Georgia Gulf Corp., Plaquemine, LA; Georgia-Pacific Corp., Bellingham, WA, and Brunswick, GA; B.F. Goodrich Co., Calvert City, KY; Hanlin Group, Inc., Acme, NC, Ashtabula, OH, Brunswick, GA, Moundsville, WV, Orrington, ME, and Syracuse, N.Y.;

La Roche Holdings, Inc., Gramery, LA; Niachlor, Inc., Niagara Falls, NY; Occidental Petroleum Corp., Covent, LA, Corpus Christi, TX, Deer Park, TX, Delaware City, DE, La Porte, TX, Mobile, AL, Muscle Shoals, AL, Niagara Falls, NY, Tacoma, WA, and Taft, LA; Olin Corp., Augusta, GA, Charleston, TN, McIntosh, AL, and Niagara Falls, NY; Oregon Metallurgical Corp., Albany, OR; Pennwalt Corp., Portland, OR, and Tacoma, WA; Pioneer Chlor Alkali Co., Henderson, NV, and St. Gabriel, LA; PPG Industries, Inc., Lake Charles, LA, and Natrium, WV; RMI Co., Ashtabula, OH; Titanium Metals Corp. of America, Henderson, NV; Trans Resources Inc., Vicksburg, MS; Vulcan Materials Co., Geismar, LA, Port Edwards, WI, and Wichita, KS; and Weyerhaeuser Co., Longview, WA.

Regulation:

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit, time-weighted average, for chlorine of .5ppm (1.5 mg/m³); short-term exposure limit is 1 ppm (3 mg/m³).

Chlorine is regulated under the Clean Water Act; Emergency Planning and Community Right-to-Know Act; Clean Air Act; Comprehensive Environmental Response, Compensation, and Liability Act; and Federal Insecticide, Fungicide, and Rodenticide Act.

Under the Emergency Planning and Community Right-to-Know Act, releases of more than one pound of

chlorine into the air, water, and land must be reported annually and entered into the Toxic Release Inventory (TRI). In 1994, 60,432,224 pounds of chlorine were released by 1,449 facilities. Of those releases, 60,357,013 pounds were released into the air, water, and land; those releases ranked 11th of the TRI's top 50 chemicals with the largest air, water, and land releases.

Releases of chlorine in 1994 represented a 20.6 percent decrease in releases from 1993's total of 76,154,785. That decrease was the third highest of the TRI's 343 chemicals and 22 chemical categories. Releases in 1994 also represented a decrease from 1992 (87,411,253 pounds), and 1988/baseline (141,426,877 pounds).

In 1994, 1,276,642 pounds of chlorine releases were fugitive or nonpoint air emissions; 58,502,168 pounds were stack or point air emissions; 516,005 pounds were surface water discharges; 74,311 pounds were released by underground injection; and 63,098 pounds were released to land.

In 1994, 2,833,114 pounds of chlorine were transferred to recycling; 4,310 pounds were transferred to energy recovery; 345,447 pounds were transferred to treatment; 883,757 pounds were transferred to publicly owned treatment works; 15,133 pounds were transferred to disposal; and 5,005 pounds were transferred off-site.

According to EPA waste management information, in 1994, 85,515,731 pounds of chlorine were recycled on-site; 2,832,062 pounds were recycled off-site; 1,303,170 pounds were used for energy recovery on-site; 4,809 pounds were used for energy recovery off-site; 216,618,766 pounds were treated on-site; 1,165,675 pounds were treated off-site; and 60,418,267 pounds were released or disposed of.

In 1994, the 10 states in which the largest amounts of chlorine were released were Utah (50,456,113 pounds); Illinois (3,660,302 pounds); Louisiana (1,365,169 pounds); New York (1,283,219 pounds); Arizona (1,081,489 pounds); Texas (959,472 pounds); Minnesota (691,525 pounds); North Carolina (555,676 pounds); Washington (415,575 pounds); and Alabama (394,409 pounds).

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Environmental Health Center

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It is also used in the manufacturing of pesticides, antifreeze, refrigerants, antiknock compounds, plastics, and resins.

It is used in the manufacturing of synthetic rubber and plastics, chlorinated hydrocarbons, polyvinyl chloride, ethylene dichloride hypochlorous acid, chlorobenzene, chlorinated lime, carbon tetrachloride, ethylene and propylene oxides, glycols, trichloroethylene, perchloroethylene, chloroform, vinylidene chloride, polychloroprene, hydrogen chloride, metal chlorides, chloracetic acid, chloral, synthetic glycerine, methyl chlorides, chlorinated benzenes, tetraethyl lead, fluorine compounds, titanium tetrachloride, monochloroacetic acid, phosgene, chloroisocyanuric acid, phosphorus chloride dichlorobutene, and chlorinate paraffins.

Chemical properties:

Chlorine is corrosive to some forms of plastics, rubber, and coatings. It is soluble in chlorides, alkali, and alcohols. It combines readily with all elements except the rare gases, excluding xenon, and nitrogen. It reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen, and finely divided metals. It is a noncombustible gas, and a strong oxidizer.

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La Roche Holdings, Inc., Gramery, LA; Niachlor, Inc., Niagara Falls, NY; Occidental Petroleum Corp., Covent, LA; Corpus Christi, TX; Deer Park, TX; Delaware City, DE; La Porte, TX; Mobile, AL; Muscle Shoals, AL; Niagara Falls, NY; Tacoma, WA, and Taft, LA; Olin Corp., Augusta, GA; Charleston, TN; McIntosh, AL, and Niagara Falls, NY; Oregon Metallurgical Corp., Albany, OR; Penawalt Corp., Portland, OR, and Tacoma, WA; Pioneer Chlor Alkali Co., Henderson, NV, and St. Gabriel, LA; PPG Industries, Inc., Lake Charles, LA, and Natrium, WV; RMI Co., Ashtabula, OH; Titanium Metals Corp. of America, Henderson, NV; Trans Resources Inc., Vicksburg, MS; Vulcan Materials Co., Geismar, LA; Port Edwards, WI, and Wichita, KS; and Weyerhaeuser Co., Longview, WA.

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Emergency Response Planning for Potential Accidental Liquid Chlorine Releases

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District**

May 1986

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Manuscript date: May 1986

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Emergency Response Planning For Potential Accidental Liquid Chlorine Releases

ABSTRACT

The Lawrence Livermore National Laboratory's Atmospheric Release Advisory Capability (ARAC) used computer models to evaluate the hazards associated with potential chlorine releases during the operation of a 13,000-gallon liquid chlorine storage facility at the Union Sanitary District Wastewater Treatment Plant in Union City, California. The FEM3 and SLAB atmospheric dispersion models predicted the following consequences of a spectrum of hypothetical accident release scenarios: (1) In the highly unlikely event of a catastrophic failure of a nearly full storage tank, concentrations of chlorine exceeding 25 ppm, a level of serious concern, are possible beyond 3000 m from the site of the spill. (2) In the somewhat more probable event that a tanker vehicle transporting liquid chlorine to the plant were to be involved in a serious collision leading to a major spill of 3200 gallons, concentrations exceeding 25 ppm are possible out to distances beyond 1700 m. (3) The more common failures involving small pipe leaks have the potential of producing concentrations exceeding 25 ppm as far as a few hundred meters from the site.

This study demonstrated the usefulness of these computer codes for developing emergency-response plans for toxic chemical facilities, including the selection of the lowest-risk transportation routes, the most effective evacuation plans, and the most cost-effective mitigation measures.

INTRODUCTION

The Atmospheric Release Advisory Capability (ARAC) at the Lawrence Livermore National Laboratory (LLNL) received a request from the Union City Fire Department (UCFD) in Union City, California, for an evaluation of the potential hazards associated with the installation and operation of a 13,000-gallon liquid chlorine storage facility at the Union Sanitary District Wastewater Treatment Plant. The facility is located in a flat area bordering the east side of the San Francisco Bay. The ARAC was developed at LLNL for the Department of Energy to provide support to federal, state, and local agencies in the area of emergency planning, response, and assessments for accidents associated with the nuclear

industry.¹ Although the ARAC has not been involved with emergency-response activities associated with heavy gas spills, other studies of the atmospheric dispersion of heavier-than-air gases have been carried out at LLNL for several years.² This request for assistance from the UCFD provided an opportunity to combine emergency-response planning expertise acquired by the ARAC staff over the past decade with other capabilities emerging from LLNL's heavy-gas-dispersion research program.

The function of the San Francisco Bay Area Air Quality Management District (BAAQMD) was to serve as an interested party and facilitator. The district has an interest in

evaluations of toxic chemical hazards as well as a decade-long association with LLNL in regard to air quality model development, evaluation, and application to Bay Area air quality issues.

This report describes a spectrum of hypothetical accident scenarios, the computer models used to estimate the consequences of these accidents, and the results of the assessments.

ACCIDENT SCENARIOS

Four hypothetical accident scenarios, bracketing the most reasonable maximum credible accidents, were postulated. These were derived by considering the chlorine storage-tank design standards, the various safety features associated with construction materials, relief valves, and chlorine detection systems, as well as various operational procedures associated with transport routes, frequency of deliveries, and off-loading procedures. On the basis of these considerations, the most likely accidents were assumed to be associated with:

- The transport of chlorine to the Union Sanitary District Plant.
- The transfer of chlorine from the tanker vehicle into the bulk storage tank.
- A rupture of a pipe or a valve connected to the bulk storage tank.
- A rupture of the tank itself.

The assumed meteorological conditions at the time of the accidents are based on on-site meteorological measurements and those acquired by the BAAQMD.

Scenario #1-Transportation accident. While enroute to the Union Sanitary District Plant, a tanker vehicle carrying 3200 gallons of liquid chlorine is involved in a vehicle collision while crossing an intersection. The impact causes a large tear in the side of the tank below the liquid level, with a resulting loss of all 3200 gallons within five minutes. The accident occurs at 1400 hours when the ambient wind speed is 3.5 m/s and the atmospheric stability is neutral. The temperature is 68°F.

Scenario #2-Pipe-leak accident. A leak occurs in a 1-in. supply line from the bulk storage tank situated at the Union Sanitary District Plant. The leak occurs at 0200 hours and is quickly detected by on-site personnel when

a chlorine detector sounds an alarm. However, since the leak is too small (less than 15 gpm) to activate the excess flow valves, 150 gallons of liquid chlorine are released over a 10-minute period before the leak is stopped. The local meteorological conditions at the time of the accident included light winds of 1 m/s, a Pasquill-Gifford E stability category, and a temperature of 55°F.

Scenario #3-Off-loading accident. At approximately mid-afternoon, while a tanker vehicle is being off-loaded at the bulk storage facility at the Union Sanitary District Plant, a transfer line ruptures. This results in a liquid chlorine release to the atmosphere at a rate that is below the 9.5 gpm needed to activate the excess flow valves. Because of the inattentiveness of the drivers, the release goes undetected for 12 minutes resulting in a spill of 80 gallons of liquid chlorine. Local meteorological conditions include an ambient wind speed of 4 m/s, a Pasquill-Gifford C stability, and a temperature of 75°F.

Scenario #4-Major storage-tank failure accident. The San Francisco Eastbay communities experience a major earthquake along the Hayward Fault. The earthquake is of sufficient magnitude to knock the storage tanks off their support structures. This induces a large tank rupture that results in the release of 9500 gallons of liquid chlorine within three minutes. Since this event can occur with equal probability during the day or night, both time periods are addressed in the modeling by assuming an ambient wind velocity of 3.5 m/s and D stability during the day and 1 m/s and E stability during the night. The temperature is 60°F for both day and night.

PHYSICAL PROCESSES ASSOCIATED WITH LIQUID CHLORINE ACCIDENTS

When liquid chlorine, stored under high pressure and at a temperature above its boiling point, is released instantaneously into the atmosphere, a fraction of the liquid flashes into vapor while the remainder spills onto the ground as a liquid pool. The fraction that flashes into vapor is a function of the ambient atmospheric temperature and typically is about 15 to 20 percent of the total chlorine released. The liquid pool of chlorine on the ground will evaporate at a rate determined by the size of the pool and the rate of heat conduction from the soil and the atmosphere. Thus, the pool will emit chlorine continuously until it has either been exhausted or is no longer exposed.

It is likely, however, that some fraction of the chlorine will create aerosols having diameters of a few micrometers or less. This fraction, which is expected to be relatively small as well as uncertain, is dependent on the flashing process and the ambient atmospheric conditions. This work assumes that because of the high molecular weight of chlorine and the low temperature relative to the ambient atmosphere, all of the chlorine forms vapor clouds that are heavier than air. The cloud produced by the initial flashing process as well as that produced by evaporation will spread horizontally like a

pancake while being transported downwind by the ambient winds and, with time, will be diluted by atmospheric turbulence. The concentrations of chlorine produced by the flashed vapor cloud will be of relatively short duration in comparison with those produced by the continuously emitting pool evaporation. Since neither the pool size nor the surface temperature is well known during most accident situations, the rate and duration of evaporation are generally poorly defined.

Chlorine gas has a greenish-yellow color with a characteristic irritating odor. Exposure to concentrations of chlorine gas as low as 3 to 6 ppm in air may cause a stinging or burning sensation in the eyes, nose, and throat. The standard set by the Occupational Health and Safety Administration (OSHA) for chlorine gas is 1 ppm averaged over a 15-minute period. The National Academy of Science's Committee on Toxicology has recommended that under emergency conditions, short-term exposure should not exceed 3 ppm.³ Exposure to concentrations of 14 to 21 ppm for one-half to one hour is dangerous, and concentrations of 100 ppm cannot be tolerated for longer than one minute.⁴ For convenience, this report will refer to a concentration of 25 ppm as one of serious, life-threatening concern.

COMPUTER MODELS

The FEM3 and SLAB computer models were used to estimate the consequences of the hypothetical accident scenarios. The atmospheric dispersion of a heavier-than-air gas, such as a chlorine vapor cloud, involves several physical phenomena that either do not occur or are unimportant in releases of neutrally buoyant and trace gases. These phenomena include gravity flow (slumping and horizontal spreading of the vapor cloud), turbulence damping (reduced mixing of the vapor cloud with the atmosphere) resulting from stable density stratification of the heavy gas cloud, and, for cold gas releases, the effects of heat flow from the

ground on cloud buoyancy and turbulence. All of these physical phenomena are treated in these computer models, which have been validated using data obtained from a number of field experiments including releases of liquefied natural gas (LNG), nitrogen tetroxide (N_2O_4), ammonia (NH_3), and propane.⁵⁻⁹

The FEM3 model¹⁰ is based on solving the time dependent, three-dimensional conservation equations of mass, momentum, energy, and species of the dispersed gas. The primary variables being calculated are density, the three velocity components, temperature, concentration of the dispersed gas, and pressure,

all of which vary in space and time. Turbulence is currently treated via a K-theory sub-model. The code can treat variable terrain and obstructions, and the gas releases can be instantaneous, continuous, or of finite duration. The completeness of the physics makes the numerical solution of these equations very complicated, requiring state-of-the-art numerical techniques and large, fast computers. This code is best suited for applications such as risk assessment, site selection, and planning, for which a good representation of the physical configuration and detailed predictions are important. Because of its complexity and high computing costs, this code is presently not suitable for real-time emergency-response situations.

The steady-state SLAB model⁸ calculates the atmospheric dispersion of a heavier-than-air gas that is continuously released at ground level. The model is based on the steady-state, crosswind-averaged conservation equations of

mass, momentum, energy, and species of the dispersed gas. The concept of air entrainment is used to account for the turbulent mixing of the gas cloud with the surrounding atmosphere. The variables being determined include density, velocity in the prevailing wind direction, crosswind gravity-flow velocity, concentration of the dispersed gas, temperature of the gas/air mixture, and cloud width and height. These variables are calculated as a function of the downwind distance, and the crosswind dependence is constructed using predetermined similarity profiles. This code, because of its numerical simplicity while maintaining the appropriate basic physics, can be executed rapidly on most modern computers, and, therefore, is very useful in complementing FEM3 for emergency-response applications. In this work, SLAB was used to extend the FEM3 calculations out to distances of several kilometers from the spill area where the concentrations are relatively low.

RESULTS

Estimates of the maximum downwind surface concentrations of chlorine resulting from the four hypothetical accident scenarios were derived using the FEM3 and the SLAB models. The input to the models was based on the specific source characteristics pertinent to each scenario, the stipulated meteorological conditions at the time of the accident, and flat terrain. Since the FEM3 model is three-dimensional and contains more detailed physics than the SLAB model, it was utilized to estimate the chlorine concentrations only within the first kilometer, where the heavier-than-air density effects are most important. The SLAB model was used to calculate the concentrations within and beyond the first kilometer, to minimize the required computational resources. These concentration fields were then merged to derive a continuous distribution of surface concentrations at a height of 1 m above the ground, out to a distance of 5 km. This required only very minimal adjustments to the individual concentration distributions.

Concentrations produced by the evaporation of chlorine from the pool formed in Scenario #4, the most severe accident, are shown as a function of downwind distance in Fig. 1 for nighttime and in Fig. 2 for daytime. The central curve in both figures is for a nominal evaporation rate of 7.2 kg/s, for a pool size of 30 m by 30 m. Since the evaporation rate for any given accident scenario is uncertain, a sensitivity study was included to evaluate the effect on downwind concentration of varying the evaporation rate. The upper and lower curves in each figure denote the increase and decrease, respectively, in concentration produced by increasing or decreasing the evaporation rate by a factor of 3. The most nominal steady-state concentration varies from about 10,000 ppm near the source to about 60 ppm at a distance of 5000 m for nocturnal conditions and from about 3000 ppm near the source to 10 ppm at 5000 m during the day. Because the spill is large, these concentrations persist over periods of approximately two to three hours. Changing

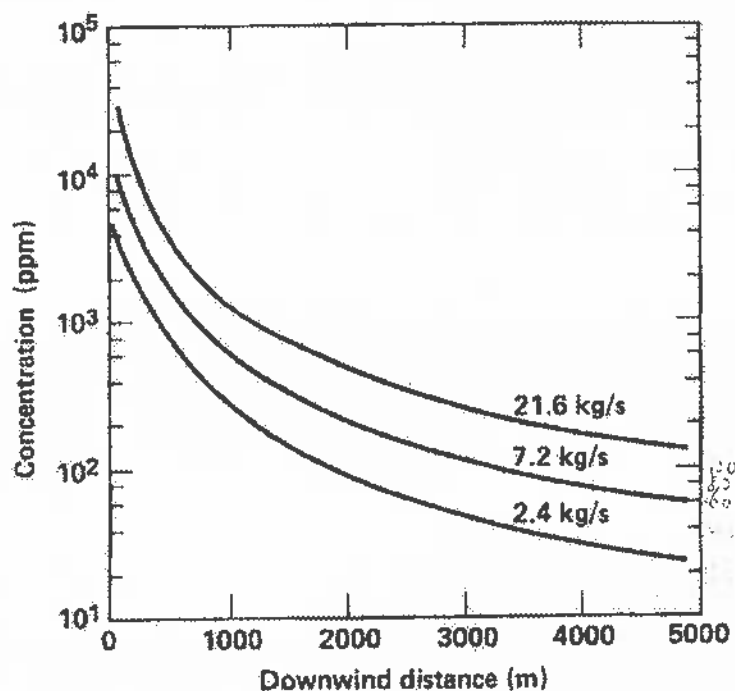


Figure 1. Surface air concentrations of chlorine resulting from Scenario #4 (center curve) involving the release of 9500 gallons of liquid chlorine during the nighttime. The upper and lower curves denote the changes in concentration that arise from varying the pool evaporation rate by a factor of three.

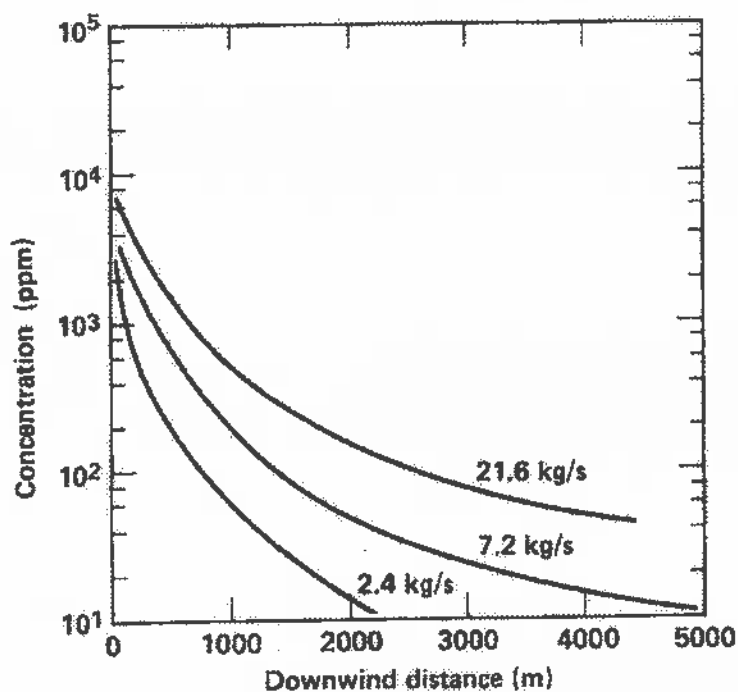


Figure 2. Surface air concentrations of chlorine resulting from Scenario #4 (center curve) involving the release of 9500 gallons of liquid chlorine during the daytime. The upper and lower curves denote the changes in concentration that arise from varying the pool evaporation rate by a factor of three.

the evaporation rate produces a roughly corresponding change in concentration. Thus, for the nominal evaporation rate of 7.2 kg/s, concentrations exceeding 25 ppm may be expected to distances beyond 5000 m under nocturnal conditions and to 3000 m during the day.

Figures 3 and 4 depict the physical dimensions of the nocturnal and daytime plumes, respectively. Only one-half of each plume is shown, since symmetry exists around the downwind axis. The nocturnal plume is much wider than the corresponding daytime plume because of the initial slumping and horizontal spreading of the heavier-than-air cold chlorine vapor and the more stable nighttime atmospheric stability condition. Hence, half-widths of about 500 m are typical during the night and 100 m during the day. Evaluation by the FEM3 model of the hazard due to the initial flashing process, which involves 15 percent of the total

amount of chlorine, gave predicted concentrations similar to those derived for the 7.2-kg/s pool evaporation rate; however, the time duration of these concentrations was only about 20 minutes instead of two to three hours.

The concentration of chlorine in surface air that results from the instantaneous release of 3200 gallons of chlorine (Scenario #1) is shown in Fig. 5 for both nocturnal and daytime conditions. The 25-ppm level is exceeded out to 5000 m at night and to 1500 m during the day. With the release of 80 gallons of chlorine over a 12-minute period during the daytime (Scenario #3), the resulting concentrations, shown in Fig. 6, exceed 25 ppm out to a distance of 115 m from the accident site. A 150-gallon release over a 10-minute period (Scenario #2) produces concentrations exceeding 25 ppm out to a distance of 700 m during the nighttime, as shown in Fig. 7.

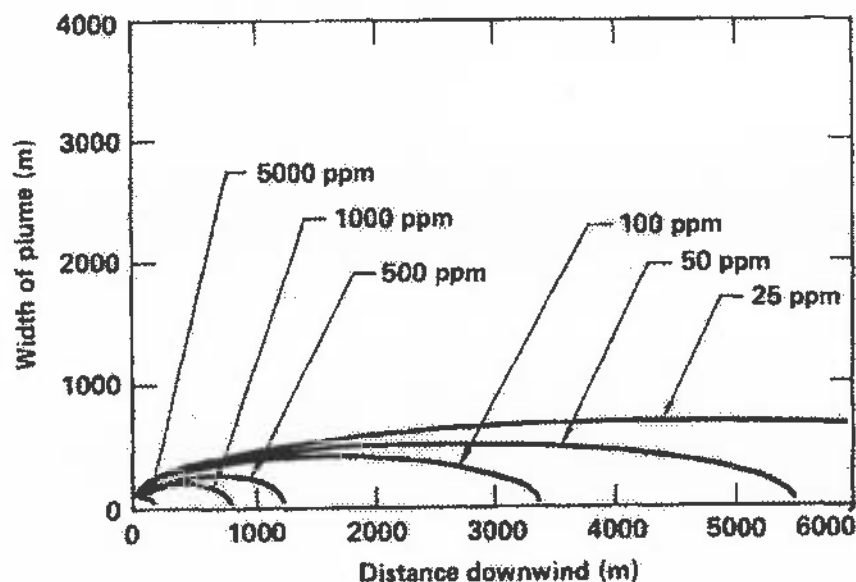


Figure 3. A plan view of the chlorine plume concentrations resulting from Scenario #4 involving the release of 9500 gallons of liquid chlorine during the nighttime. Only one-half of the plume is shown since symmetry exists around the downwind axis.

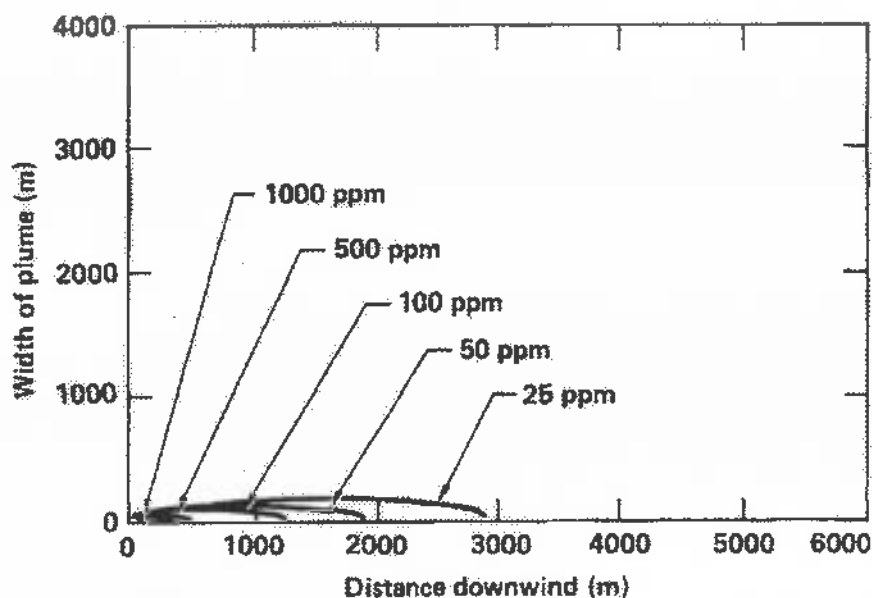


Figure 4. A plan view of the chlorine plume concentrations resulting from Scenario #4 involving the release of 9500 gallons of liquid chlorine during the daytime. Only one-half of the plume is shown since symmetry exists around the downwind axis.

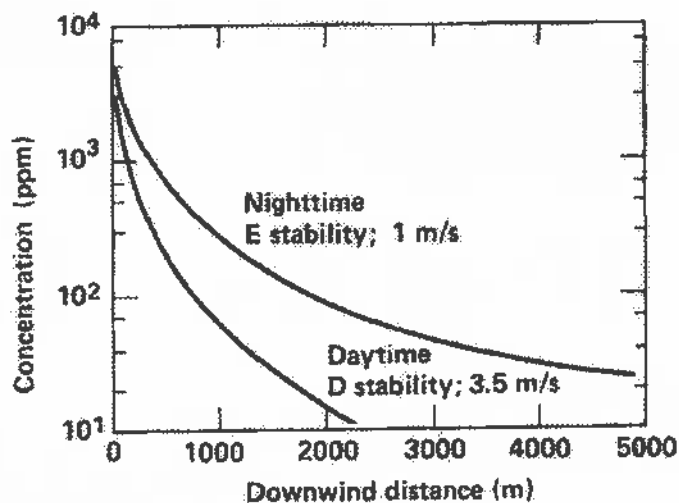


Figure 5. Surface air concentrations of chlorine resulting from Scenario #1 involving the release of 3200 gallons of liquid chlorine.

Figure 6. Surface air concentrations of chlorine resulting from Scenario #3 involving the release of 80 gallons of liquid chlorine.

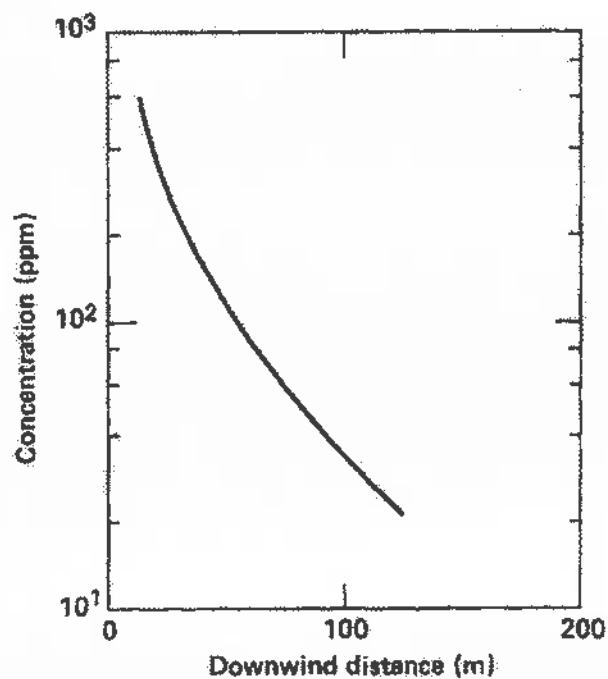
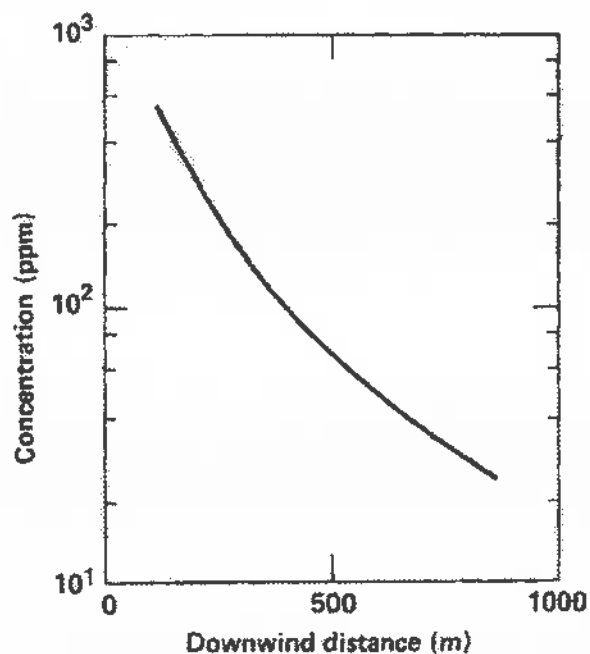


Figure 7. Surface air concentrations of chlorine resulting from Scenario #2 involving the release of 150 gallons of liquid chlorine.



CONCLUSIONS

This work has demonstrated that the FEM3 and SLAB models are useful tools for estimating the consequences of accidental liquid chlorine spills. Such tools can be used to develop for toxic chemical facilities emergency-response plans that include the selection of the lowest-risk transportation routes, the most appropriate evacuation plans, and the most cost-effective mitigation measures to ensure the least possible impact on the public health and safety. The FEM3 model is particularly useful for emergency-response planning and detailed post-accident analysis, while the SLAB model is well suited for real-time emergency planning and assessment. Thus, this work supports the following recommendations:

- Use the FEM3 model to evaluate various accident-mitigating measures such as "berm"

or "moat" designs emplaced about the chlorine storage facility.

- Implement the SLAB model on a small computer connected to a network of meteorological sensors. Make real-time assessments of hypothetical accidents during normal transfer operations, to permit a rapid and effective response in the event of an actual accidental chlorine release.

- Continue to evaluate these models using data acquired from field experiments involving the release of a wide spectrum of toxic chemicals under a variety of meteorological conditions. Such experiments will increase our confidence in the model results and will also provide valuable data on the effectiveness of various mitigation measures such as fences, sprays, walls, pits, etc.

REFERENCES

1. Dickerson, M.H., P.H. Gudiksen, and T.J. Sullivan, *The Atmospheric Release Advisory Capability*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52802-83 (1983).
2. Koopman, R.P., *A Facility for Large-Scale Hazardous Gas Testing Including Recent Test Results*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-93424 (1985); presented at the Hazardous Materials Management Conference and Exhibition, Long Beach, California, December 3-5, 1985.
3. National Academy of Sciences, National Research Council Committee on Toxicology, *Guides for Short-Term Exposure to the Public - Guide for Chlorine*, Prepared for EPA contract CPA 70-57. Available from National Technical Information Service publication PB 244-339 (1983).
4. F.A. Patty (ed.), *Industrial Hygiene and Toxicology* (2nd ed. rev.), Vol. IV, *Toxicology* (Interscience, New York, 1963).
5. Ermak, D.L., S.T. Chan, D.L. Morgan, and L.K. Morris, "A Comparison of Dense Gas Dispersion Model Simulations with Burro Series LNG Spill Test Results," *J. of Haz. Mat.*, 6 (1, 2) 129-160, (1982); also in *Dense Gas Dispersion* (Elsevier Scientific Publishing Co., Amsterdam, 1982).
6. Chan, S.T., H.C. Rodean, and D.L. Ermak, "Numerical Simulations of Atmospheric Releases of Heavy Gases Over Variable Terrain," in *Air Pollution Modeling and its Application III* (Plenum Press, 1984), pp. 295-341.
7. Kansa, E.J., D.L. Ermak, S.T. Chan, and H.C. Rodean, "Atmospheric Dispersion of Ammonia: An Ammonia Fog Model," in *Proceedings of the Multiphase Synfuels Heat Transfer 21st ASME/AICHE National Heat Transfer Conference*, Seattle, WA, July 24-28, 1983.
8. Ermak, D.L. and S.T. Chan, "A Study of Heavy Gas Effects on the Atmospheric Dispersion of Dense Gases," in *Proceedings of the 15th International Technical Meeting on Air Pollution Modeling and its Application*, St. Louis, MO, April 15-19, 1985.
9. Chan, S.T. and D.L. Ermak, "Further Assessment of FEM3- A Numerical Model for the Dispersion Simulation of Heavy Gases Over Complex Terrain," presented at the JANNAF Safety and Environmental Protection Subcommittee Meeting, Monterey, CA, November 1985.
10. S.T. Chan, *FEM3-A Finite Element Model for the Simulation of Heavy Gas Dispersion and Incompressible Flow: User's Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53397 (1983).



Documentation for Immediately Dangerous To Life or Health Concentrations (IDLHs)*

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention

National Institute for Occupational Safety and Health
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PREFACE

This publication documents the criteria and information sources that have been used by the National Institute for Occupational Safety and Health (NIOSH) to determine immediately dangerous to life or health concentrations (IDLHs). IDLHs were originally determined for 387 substances in the mid-1970's as part of the Standards Completion Program (SCP), a joint project by NIOSH and the Occupational Safety and Health Administration (OSHA), for use in assigning respiratory protection equipment. NIOSH is currently evaluating the scientific adequacy of the criteria and procedures used during the SCP for establishing IDLHs. In the interim, the IDLHs have been reviewed and, (if appropriate) revised. In this document, IDLHs are listed with the basis and references for the current values as well as with the original IDLHs and their documentation (as paraphrased from the SCP draft technical standards).

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IDLHs--Chemical Listing and Documentation

IDLH Viewer (Electronic hypertext version)

ACKNOWLEDGMENTS

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Documentation for Immediately Dangerous To Life or Health Concentrations (IDLHs)

INTRODUCTION

Background, The Standards Completion Program, Discussion of Original IDLHs,
Current NIOSH Use of IDLHs, Revised Criteria for Determining IDLHs, References

The "immediately dangerous to life or health air concentration values (IDLHs)" used by the National Institute for Occupational Safety and Health (NIOSH) as respirator selection criteria were first developed in the mid-1970's. The Documentation for Immediately Dangerous to Life or Health Concentrations (IDLHs) is a compilation of the rationale and sources of information used by NIOSH during the original determination of 387 IDLHs and their subsequent review and revision in 1994.

Background

Immediately Dangerous to Life or Health Conditions and Respirator Selection The concept of using respirators to protect workers in situations that are immediately dangerous to life or health was discussed at least as early as the 1940's. The following is from a U.S. Department of Labor bulletin:

The situations for which respiratory protection is required may be designated as, (1) nonemergency and (2) emergency. Nonemergency situations are the more or less normal ones that involve exposure to atmospheres that are not immediately dangerous to health and life, but will produce marked discomfort, sickness, permanent harm, or death after a prolonged exposure or with repeated exposure. Emergency situations are those that involve actual or potential exposure to atmospheres that are immediately harmful and dangerous to health or life after comparatively short exposures. [Yant 1944]

The Occupational Safety and Health Administration (OSHA) defines an immediately dangerous to life or health concentration in their hazardous waste operations and emergency response regulation as follows:

An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere. [29 CFR* 1910.120]

In the OSHA regulation on permit-required confined spaces, an immediately dangerous to life or health condition is defined as follows:

Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a permit space. Note: Some materials--hydrogen fluoride gas and cadmium vapor, for example--may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12-72 hours after exposure. The victim "feels normal"

from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be "immediately dangerous to life or health." [29 CFR 1910.146]

As part of their current respiratory protection standard [29 CFR 1910.134(e)], OSHA requires that a standby person be present with suitable rescue equipment when self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health. Furthermore, persons using air-line respirators in atmospheres immediately hazardous to life or health must be equipped with safety harnesses and safety lines for lifting or removing workers from hazardous atmospheres. [Go to top of page.](#)

The Standards Completion Program

In 1974, NIOSH and OSHA jointly initiated the development of occupational health standards consistent with Section 6(b) of the Occupational Safety and Health Act of 1970 for substances with then-existing OSHA permissible exposure limits (PELs). This joint effort was called the Standards Completion Program (SCP) and involved the cooperative efforts of personnel from various divisions within NIOSH and OSHA, and several contractors. The SCP developed 387 substance-specific draft standards with supporting documentation that contained technical information and recommendations needed for the promulgation of new occupational health regulations. Although new standards were not promulgated at that time, these data became the original basis for the NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards [NIOSH/OSHA 1981].

As part of the respirator selection process for each draft technical standard, an IDLH was determined. The definition for an IDLH that was derived during the SCP was based on the definition stipulated in 30 CFR 11.3(t). The purpose for establishing this IDLH was to determine a concentration from which a worker could escape without injury or without irreversible health effects in the event of respiratory protection equipment failure (e.g., contaminant breakthrough in a cartridge respirator or stoppage of air flow in a supplied-air respirator) and a concentration above which only "highly reliable" respirators would be required. In determining IDLHs, the ability of a worker to escape without loss of life or irreversible health effects was considered along with severe eye or respiratory irritation and other deleterious effects (e.g., disorientation or incoordination) that could prevent escape. Although in most cases, egress from a particular worksite could occur in much less than 30 minutes, as a safety margin, IDLHs were based on the effects that might occur as a consequence of a 30-minute exposure. However, the 30-minute period was NOT meant to imply that workers should stay in the work environment any longer than necessary following the failure of respiratory protection equipment; in fact, **EVERY EFFORT SHOULD BE MADE TO EXIT IMMEDIATELY!**

IDLHs were determined for each substance during the SCP on a case-by-case basis, taking into account the toxicity data available at the time. Whenever possible, IDLHs were determined using health effects data from studies of humans exposed for short durations. However, in most instances, a lack of human data necessitated the use of animal toxicity data. When inhalation studies of animals exposed for short durations (i.e., 0.5 to 4 hours) were the only health effects data available, IDLHs were based on the lowest exposure causing death or irreversible health effects in any species. When lethal dose (LD) data from animals were used, IDLHs were estimated on the basis of an equivalent exposure to a 70-kg worker breathing 10 cubic meters of air.

Since chronic exposure data may have little relevance to acute effects, these types of data were used in determining IDLHs only when no acute toxicity data were available and only in conjunction with competent scientific judgment. In a number of instances when no relevant human or animal toxicity data were available, IDLHs were based on analogies with other substances with similar toxic effects. [Go to top](#)

of page.

Discussion of Original IDLHs

The basis for each of the 387 IDLHs determined during the SCP were reviewed and paraphrased from the individual draft technical standards for this publication. Also included is a complete listing of references cited in the SCP; in many cases where only secondary references were cited, the original sources have also been added. Whenever available, the references (secondary and primary) were obtained to verify the information cited in the SCP. However, a few of the original references such as personal communications and foreign reports could not be located.

Although 387 substances were originally included in the SCP, IDLHs were not specifically determined for all of them. The published data at that time for 40 of these substances (e.g., DDT and triphenyl phosphate) showed no evidence that an acute exposure to high concentrations would impede escape or cause any irreversible health effects following a 30-minute exposure and the designation "NO EVIDENCE" was used in the listing of IDLHs. For all of these substances, respirators were selected on the basis of assigned protection factors. For some (e.g., copper fume and tetraethyl lead), an assigned protection factor of 2,000 times the PEL was arbitrarily used to determine the concentration above which only the "most protective" respirators were permitted. However, for most particulate substances for which evidence for establishing an IDLH did not exist (e.g., ferbam and oil mist), the use of an assigned protection factor of 2,000 would have resulted in the assignment of respirators at concentrations that were not likely to be encountered in the occupational environment. In addition, exposure concentrations greater than 500 times the PEL for many airborne particulates could result in exposures that would hamper vision. Therefore, it was decided as part of the SCP (and during the review and revision of the IDLHs) that for such particulate substances, only the "most protective" respirators would be permitted for use in concentrations exceeding 500 times the PEL.

IDLHs could not be determined during the SCP for 22 substances (e.g., bromoform and calcium oxide) because of a lack of relevant toxicity data and therefore the designation "UNKNOWN" was used in the IDLH listing. For most of these substances, the concentrations above which only the "most protective" respirators were allowed were based arbitrarily on assigned protection factors that ranged from 10 to 2,000 times the PEL, depending on the substance. There were also 10 substances (e.g., n-pentane and ethyl ether) for which it was determined only that the IDLHs were in excess of the lower explosive limits (LELs). Therefore, the LEL was selected as the IDLH with the designation "LEL" added in the IDLH listing. For these substances, only the "most protective" respirators were permitted above the LEL in the SCP draft technical standards.

For 14 substances (e.g., beryllium and endrin), the IDLHs determined during the SCP were greater than the concentrations permitted based on assigned respiratory protection factors. In most instances the IDLHs for these substances were set at concentrations 2,000 times the PEL. [Go to top of page.](#)

Current NIOSH Use of IDLHs

The current NIOSH definition for an immediately dangerous to life or health condition, as given in the *NIOSH Respirator Decision Logic* [NIOSH 1987], is a situation "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment." It is also stated that the purpose of establishing an IDLH is to "ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment." The NIOSH respirator decision logic uses an IDLH as one of several respirator selection criteria. Under the NIOSH respirator decision logic, "highly reliable" respirators (i.e., the most protective respirators) would be selected for emergency situations, fire

fighting, exposure to carcinogens, entry into oxygen-deficient atmospheres, entry into atmospheres that contain a substance at a concentration greater than 2,000 times the NIOSH REL or OSHA PEL, and for entry into immediately dangerous to life or health conditions. These "highly reliable" respirators include either a self-contained breathing apparatus (SCBA) that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode, or a supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in a pressure-demand or other positive-pressure mode.

When the IDLHs were developed in the mid-1970's, only limited toxicological data were available for many of the substances. NIOSH has recently requested information on the current uses of IDLHs in the workplace and on the scientific adequacy of the criteria and procedures originally used for establishing them [Federal Register, Volume 58, Number 229, p. 63379, Wednesday, December 1, 1993]. The information received in response to the Federal Register announcement is being evaluated and will be used to establish future actions concerning IDLHs. In the interim, however, NIOSH decided to review the existing IDLHs, and revise them as appropriate.

This document includes IDLHs for 85 substances (e.g., benzene and methylene chloride) determined by NIOSH to meet the OSHA definition of "potential occupational carcinogen" as given in 29 CFR 1910.103. For all of these substances, except ethylene oxide and crystalline silica, NIOSH recommends that the "most protective" respirators be worn by workers exposed at concentrations above the NIOSH REL, or at any detectable concentration when there is no REL. For ethylene oxide and crystalline silica, NIOSH recommends that the "most protective" respirators be worn in concentrations exceeding 5 ppm and 25 mg/m³, respectively [NIOSH 1989, 1994]. [Go to top of page.](#)

Revised Criteria for Determining IDLHs

The criteria utilized to determine the adequacy of existing IDLHs were a combination of those used during the SCP and a newer methodology developed by NIOSH. These criteria form a tiered approach with acute human toxicity data being used preferentially, followed next by acute animal inhalation toxicity data, and then finally by acute animal oral toxicity data to determine an updated IDLH. When relevant acute toxicity data were insufficient or unavailable, then the use of chronic toxicity data or an analogy to a chemical with similar toxic effects was considered. In order to facilitate the revision process, secondary toxicological data were primarily used. Once a preliminary IDLH was developed, it was compared to the existing IDLH and to several other factors (e.g., existing short-term exposure guidelines and lower explosive limits).

The following "hierarchy" was followed to develop a "preliminary" value for the revised IDLH:

A. Human acute toxicity data were used if sufficient to determine a concentration that for up to 30 minutes does not cause death, serious or irreversible health effects, or does not impair or impede the ability to escape.

B. Animal acute lethal concentration (LC) data were considered next. The only animal lethal concentration data used involved mammals; the vast majority of the data was from studies of rats, mice, guinea pigs, and hamsters. It was decided to generally use the lowest reliable LC data, with LC50 data preferred. If acute LC data determined during a 30-minute period were not available, then the data, based on a study by ten Berge et al. [1986], were "adjusted" to an equivalent 30-minute value using the following relationship:

$$\text{Adjusted LC50 (30 minutes)} = \text{LC50}(t) * (t/0.5)^{0.5} * (1/n)$$

where: LC50(t) = LC50 determined over t hours

n = constant*

*Note: ten Berge et al. [1986] determined the relationship shown above based on experimental data.

The constant "n" was determined by ten Berge et al. to be less than 3.0 for 18 of the 20 substances studied. Although the individual "n" values determined by ten Berge et al. [1986] were utilized when applicable during the review and revision of the original IDLHs, as a conservative estimate, an "n" = 3.0 was assumed when "adjusting" the LC data to 30 minutes for all other substances. This equation with an "n" = 3.0 results in the following correction factors:

t (hours)	correction factor
0.5	1.0
1	1.25
2	1.6
3	1.8
4	2.0
5	2.15
6	2.3
7	2.4
8	2.5

The LC values (after "adjusting" if necessary to 30 minutes) were divided by a safety factor of 10 to determine a "preliminary" IDLH for comparison purposes.

C. Animal lethal dose (LD) data were considered next. As was the case with the lethal concentration data, the only animal lethal dose data used involved mammals; the vast majority of the data were from studies of rats, mice, guinea pigs, and hamsters. It was decided to generally use the lowest LD data with oral LD50 data preferred. The LD data was used to determine the equivalent total dose to a 70-kg worker and, as was done during the SCP, the air concentration containing this dose was determined by dividing by 10 cubic meters. [Note: A worker breathing at a rate of 50 liters per minute for 30 minutes would inhale 1.5 cubic meters of air.] A "preliminary" IDLH for comparison purposes was determined by dividing these air concentrations by a safety factor of 10.

D. Chronic toxicity data were considered if no relevant acute toxicity data existed. However, the fact that chronic exposures may have limited relevance to acute effects was taken into consideration.

E. When relevant toxicity data applying specifically to the chemicals in question were lacking, and if it was determined to be justified, then analogies to substances with similar acute toxic effects were considered.

F. All "preliminary" IDLHs derived during this update were checked against the following factors prior to establishing the final "revised" IDLH:

1. Lower explosive limit (LEL): It was decided to restrict the "routine" entry into a possible explosive atmosphere to concentrations no greater than 10% of the LEL. [Note: SCP-derived IDLHs were set at 100% of the LELs if there were no known serious health hazards below these values. However, OSHA considers concentrations in excess of 10% of the LEL to be a hazardous atmosphere in confined spaces [29 CFR 1910.146(b)].]

2. RD50 data: An RD50 is defined as the 10-minute exposure concentration producing a 50% respiratory rate decrease in mice or rats and can be used to estimate severe respiratory irritation. Prolonged exposure to an RD50 concentration has been shown to produce respiratory tract lesions consistent with irritation [Alarie 1981; Buckley et al. 1984].
3. Other short-term exposure guidelines such as the American Industrial Hygiene Association's emergency response planning guidelines (ERPGs) and the National Research Council's emergency exposure guidance levels (EEGLs) and short-term public emergency guidance levels (SPEGLs), and occupational exposure standards or recommendations such as OSHA PELs, NIOSH RELs, or the American Conference of Governmental Industrial Hygienists (ACGIH) TLVs.
4. Based on the NIOSH respirator decision logic, the revised IDLHs could not be greater than 2,000 times the NIOSH REL (or OSHA PEL).
5. The revised IDLHs would not be greater than the original IDLHs derived during the SCP.

Anyone who is aware of additional published data that may affect the IDLHs determined for particular substances is encouraged to make this information available to NIOSH. All data will be reviewed and consideration will be made regarding subsequent revision of the IDLHs. [Go to top of page.](#)

References

Alarie Y [1981]. Dose-response analysis in animal studies: prediction of human responses. *Environ Health Persp* 42:9-13.

Buckley LA, Jiang XZ, James RA, Morgan KT, Barrow CS [1984]. Respiratory tract lesions induced by sensory irritants at the RD50 concentration. *Toxicol Appl Pharmacol* 74(3):417-429.

NIOSH/OSHA [1981]. Occupational health guidelines for chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 81-123 (NTIS Publication No. PB-83-154609).

NIOSH [1987]. NIOSH respirator decision logic. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108 (NTIS Publication No. PB-88-149612).

NIOSH [1989]. Current Intelligence Bulletin 52. Ethylene oxide sterilizers in health care facilities. Engineering controls and work practices. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 89-115 (NTIS Publication No. PB-90-142571).

NIOSH [in preparation]. Criteria for a recommended standard: occupational exposure to respirable coal mine dust. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

ten Berge WF, Zwart A, Appleman LM [1986]. Concentration-time mortality response relationship of irritant and systematically acting vapours and gases. *J Haz Mat* 13:301-309.

Yant WP [1944]. Protecting workers against temporary and emergency exposures. In: Protecting plant manpower through the control of air contaminants. Special Bulletin No. 14. Washington, DC: U.S. Department of Labor, Division of Labor Standards. [Go to top of page.](#)

*Code of Federal Regulations

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Documentation for
Immediately Dangerous
To Life or Health
Concentrations (IDLHs)

NIOSH CHEMICAL LISTING
AND DOCUMENTATION OF
REVISED IDLH VALUES
(AS OF 3/1/95)

Questions should be directed to: 1-800-35-NIOSH

SUBSTANCE	ORIGINAL IDLH VALUE	REVISED IDLH VALUE
Acetaldehyde	10,000 ppm	2,000 ppm
Acetic acid	1,000 ppm	50 ppm
Acetic anhydride	1,000 ppm	200 ppm
Acetone	20,000 ppm	2,500 ppm (LEL)
Acetonitrile	4,000 ppm	500 ppm
Acetylene tetrachloride	10 ppm	8 ppm
Acrolein	5 ppm	12 ppm
Acrylamide	Unknown	60 mg/m3
Acrylonitrile	500 ppm	65 ppm
Alumin	100 mg/m3	25 mg/m3
Allyl alcohol	150 ppm	20 ppm
Allyl chloride	300 ppm	250 ppm
Allyl glycidyl ether	270 ppm	50 ppm
2-Aminopyridine	5 ppm	5 ppm (Unch)
Anestonia	500 ppm	300 ppm
Arsenolium sulfamate	5,000 mg/m3	1,500 mg/m3
n-Butyl acetate	4,000 ppm	1,000 ppm
Isopropyl acetate	9,000 ppm	1,100 ppm
Aniline	100 ppm	100 ppm (Unch)
n-Butylamine	50 mg/m3	50 mg/m3 (Unch)
n-Butylamine	50 mg/m3	50 mg/m3 (Unch)
Aniline compounds (as Sd)	80 mg Sd/m3	50 mg Sd/m3
ANTU	100 mg/m3	100 mg/m3 (Unch)
Arsenic (inorganic compounds, as As)	100 mg As/m3	10 mg As/m3
Acids	6 ppm	3 ppm
Azobenzene	20 mg/m3	10 mg/m3
Benzene (soluble compounds, as Bz)	1,100 mg Bz/m3	50 mg Bz/m3
Benzene	3,000 ppm	500 ppm
Benzoyl peroxide	7,000 mg/m3	1,500 mg/m3

Chlorine

IDLH Documentation

CAS number: 7782-50-5

NIOSH REL: 0.5 ppm (1.45 mg/m³) 15-minute CEILINGCurrent OSHA PEL: 1 ppm (3 mg/m³) CEILING1989 OSHA PEL: 0.5 ppm (1.5 mg/m³) TWA, 1 ppm (3 mg/m³) STEL1993-1994 ACGIH TLV: 0.5 ppm (1.5 mg/m³) TWA, 1 ppm (2.9 mg/m³) STEL

Description of Substance: Greenish-yellow gas with a pungent, irritating odor.

LEL: ... Nonflammable Gas

Original (SCP) IDLH: 30 ppm

Basis for original (SCP) IDLH: The chosen IDLH is based on the statement by ILO [1971] that exposure to 30 ppm will cause intense coughing fits, and exposure to 40 to 60 ppm for 30 to 60 minutes or more may cause serious damage.

Existing short-term exposure guidelines: National Research Council (NRC 1984) Emergency Exposure Guidance Levels (HEELs):

1-hour EEL: 3 ppm

24-hour EEL: 0.5 ppm

ACUTE TOXICITY DATA

Lethal concentration data:

Species	Reference	LC ₅₀ (ppm)	LC _{Lo} (ppm)	Time	Adjusted 0.5-hr LC (CF*)	Derived value
Rat	Back et al. 1972	293	-----	1 hr	357 ppm (1.22)	36 ppm
Mouse	Back et al. 1972	137	-----	1 hr	167 ppm (1.22)	17 ppm
C. pig	Lehmann 1887	-----	3,200	3 hr	5,342 ppm (1.67)	534 ppm
Human	Prentiss 1937	-----	858	30 min	858 ppm (1.0)	86 ppm
Human	Tab Biol Per 1933	-----	550	5 min	330 ppm (0.60)	33 ppm

*Note: Conversion factor (CF) was determined with "n" = 3.5 [ten Berge et al. 1986].

Other animal data: RD₅₀ (mouse), 9.34 ppm [Alarie 1981].

Other human data: Exposures to 30 ppm have been reported to cause intense coughing fits and exposure to 40 to 60 ppm for 30 to 60 minutes or more may cause serious damage [ILO 1971]. A concentration of 34 to 51 ppm has been reported to be lethal in 1 to 1.5 hours [Freitag 1941] while 14 to 21 ppm has been suggested as being dangerous within 0.5 to 1 hour [NPRI 1983].

Revised IDLH: 10 ppm

Basis for revised IDLH: The revised IDLH for chlorine is 10 ppm based on acute inhalation toxicity data in humans [Freitag 1941; ILO 1971; NPRI 1983].

REFERENCES:

1. Alarie Y [1981]. Dose-response analysis in animal studies: prediction of human responses. *Environ Health Perspect* 42:9-13.
2. Back KC, Thomas AA, MacEwen JD [1972]. Reclassification of materials listed as transportation health hazards. Wright-Patterson Air Force Base, OH: 6570th Aerospace Medical Research Laboratory, Report no. TSA-20-72-3, pp. A-182 to A-183.
3. Freitag [1941]. Danger of chlorine gas. *Z. Gesamte Schiess Sprengstoffwiss.*
4. ILO [1971]. Chlorine and compounds. In: *Encyclopaedia of occupational health and safety*. 2nd ed. Vol. 1 (A-K). Geneva, Switzerland: International Labour Office, pp. 287-288.
5. Lehmann KB [1887]. Experimentelle studien über den einfluss technisch und hygienisch wichtiger gase und dämpfe auf den organismus. Thiel III und IV: Chlor und brom. *Arch Hyg* 7:231-285 (in German).
6. NPRI [1983]. Raw materials data handbook, physical and chemical properties, fire hazard and health hazard data. Vol. II. 2nd ed. Organic solvents. Bethlehem, PA: National Printing Ink Research Institute.

pp. 831-857.

7. NRC [1984]. Emergency and continuous exposure limits for selected airborne contaminants. Vol. 2. Washington, DC: National Academy Press, Committee on Toxicology, Board on Toxicology and Environmental Health Hazards, Commission on Life Sciences, National Research Council, pp. 5-11.
8. Prentiss AM [1937]. Chemicals in war. A treatise on chemical warfare. New York, NY: McGraw-Hill Book Company, Inc., p. 150.
9. Tab Biol Per [1933]: 3:231 (in German).
10. ten Berge WF, Zwart A, Appelman LM [1986]. Concentration-time mortality response relationship of irritant and systemically acting vapours and gases. J Haz Mat 13:301-309.

Go back to the [Documentation for Immediately Dangerous To Life or Health Concentrations \(IDLHs\)](#)

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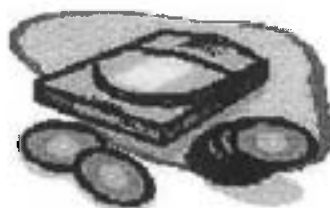
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ACCIDENTAL RELEASE & PREVENTION PAGE

U.S. ENVIRONMENTAL PROTECTION AGENCY: REGION VII

ELECTRONIC TOOLS

● **CEPPO ELECTRONIC TOOLS**--This page discusses electronic tools (computer models and software) and connects to the following: Accidental Release Information Program (ARIP); Chemical Accident Investigation Team (CAIT); Computer Aided Management of Emergency Operations (CAMEO); Emergency Response Notification System (ERNS); Hazardous Analysis for Toxic Substances (HATS); Landview; Questions and Answers; Tier2 Reporting & Inventory System - EPA's; Title III List of Lists; Atmospheric Dispersion of Reacting Agents (Adora); Palmtop Emergency Action for Chemicals (PEAC); PLG Off-Site Consequence Analysis Guidance Software; Tier2 Reporting from an MSDS/Inventory Database-Pardalis Software, Inc..

● **Public Domain Accidental Release Models**

- **ADAM**--(Air Force Dispersion Assessment Model) Performs release rate, pool evaporation, and neutral and dense gas dispersion calculations. ADAM uses refined methods. It has a chemical database of eight chemicals and little or no modeling experience is required.
- **AFTOX**--(Air Force Toxic Chemical Dispersion Model) Predicts toxic pollutant concentrations from continuous and instantaneous point and area sources. The model also calculates evaporation from a liquid spill and the subsequent transport and dispersion of the vapor cloud.
- **ARCHIE**--(Automated Resource for Chemical Hazard Incident Evaluation) Performs release rate, pool evaporation, neutral and dense gas dispersion, pool fire, jet fire, fireball, BLEVE, and vapor cloud explosion calculations. ARCHIE uses simple methods. The user must provide chemical data (no chemical database) and little or no modeling experience is required.
- **DEGADIS**--(Dense Gas Dispersion Model) Performs dense gas dispersion calculations. DEGADIS uses refined methods. It has a limited chemical database and substantial modeling experience is required.
- **SLAB**--Performs dense gas dispersion calculations. It uses refined methods. The user must provide chemical data (no chemical database) and substantial modeling experience is required.
- **TOXST**--(Toxic modeling system Short-Term) Estimates the dispersion of toxic air pollutants from point, area, and volume sources at a complex industrial site. This system allows the estimation of ambient concentration impacts for single and multiple pollutants from continuous and intermittent sources. In addition, the model estimates the average annual frequency with which user-specified concentration thresholds are expected to be exceeded at receptor sites around the modeled facility.

● **TSCREEN**—(Toxic Screening Model) Performs release rate, pool evaporation , and natural and dense gas dispersion calculations. TSCREEN uses simple methods. It is primarily used for screening and little or no modeling experience is required.



If you have any comments, suggestions, or questions about upcoming events, e-mail Mark Smith at smith.marka@epamail.epa.gov

Environmental Health Center

CAMEO for Windows Demo

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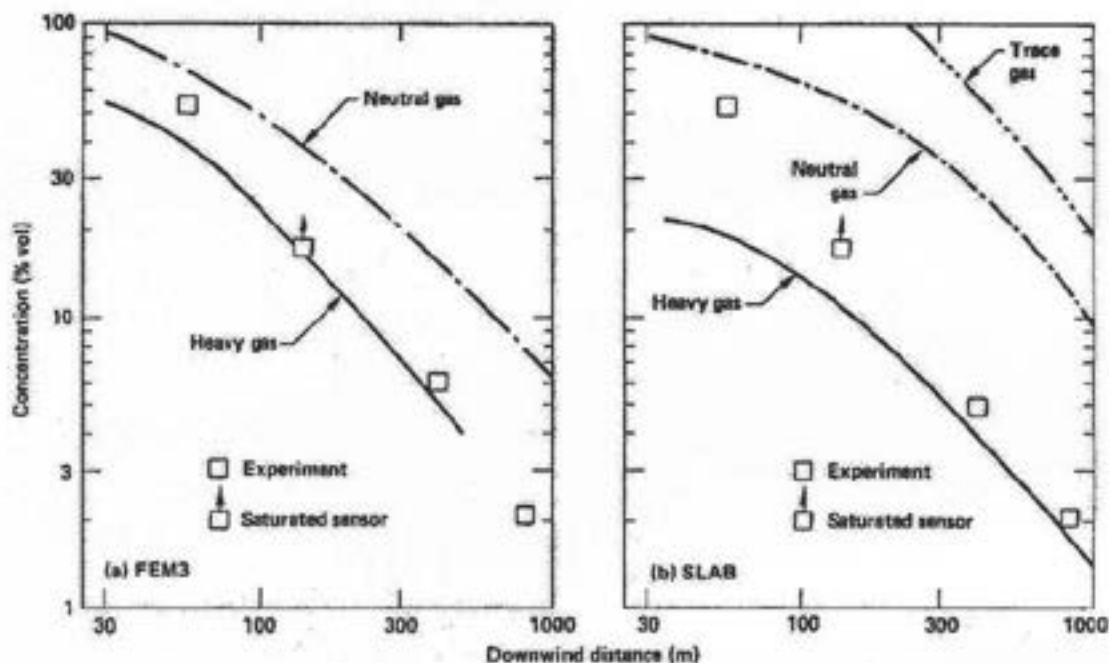


Figure 15. Burro 8 maximum concentration versus downwind distance: (a) FEM3, (b) SLAB.

experience with the model. Further, they have only finite grid resolution that cannot do complicated obstacle fields such as factories or towns. In addition, they are impractical for calculating far field concentrations many kilometers downwind where dense gas effects are negligible. Recent efforts with Lagrangian models (Schorling (23)) are attempting to overcome some of these difficulties.

Model Validation

The availability of good quality dense gas dispersion data has made model validation possible. There is work in progress in this extremely important area everywhere in which heavy gas dispersion research is ongoing. At LLNL, under U.S. Air Force sponsorship, we are involved in a model validation program which includes development of a model assessment methodology, survey of experimental data to identify benchmark data sets, and model/data comparison using FEM3 or SLAB. The model validation process also includes evaluation of the:

- inherent accuracy of the models' mathematical framework,
- accuracy of available input data,
- accuracy of meteorological description.

appropriateness of model assumptions, accuracy of representation of physical processes, comparisons with laboratory scale, and comparison with field scale.

Thus, field experiments and model development are tied together through model/data comparison and model validation.

SUMMARY

Much progress has been made in our understanding of dense gas dispersion, and much improvement has occurred in our ability to predict the consequences of accidental releases. Even as we gain confidence in our abilities to predict the outcome of simple releases of simple substances, real world demands outstrip these abilities.

This paper has briefly discussed the causes of dense gas behavior including large size, low temperature, flashing two-phase flow, chemical reactions, evaporative cooling, and high molecular weight releases. Many of these causes are beginning to appear in theoretical models of dense gas dispersion. It will be necessary to continue this process if models are to be reliably used for predictions.

Emergency Response Planning for Potential Accidental Liquid Chlorine Releases

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Lawrence Livermore National Laboratory**

**M. Brown, J. Perry and M. Vonada
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**L. Robinson
San Francisco Bay Area Air Quality Management
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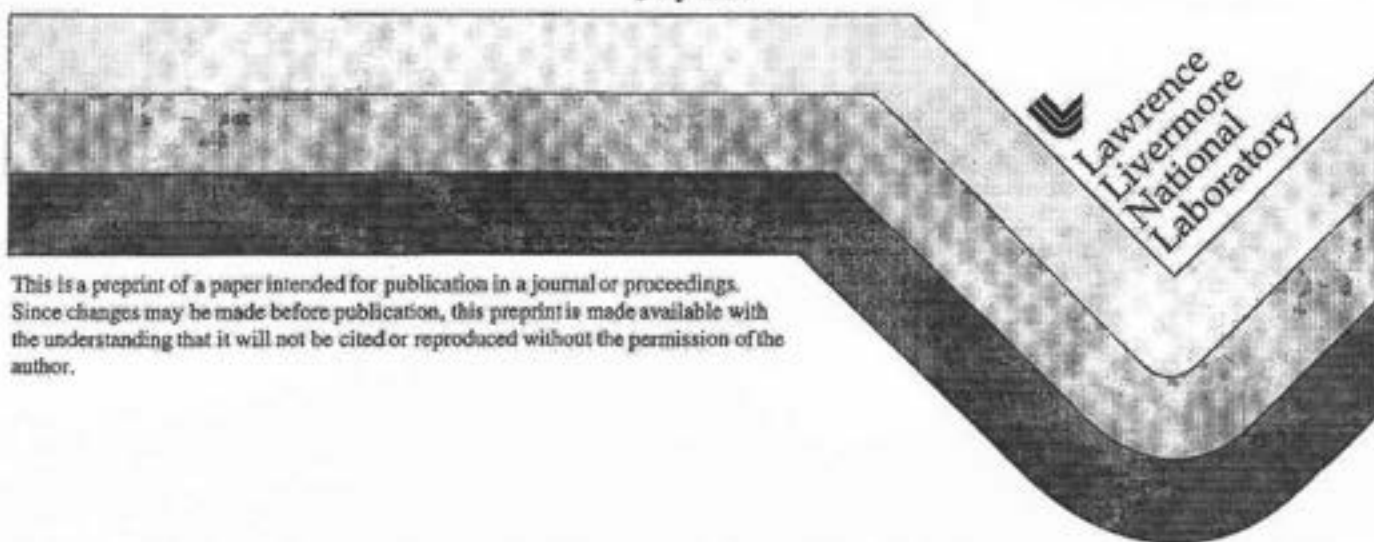
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The Expansion of ARAC for Chemical Releases

R.L. Baskett
M.D. Blair
C.S. Foster
A.G. Taylor

This paper was prepared for submittal to the
*American Nuclear Society 6th Topical Meeting on
Emergency Preparedness and Response*
San Francisco, CA
April 21-25, 1997

July 1997



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THE EXPANSION OF ARAC FOR CHEMICAL RELEASES

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SUMMARY

In 1996 the Atmospheric Release Advisory Capability (ARAC) at Lawrence Livermore National Laboratory (LLNL) completed an effort to expand its national emergency response modeling system for chemical releases. Key components of new capability include the integration of:

- An extensive chemical property database
- Source modeling for tanks and evaporating pools
- Denser-than-air dispersion
- Public exposure guidelines
- An interactive graphical user interface (GUI).

Recent use and the future of the new capability are also discussed.

I. INTRODUCTION

As a centralized US Department of Energy (DOE) resource, ARAC's primary role is to respond to incidents involving nuclear material. However, one-third of ARAC's more than 80 responses and alerts in the past 20 years have involved using limited tools to respond to chemical releases. For example in July 1993, when state and local agencies asked ARAC to estimate the extent of sulfuric acid mist cloud due to a 7258-kg (8-ton) oleum railcar release in Richmond, California, we relied on simple conservative constant source rate estimates.¹ Also, we displayed air concentrations rather than public health effects guidelines on our plots.

II. SOFTWARE GOALS AND REQUIREMENTS

Our primary goal was to implement a generalized set of tools for a wide variety of common industrial chemicals and release mechanisms within our existing 3-D diagnostic modeling system.² An emergency manager faced with immediate decisions regarding public health and safety requires timely and credible model products.

Timeliness demands highly automated computer tools with readily available defaults accessed through an easy-to-use GUI. Our goal is to deliver a set of initial plots in less than 15 minutes to an ARAC-supported site for predetermined default scenarios. Credibility requires maintaining a balance in the accuracy of the three principle model components—source modeling, dispersion modeling, and exposure limits. Evaluations of the ARAC models have shown that accuracy of a factor of two is achievable.³ However, depending on the quality of the accident information, source modeling may not sustain this accuracy. Significant uncertainties also exist in setting health-based acute exposure limits.

For this first implementation we decided to:

- Treat only single component chemicals representing stable products of completed reactions
- Implement a flexible source modeling tool
- Treat positively, neutrally, and negatively buoyant release mechanisms
- Provide defaults for common process, storage, and transportation sources
- Be able to model multiple simultaneous releases consisting of either multiple chemicals or multiple accident locations
- Deliver the initial plots in an easy-to-understand format with health-effect guidelines.

III. COMPONENTS OF CHEMICAL MODELING

Figure 1 illustrates the components of the current ARAC-II modeling system we modified to simulate toxic chemical releases. We relied on some public-domain software to accelerate implementation. While several toxic chemical modeling systems have matured over the last decade,⁴ the National Oceanographic and Atmospheric Administration (NOAA) Areal Locations of Hazardous Atmospheres (ALOHA) model⁵ was one of the few readily available public-domain codes.

A. Chemical Properties

We used the American Institute of Chemical Engineers (AIChE) Design Institute for Physical Property Data (DIPPR) chemical property database⁵ for inputs into the source modeling. ALOHA Version 5.2 contains a list of 906 industrial chemicals that could be released to the atmosphere, 477 of which are included in the current DIPPR Version 10 database of 1458 chemicals. Fortunately most of the common industrial chemicals are included in the intersection of the DIPPR and ALOHA databases. We also added properties for many non-DIPPR chemicals. We built a GUI to access the 26 single-value constants and 13 temperature-dependent functions for DIPPR chemicals and included the ability to easily add new chemicals.

B. Chemical Release Mechanisms

We developed software to calculate source rates and geometries for two new chemical source types—tanks and pools. For these source models, we consulted ALOHA's developers and adapted their code to the ARAC Questionnaire GUI using X-Windows Motif designs. Single phase (gas or liquid) or two-phase (gas and aerosol) release rates from tanks containing gas, liquid, or pressurized or refrigerated liquefied gas are determined using the Fauske-Epstein homogeneous equilibrium model. Evaporation from an instantaneously-formed, constant-radius pool is modeled with an energy balance method with atmospheric and ground condition inputs. While ALOHA has a one-hour source duration limit with five equal source rate intervals, we allow the user to select the time step for the time-varying release rate calculation and allow a release to last up to 24 hours.

Also, we already had three other source types without source rate calculations. For these we specify the source rate directly or estimate it as a fraction of the available inventory. For each of these sources, we provide time-dependent source geometries in our Lagrangian particle model. For stack or direct releases, the user specifies parameters to calculate the time-dependent plume rise if the source is buoyant. For building or fuel fires we estimate the heat emission and employ modified Briggs plume rise equations. For products involved in explosions, we use either a the time-dependent integral plume rise explosive cloud method or a fixed stabilized cloud source geometry.⁷

C. Denser-than-Air Dispersion

The SLAB model developed and evaluated by LLNL⁸ was a natural choice for us to quickly implement a denser-than-air dispersion capability. We modified SLAB's

steady-state inputs to incorporate time-varying meteorology and source rates. Time-varying wind speed and direction at the source location are extracted from ARAC's mass-consistent wind field model, MATHBW. To simulate time-varying source conditions, the source rate is proportioned into several steady-state SLAB model runs. While terrain influences the MATHBW wind field, terrain is not treated in SLAB's dispersion.

D. Exposure Guidelines and Default Plots

We display simple health-effect wording for the current set of 73 American Industrial Hygiene Association (AIHA) Emergency Response Planning Guidelines (ERPGs) and the 327 DOE Subcommittee on Consequence Assessment and Protective Actions (SCAPA) Temporary Emergency Exposure Limits (TEELs).⁹ In addition to showing the three ERPGs or TEELs, we frequently show a fourth contour for 10% of the ERPG-1 or TEEL-1. While below any health effect, this fourth contour is included to conservatively represent a potential order-of-magnitude uncertainty in the overall calculation.

We generate two types of default plots—one set of hourly-average air concentrations and a second plot representing the composite short-term (5-minute) average air concentration for the entire model run. Figure 2 illustrates an example of the latter plot type displayed using US Census TIGER street-level geography.

IV. OPERATIONAL USE

In 1996 ARAC-supported facilities around the country began exercising the chemical response capability. Each facility has an ARAC Site Workstation System¹⁰ with automated Totally-Automated Hands-Off Exercise (TAHOE) software. Users simply enter the time, location, and release type in the Questionnaire. Typically a site will receive the default set of plots in less than 10 minutes.

In 1995-96, we also conducted several in-house practices to test and train on the new software. Figure 2 shows a plot for a practice response based on information from the news. We interpolated meteorological conditions to Bogalusa, Louisiana and estimated the release rate from a nitrogen tetroxide tank car over a 20-hour period.

In addition in 1996, we responded to several requests to simulate actual chemical incidents including:

- A train derailment near Cajon Pass, California
- A mercaptan tank spill in Newark, California
- A potential hydrazine spill from an F-16 aircraft incident at Kirtland AFB, New Mexico
- A refinery fire in Wilmington, California
- A nitric acid spill at Idaho Natl. Engineering Lab

While the vast majority of chemical releases can readily be simulated using desk-top Gaussian-based systems, a centralized modeling system has certain advantages, one of the most important of which is centralized expertise. Also, ARAC's access to worldwide meteorological data makes the system well suited to respond to transportation or other accidents where no on-site meteorological data exist.

In addition, a Lagrangian particle model may be useful in chemical accidents involving:

- Complex terrain settings
- Complex meteorological conditions
- Large or extended incidents
- Multiple simultaneous hazardous material spills, such as those caused by earthquakes¹¹
- Detailed near-in impacts of complex release mechanisms or dispersion in city street canyons
- Complex post-accident analyses.

V. FUTURE DEVELOPMENTS

In 1997-1998, the ARAC service will expand to US emergency operational centers throughout the country on the DOE Emergency Communication Network (ECN).¹²

In addition, potential future developments include:

- Chemical mixtures
- Combustion chemistry
- Reactions and state changes in the atmosphere
- Peak air concentrations
- Integration of a new denser-than-air Lagrangian particle model over continuous terrain with a prognostic capability.¹³

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REFERENCES

1. R.L. Baskett, P.J. Vogt, W.W. Schalk, III, C.S. Foster, and J.S. Ellis, "The Challenge of emergency response dispersion models on the meso-gamma urban scale: A case study of the July 26, 1993 oleum tank car spill in Richmond, Calif.," *Proc. ANS 5th Topical Meet. on Emerg. Prepared. & Response*, April 18-21, 1995, Savannah, GA, p. 248-252 (1995).*
2. T.S. Sullivan, et. al., "Atmospheric Release Advisory Capability: Real-time modeling of airborne hazardous materials," *Bull. Amer. Meteor. Soc.* 74: 2343-2361, (1993).
3. K.T. Foster and M.H. Dickerson, "An updated summary of MATHEW/ADPIC model evaluation studies," UCRL-JC-104134, LLNL, Livermore, CA (1990).
4. S. Brereton, D. Hesse, D. Kalinich, M. Lazaro, V. Mubayi, J. Shim, "Preliminary results of the APAC Spills Working Group," *Proc. ANS 6th Topical Meet. on Emerg. Prepared. & Response*, April 22-25, 1997, San Francisco* (1997).
5. US Dept. of Commerce, *ALOHA (Areal Locations of Hazardous Atmospheres) 5.0 Theoretical Description*, NOAA Tech. Memo. NOS ORCA 65. Natl. Oceanic and Atmos. Admin., Natl. Ocean Service, Seattle, WA (1992).
6. T.E. Daubert and R.P. Danner, *DIPPR Data Compilation of Pure Compound Properties, Version 10*, US Dept. of Commerce, Natl. Inst. of Standards & Technology, Gaithersburg, MD (1995).
7. R.L. Baskett, J.S. Nasstrom, and R.P. Freis, "Evaluation of the Atmospheric Release Advisory Capability emergency response model for explosive sources," *Proc. 20th Intl. NATO/CCMS Intl. Tech. Meet. on Air Poll. Modeling & its Appl.*, Valencia, Spain, North Atlantic Treaty Org., Bruxelles, Netherlands (1993).
8. D.L. Ermak, *SLAB User's Guide: An atmospheric dispersion model for denser-than-air releases* Natl. Tech. Info. Service DE91-008443, Springfield, VA (1990).
9. D.K. Craig, J.S. Davis, D.I. Hansen, A.J. Petroschi, T.J. Powell, "The use of published acute toxicity data to derive temporary emergency exposure limits," *Proc. ANS 6th Topical Meet. on Emerg. Prepared. & Response*, April 22-25, 1997, San Francisco (1997).*
10. R.O. Abriam and R.M. Moore, "ARAC's Site Workstation final design and deployment," *Proc. ANS 5th Topical Meet. on Emerg. Prepared. & Response*, April 18-21, 1995, Savannah, GA, p. 218-220 (1995).*
11. M.K. Lindell and R.W. Perry, "Identifying and managing cojoint threats: Earthquake-induced hazardous materials releases in the US," *J. Hazard. Mater.* 50: 31-46 (1996).
12. R.A. Lambert, "The Department of Energy's Emergency Communication Network," *Proc. ANS 6th Topical Meet. on Emerg. Prepared. & Response*, April 22-25, 1997, San Francisco (1997).*
13. R.L. Lee, J.R. Albritton, S. Chan, J.M. Leone, J.S. Nasstrom, and G. Sugiyama, "ARAC-III, A new generation emergency response modeling system," *Proc. ANS 6th Topical Meet. on Emerg. Prepared. & Response*, April 22-25, 1997, San Francisco (1997).*

*Amer. Nucl. Soc., La Grange Park, IL.

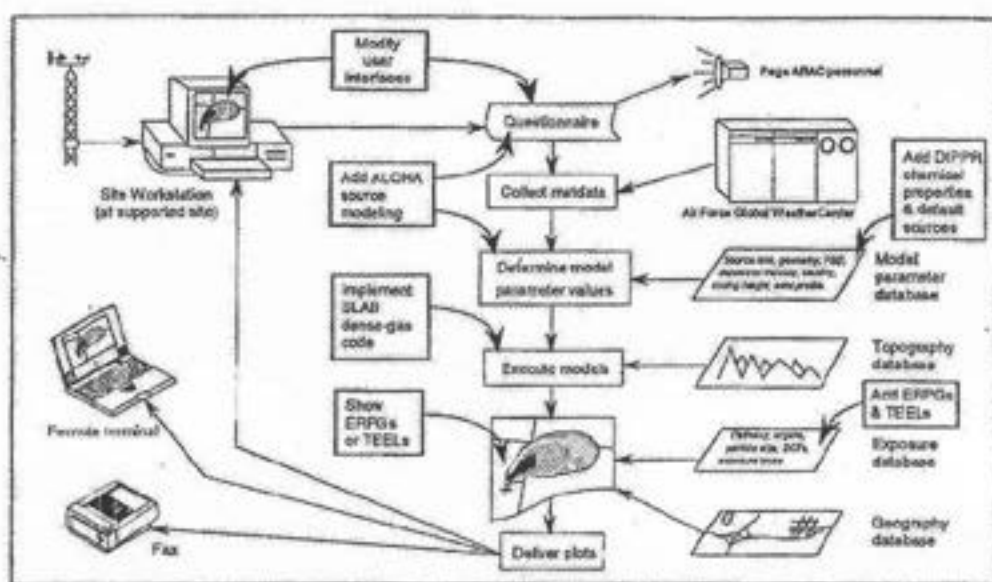


Figure 1. Changes to the ARAC modeling system for chemical responses.

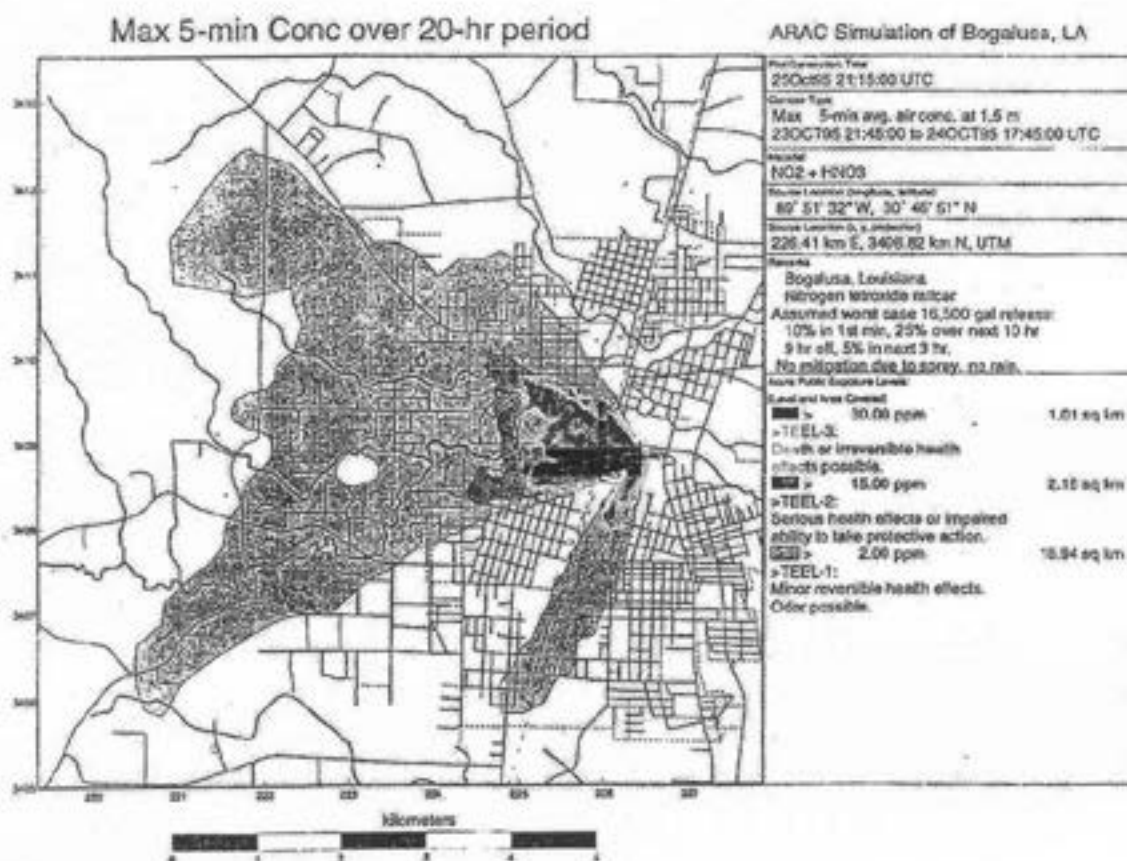
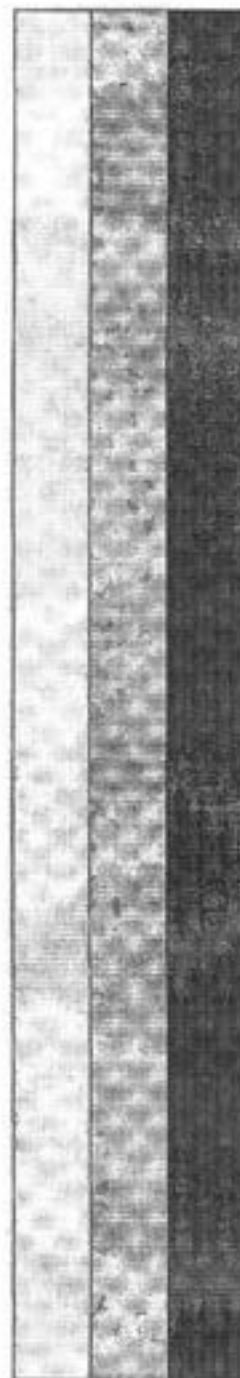


Figure 2. Example ARAC plot for the October 24, 1995 nitrogen tetroxide release in Bogalusa, Louisiana.

Technical Information Department • Lawrence Livermore National Laboratory
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FREE GRI SOFTWARE PROGRAMS

Several computer programs relating to LNG safety have been developed under the sponsorship of Gas Research Institute (GRI). Three of these programs, LNGFIRE3, SOURCE5 and DEGADIS 2.1 were cited in NFPA's 1996 standard on LNG Safety (59A). GRI is making available the latest version of these programs together with the full text of the original reports to the technical community through this web site at no cost. Unlimited technical support to *registered* users of these programs for a period of one year is also available by completing and returning the [E-mail page](#) from this web site, or by fax at (847) 390-7625.

To download, LNGFIRE3, SOURCE5 OR DEGADIS 2.1, together with the abbreviated users' guides and to download the full text of the LNGFIRE, SOURCE, or DEGADIS REPORTS, simply select the desired program by clicking the appropriate button and follow the instructions. To install LNGFIRE3, SOURCE5, OR DEGADIS from the self-extracting compressed files LNGINST.EXE, SRCINST.EXE or DEGINST.EXE that you downloaded, type LNGINST, SRCINST or DEGINST at the DOS command prompt. Documentation files are provided with each program. These files (LNGFIRE.DOC, LNGFIRE.WPD, SOURCE.DOC, SOURCE.WPD, DEGADIS.DOC and DEGADIS.WPD) are available in MS WORD 6.0 and Word Perfect 6.1 formats. Retain the version that you wish and erase the other.

LNGFIRE3 allows the user to calculate the radiant flux levels to horizontal and vertical targets and the maximum flux level from confined LNG pool fires at up to ten user-specified distances, and the exclusion zones to the four flux levels specified by the federal standard 49 CFR 193.2057. This program supersedes the program LNGFIRE originally included in the report entitled *LNGFIRE: A Thermal Radiation Model for LNG Fires* (GRI Report Number 89/0176). This report may be downloaded by clicking on the DOWNLOAD LNGFIRE REPORT button. This file is 640 KB in size. This report is also available from NTIS (PB91-220137). **LNGFIRE3** supersedes the program provided with *LNGFIRE2: User's Guide*, GRI Report Number GRI-92/0532.

SOURCE5 supersedes all previous versions of SOURCE, originally distributed as part of the report: *"The Spread and Vaporization of LNG,"* GRI Report No. 92/0534. SOURCE5 allows the user to develop the transient vapor generation rate from an instantaneous or continuous spill of LNG on land or water. Spills in dikes of various shapes and substrates and the presence of a sump are also addressed. The results are presented in a file which may be directly imported into the vapor dispersion program DEGADIS (or its WindowsTM version, DEGATEC). *The Spread and Vaporization on LNG* report which is 434 KB in size, may be downloaded by clicking on the DOWNLOAD SOURCE REPORT button.

DEGADIS 2.1 is a dense gas vapor dispersion program designed to model the atmospheric

dispersion of ground-level, area-source dense gas (or aerosol) clouds released with zero (initial) momentum into an atmospheric boundary layer over flat, level terrain. A jet plume model has been interfaced with DEGADIS to predict the trajectory and dilution of vertically oriented gas or aerosol jets with positive, neutral, or negative buoyancy. For negatively buoyant jets, if the jet/plume returns to ground level, DEGADIS predicts the ensuing ground-level plume dispersion. The results are presented in tabular form. Users **must** have access to either "LNG Vapor Dispersion Prediction with the DEGADIS Dense Gas Dispersion Model," by Jerry Havens and Tom Spicer, Gas Research Institute Report No. GRI 89/0242,(1990) also available from NTIS #PB91-509711 or "User's Guide for the DEGADIS 2.1 Dense Gas Dispersion Model," by Tom Spicer and Jerry Havens, US Environmental Protection Agency Report No. EPA-450/4-89-019,(1989), NTIS #PB90-213893. The former report is n/a KB in size. It may be downloaded by clicking on the DOWNLOAD DEGADIS REPORT button.



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**Industrial
Partnerships &
Commercialization**

FEM3A

The FEM3A modeling code accurately predicts the dispersion of heavier-than-air clouds from hazardous spills

Applications

Why is this code important?

Large spills of hazardous materials, such as chlorine, hydrogen cyanide or sulfuric acid, often produce heavier-than-air gas clouds. Unlike trace gases, these clouds tend to hug the ground and dissipate slowly, thus creating potentially higher risks to health and the environment. FEM3A can help address one of the important environmental problems of our time: how to be prepared to deal with these spills *before the fact* and when they occur.

FEM3A can handle complex situations with greater accuracy

FEM3A takes into account terrain and obstructions, extremely important factors in predicting cloud movement. Because the code is fully three-dimensional, FEM3A can simulate complicated cloud structures that are beyond the prediction capability of simpler models. The code can deal with instant releases of hazardous materials, such as a burst tank of liquified natural gas or chlorine, or releases of finite or continuous duration.

FEM3A designs and locates safer facilities for hazardous chemicals

FEM3A has been used to assess the potential hazards associated with storing more than 10,000 gallons of liquid chlorine at a sewage treatment plant located near San Francisco Bay. Researchers are also using the FEM3A model, in conjunction with wind tunnel experiments, to evaluate potentially effective mitigation techniques for accidental releases involving heavier-than-air gas clouds.

The accuracy of FEM3A has been validated at the Spill Test Facility at the Nevada Test Site.

Hardware

FEM3A runs most efficiently on a mainframe computer, such as the Cray-1 or Cray-2.

Open for collaboration

The Laboratory is seeking an organization interested in collaborating on further improvements to FEM3A. The Technology Transfer Office will work with interested companies to tailor agreements that

meet their needs.

Contact:

*Diana "Cookie" West
Tel. No.: (510) 422-6416
Mail Code: L-795*

Applications

- *predict movement of heavier-than-air gaseous clouds from hazardous spills*
 - *assess potential hazards at chemical processing and storage sites*
 - *evaluate mitigation techniques for accidental releases*
 - *perform site assessment studies for facilities using hazardous chemicals*
-

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The Industrial Partnerships and Commercialization office at Lawrence Livermore National Laboratory invites industries to call and explore the possibility of a match between their technological needs and our Laboratory's multidisciplinary capabilities. Our "specialists" know how to connect industry representatives with researchers in their field of interest. To start, simply phone, write a letter, or e-mail to:

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Tech Papers**FLIXBOROUGH - 20 YEARS AFTER**

Trevor Kletz

2nd Biennial Canadian Conference on Process Safety and Loss Prevention

1 Introduction

On 1 June 1974 a vapor cloud explosion destroyed the Nypro cyclohexane oxidation plant at Flixborough, killing 28 people. Other plants on the site were seriously damaged or destroyed and the site presented a scene of utter devastation. Twenty years later it is timely to look back and see whether or not we learnt the lessons spelt out in the official report¹ and other publications², and if we still remember them.

About half the people who now work in the chemical industry were at school or university when the explosion occurred. They did not experience the shock, the public reaction and the soul-searching that went on at the time and may not know what happened, so here is a brief summary.

The plant was a stage in the production of Nylon. It manufactured a mixture of cyclohexanone and cyclohexanol (known as KA, or ketone/alcohol mixture) by oxidising cyclohexane, a hydrocarbon similar to petrol in its physical properties, with air in a series of reactors. One of them developed a leak and had to be removed for repair and a temporary pipe was constructed to replace it. There was no professional mechanical engineer on site at the time as the works engineer had left and his replacement had not arrived. The men who were asked to design and install the temporary pipe had great practical experience and drive; they had the plant back on line in a few days. However, they did not realize that designing large pipes (20 inch bore) to operate at high temperature (150°C) and pressure (10 bar) was a job for experts. Their only drawing was a full-size sketch in chalk on the workshop floor; the only support was scaffolding on which the pipe rested. We cannot blame them as they were asked to do a job beyond their professional capabilities and they did not know it was beyond them.

2 The need to control modifications

The explosion showed that we need systems for the control of modifications, including temporary ones. No change should be made to a plant or process until suitably qualified people have examined it systematically, looking for unforeseen consequences and checking that it has been designed to the original standard. Since then many, perhaps most, companies have set up formal procedures for the control of modifications but nevertheless many incidents still occur because there is no procedure, or it is not followed or it is followed in a perfunctory way^{3,4}. Every fresh intake of employees has to be trained in the need for these procedures and old hands need to be reminded from time to time. Instructions alone are not enough. The Institution of Chemical Engineers has recently updated its training package, developed soon after Flixborough, on the control of modifications⁵.

BREEZE™ HAZ



BREEZE HAZ models analyze emissions from accidental liquid, gaseous, and dense gas releases. These models make it easier to model toxic gas releases for the preparation of emergency response plans, meeting toxic release analysis requirements, determining human exposure risks, and performing probabilistic risk analysis. The *BREEZE HAZ* products are:

ADVISOR - This valuable utility is an interactive version of EPA's guidance for off-site consequence analyses.

EXPERT - This powerful software performs the initial source term analysis required to determine the source parameters for an accidental release modeling analysis, and recommends the appropriate dispersion model.

AFTOX - This Windows-based puff/plume dispersion model predicts concentrations from continuous and instantaneous, liquid and gas, surface and elevated releases of toxic chemicals from point or area sources.

DEGADIS+ - This chemical-specific model predicts dispersion from instantaneous, steady-state, and transient releases of LNG, LPG, ammonia, chlorine, hydrogen fluoride and other dense gases.

INPUFF - This EPA multiple puff model analyzes non-continuous toxic gas releases occurring at up to 144 user-selected time steps or the more typical continuous plume from a stack.

HOT SPILLS - This model first calculates the products of combustion and heat balance from burning chemical releases. It then predicts downward dispersion and ground-level concentrations of the resulting chemical products at preprogrammed and/or user-specified downwind distances.

BREEZE HAZ SUITE - A seamlessly integrated product that includes the BREEZE HAZ EXPERT, for performing the source term analyses and the DEGADIS and AFTOX dispersion models for analyzing a wide range of accidental releases.

LFGRISK - This is a Microsoft Windows based software package consisting of a suite of hazard prediction models for accidental releases of Liquefied Fuel or Flammable Gases (LNG and LPG). It predicts hazard zones surrounding confined pool fires, unconfined pool fires, and jet flames. The software is used to determine the rate of vapor cloud generation for use with DEGADIS+ and SLAB.

XPLOSION - A Microsoft DOS application for predicting hazard zones from Unconfined Vapor Cloud Explosions (UVCEs) and from Boiling Liquid Vapor Explosions (BLEVEs) from cylindrical and spherical vessels.

Estimating Emission Rates from Haz Mat Releases

Here's a few ways to quickly estimate the emission rates and ambient

by Ajay Kumar

Under Section 112(r) of the Clean Air Act Amendments of 1990, the U.S. Environmental Protection Agency (EPA) has developed requirements for owners and operators of facilities regulated for hazardous substances to implement accidental release prevention programs to include release prevention, emergency planning and risk management plan registration.

To plan for an accidental release prevention program, plant owners and operators should assess the severity of any accidental release of hazardous liquids or gases at their facilities. In addition, plant personnel working with hazardous materials also should be educated regarding the severity of any accident involving the release of hazardous materials. Once the accidental release has occurred, some simplified equations can be used to quickly estimate emission rates and ambient concentrations of hazardous materials in the vicinity of accidental releases.

The following are three instances that illustrate the use of the estimation formulas.

Case one

Accidental release of low volatile liquid from a tank onto the ground --

For spills of liquids which do not boil at ambient temperature, the liquid evaporation rate can be calculated using the following formula:

$$Q = 5.10 \times 10^{-6} U^{0.78} P v M w^{0.67} A p^{0.94} (1)$$

Case two

Accidental release of highly volatile liquid from a tank onto the ground --

Evaporation rate from a small accidental release of highly volatile liquids can be assumed to be instantaneous. If the leak is significant and not small, a pool of the boiling liquid will form. In either case, the evaporation rate of the spilled liquid can be assumed to be equal to the liquid release rate. Liquid release rate from a tank can be estimated

GIS/LIS (1994), p154-163, copyright GIS/LIS

ESTIMATING THE POPULATION CHARACTERISTICS OF AREAS AFFECTED BY HAZARDOUS MATERIALS ACCIDENTS

Jayajit Chakraborty
and
Marc P. Armstrong
*Department of Geography
The University of Iowa
316 Jessup Hall
Iowa City, IA 52242
319/335-0153
319/335-2725 (fax)*

ABSTRACT

In this paper we develop an approach to determine the demographic composition of a population likely to be affected by the release of toxic substances resulting from vehicle accidents. In this approach a dispersion model provides a toxic dispersal "footprint", given local weather conditions and the type of chemical released. This footprint is overlaid on a demographic database to determine the composition of the affected population. The system was implemented for the city of Des Moines, Iowa. We obtained the locations of the 50 intersections that had experienced the highest frequency of truck accidents from 1990 to 1992. At each of these locations we generated a plume footprint based on the release of chlorine, a commonly transported toxic material in Des Moines, and a set of specific weather conditions. Using GIS software, we calculated the racial and economic characteristics of the population in each plume. We also generated similar plumes at 50 random locations in the city and made similar measures. The areas most likely to experience exposure to hazardous materials were those with a higher concentration of minorities and low-income households, as compared to the city as a whole.

INTRODUCTION

Each year more than 1.5 million tons of hazardous materials are transported across U.S. highways, railroads, waterways, and air routes (Office of Technological Assessment, 1986). As a result of increased public awareness about the dangers involved in transporting these hazardous materials, regulatory policies and legislation are being introduced with the aim of reducing the risks from hazardous shipments. Previous policies in this area have tended to focus on specific materials and types of shipments (e.g. the movement of radioactive materials), but with the passage of the Hazardous Materials Transportation Uniform Safety Act of 1990, this attention has been expanded to encompass a major segment of the transportation industry (Abkowitz and Lepofsky, 1993). As transportation hazard analysis and incident management operations are now recognized as important components of contemporary transportation operations and regulations, there is a growing need to develop conceptual frameworks and methods that can be used to assist decision-makers and emergency personnel in dealing with these problems. The purpose of this paper is to demonstrate how GIS technology can be used to estimate the impact of accidents involving hazardous materials on the surrounding population. The approach can be used to determine the number of people likely to be affected and the composition of the population at risk.

Integrating Atmospheric Dispersion Modeling with ARC/INFO:

A Case Study of the Regional Atmospheric Response Center, Denver Colorado

Reed Hodgins, John Ciolek, David J. Buckley, David Bouwman

Abstract

Recent developments in the sophistication of GIS application programming interfaces (API) combined with advances in the science of atmospheric dispersion modeling, communications, and computer hardware have provided the platform for development of an atmospheric modeling system for emergency response. The Regional Atmospheric Response Center (Denver, Colorado) has developed an advanced system for predicting the path and impacts from toxic chemical emergencies. The Computer Assisted Protective Action Recommendations System (CAPARS) reflects the latest in integration between GIS, inter-application communication, and atmospheric dispersion modeling.

The Terrain Responsive Atmospheric Code (TRAC) model provides plume and health impact predictions within CAPARS. The TRAC model simulates realistic plume paths for releases and spills in the most complex terrain. In particular, CAPARS and TRAC are operational in one of the world's most demanding environments: emergency response at the U.S. Department of Energy's Rocky Flats Research Facility, a former nuclear weapons and plutonium manufacturing plant in the mountainous terrain of Colorado.

The integration of sophisticated atmospheric dispersion modeling, TRAC, with GIS technology is a major innovation within CAPARS. Utilizing ARC/INFO as the foundation for spatial data management, CAPARS affords timely and accurate predictions and recommendations to emergency scenarios.

This paper summarizes the integration of sophisticated atmospheric modeling technology with a Geographic Information System (GIS), namely ARC/INFO, to conduct rapid response assessments of health impacts following hazardous materials emergencies. The Regional Atmospheric Response Center is introduced. An upgraded atmospheric modeling system used at the Center, termed the Computer-Assisted Protective Action Recommendation System, is discussed. This paper reviews the design and implementation of CAPARS with a particular reference to issues of GIS application development and functional capabilities.

1.0 The Regional Atmospheric Response Center

Meeting the challenges of planning, compliance, and emergency response to accidental airborne releases of hazardous materials is difficult and expensive, but they must be met for the protection of our workers, the public, the community, and the businesses that are essential to our economic strength. The answer lies in the recognition that the challenges discussed above are shared throughout the community. It is not necessary that each organization attack these problems alone, as is now the case. In fact, this is inefficient, wasting scarce resources and funds. The best solution is a common effort to address a common problem...

Search

Working Notes on Community Right-to-Know * November-December 1994

Working Group on Community Right-to-Know

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E-mail: orum@rtk.net
Paul Orum, Editor

Changes Modify Right-to-Know

The U.S. Environmental Protection Agency (EPA) has completed two major changes to the Toxics Release Inventory (TRI), our right-to-know law for toxic chemical waste from industrial facilities.

First, after years of advocacy by public interest groups, EPA has added 286 substances to the list of right-to-know chemicals, bringing the total TRI list to 654.1 These additions are a major expansion, one of several steps supported by EPA Administrator Carol Browner.

Second, EPA reduced reporting requirements for facilities that produce less than 500 pounds of a TRI waste.2 Industry groups had pushed hard for a special exemption for "small" TRI releases (up to 5,000 pounds!). However, after receiving widespread objections from public interest groups, EPA adopted an approach that keeps most information in the right-to-know data base and avoids creating a new "recycling" loophole.

More chemicals

Last January, EPA proposed to add over 300 chemicals to TRI, including many pesticides, after reviewing substances regulated as toxic under other environmental laws and programs. The agency's final rule, announced November 30, added 286 chemicals to TRI, but deferred action on about 40 others. EPA indicated that its next action to expand the TRI list would address both these remaining chemicals and persistent bioaccumulative substances, such as dioxin, that fall below current reporting thresholds.

Listing 286 chemicals partially completes EPA's "phase I" expansion of the TRI program. The agency continues work on two additional TRI expansion efforts: "phase II" will add many currently exempt non-manufacturing industries to the program (a proposal is expected during 1995), and "phase III" will explore ways to require reporting on chemical use and worker exposure.

Alternate threshold

Facilities that generate less than 500 pounds of waste (prior to recycling, treatment, or disposal) will no longer file full TRI reports under a new alternate threshold.* 500 pounds is roughly equivalent to a 55 gallon drum of toxic waste. Companies that use the alternate threshold won't have to tell where these wastes go. Instead these companies will file a simple annual certification (entered into the TRI database), and keep records documenting the exemption.

The alternate certification affects about 20,000 reports (from some 10,000 facilities) out of over 80,000 total reports filed.

**RADIAN REPORT**

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SEARCH

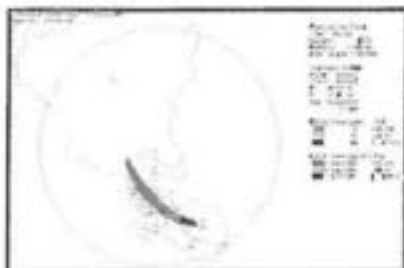
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Effective modeling for RMP hazard assessment

By Buzz Harris and Jennifer Baker

A CHARM screen displays the path, size, and concentration of an airborne chlorine plume, overlaid on a map showing population densities.

The Risk Management Program (RMP) rule was signed by EPA Administrator Carol Browner on May 24, 1996. By the compliance date of June 21, 1999, facilities subject to the RMP rule must perform a hazard assessment, implement both a prevention program and an emergency response program, and prepare and submit a risk management (RM) plan.

Conducting a hazard assessment will require companies to perform release modeling as part of their RM plan. With the impending RM plan, companies will want to release to the public estimates that represent, realistically and accurately, minimal impacts for worst-case scenario and alternative release scenarios. But deciding which model is appropriate is not a simple choice. As statistician George Box has stated, "All models are wrong, but some are useful."

The predicted impact distance from each model varies with the chemical, release scenario, concentration of interest, and/or distance from the release point. No single model exists that will consistently give the lowest or best results for all scenarios that a facility will have to model.

Many types of software are available for modeling release scenarios. EPA has provided "lookup tables" in the Offsite Consequences Analysis Guidance document. The lookup tables have been prepared by running public domain computer models for thousands of generic release scenarios. Public domain computer models (such as CAMEO/ALOHA, ARCHIE, SLAB, etc.) can also be used, but they generally offer little advantage over the lookup tables, since EPA developed their tables using the (public domain) computer models.

A wide range of sophisticated commercial computer models is also available that can usually provide a more accurate, refined estimate of impacts than is possible from the lookup tables or the public domain models. In general, the refined models offer more benefits in modeling the alternative release scenarios. This is because EPA has so narrowly defined the allowable modeling parameters for the worst-case scenarios-in effect negating much of the flexibility of the

**For Presentation at the Air & Waste Management Association's
90th Annual Meeting & Exhibition, June 8-13, 1997, Toronto,
Ontario, Canada**

97-TA33.03

Show Paper

Accidental Release Analysis for Chlorine Gas: A Comparison of CAMEO, HGSYSTEM and JET/DEGADIS

Harry K. Bishop and Lawrence B. Gratt

IWG Corp., 2241 Kettner Blvd., Suite 220, San Diego, CA 92101

David McKinley

The NutraSweet Kelco Company, 2145 East Belt Street, San Diego, CA 92113

Abstract

Environmental regulation, such as the Clean Air Act Amendments of 1990, now require the preparation of risk management plans (RMP) for facilities that handle hazardous materials such as chlorine. Air dispersion models have been developed to predict the probable impact of an accidental release of such materials. For a specific release, the concentrations to reach various reference levels calculated by each model may vary. Guidance as to which model to use and the differences between models for specific chemicals and scenarios is lacking. This paper will present the results for three different models for high, moderate and low chlorine release rates for an actual facility on the coastline of San Diego, California.

The CAMEO/ALOHA, JET/DEGADIS and HGSYSTEM air dispersion models were used to predict downwind ranges to the IHDL chlorine concentration (10 ppm) for all scenarios. The calculation of plume concentrations at low release rates is frequently limited. CAMEO/ALOHA and JET/DEGADIS use much the same calculations and predict similar concentrations following a release. All three models, particularly CAMEO/ALOHA and JET/DEGADIS, exhibit difficulty in predicting the consequence of a low level release. The minimum release rate that can be effectively analyzed by the CAMEO/ALHOA and DEGADIS models is approximately 1 g/s.

Lower concentrations are predicted by the CAMEO/ALOHA model. Concentrations predicted by the HGSYSTEM models were found to be two to three times greater than those predicted by the CAMEO/ALOHA and JET/DEGADIS models. Further research is needed to establish the cause of these differences.

RTK NET

The Right-to-Know Network

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Welcome to RTK NET, a network providing free access to numerous databases, text files, and conferences on the environment, housing, and sustainable development. With the information available on RTK NET, you can identify specific factories and their environmental effects; analyze reinvestment by banks in their communities; and assess people and communities affected.

There are no fees; RTK NET is free. It was established in order to empower citizen involvement in community and government decision-making. You can access RTK NET via the web, bbs, or telnet. RTK NET offers the following:

- **Databases:** We provide access to government databases and we let you search them for free. We have many databases on the environment and housing. We are continuously adding and updating our databases. See the "What's New" section for updates.
- **Technical Support:** We provide a user manual and other materials that help you access and search the databases (online access to these materials are available under help and documents). In addition, you are welcome to call us if you have problems accessing or searching the databases.
- **Trainings:** RTK NET staff conduct trainings around the country at a variety of venues. Through our trainings, users learn how to access and understand the data. We encourage you to browse through our schedule to see when a training is scheduled near you.

RTK NET was started in 1989 in support of the Emergency Planning and Community Right to Know Act (EPCRA), which mandated public access to the Toxic Release Inventory. It is operated by two nonprofit organizations--[OMB Watch](#) and [The Unison Institute](#)--and funded by various government agencies and foundations.

1742 Connecticut Avenue, NW; Washington, DC 20009
Phone: 202/234-8494|Fax: 202/234-8584|Email:webmaster@rtk.net

Revised: Jan 28 1998

Facility: PIONEER CHLOR ALKALI
Address: 8000 LAKE MEAD BLVD.
City: HENDERSON
County: CLARK
Phone: (702) 565-8781
Owner: CLIFFORD H. BARR
Primary Product: CHLORINE, SODIUM HYDROXIDE, HYDROCHLORIC ACID
Release : 8000 LAKE MEAD BLVD.
City: HENDERSON
County: CLARK

Reporting Year: 1991
State: NV Zip: 89015
Dun & Bradstreet #: 06-208-1500
SIC(s): 2812 2819 2869
Number of employees: 170
State: NV Zip: 89015
Phone: (702) 565-8781

Release start date: 05/06/1991 Time: 01:10
Release end date : 05/06/1991 Time: 07:30

Chemical Name: CHLORINE CAS Number: 7782505

Concentration (%): 100% Physical State: GAS
Air: 84,000.00 Surface Water: 0.00 (lbs)
Land: 0.00 Treatment Facility: 0.00 (lbs)
Total: 84,000.00 (lbs)

	Responders	Employees	Contractors	Public	Total
Injuries :	0	1	0	759	760
Hospitalized:	0	0	0	15	15
Deaths :	0	0	0	0	0
Evacuated :		10	1	378	389
Shelter-in-place:		0	0	770	770
Facility Cost: \$2,425,000	Public Cost: \$1,125,000	Total Cost: \$2,425,000			

Authorities notified-

Name	Date	Time	Contact Name
NV SERC	05/06/1991		
CLARK CO. ACB	05/06/1991	08:00	LORI ANDERSON

Miscellaneous-

ERNS ID: 913937 NRC ID: 70909 ARIF ID: 3903

Latitude: 36:02 Longitude: 115:00

Release caused by: A (A=Equipment Failure, B=Operator Error)

Location of loss of containment: PIPING: ELBOW

EPA Region: 09 ERNS Report Date: 05/06/1991 Time: 10:21

When release occurred-

DURING ROUTINE OPERATION

Status of process line-

OTHER (PLEASE DESCRIBE)

How release was discovered-

CHEMICAL SPECIFIC DETECTOR, ALARM

Immediate activities in response to release-

PLANT/PROCESS SHUTDOWN

Causes(s) of release-

OTHER (PLEASE DESCRIBE)

End effect(s) of release-

VAPOR RELEASE

Environmental effect(s)-

VEGETATION DAMAGE

Methods of communication with public-

DOOR-TO-DOOR NOTIFICATION

RADIO

TELEVISION

TELEPHONE

Training, procedures, and management used before this release-

PREVENTIVE MAINTENANCE/INSPECTIONS

ACCIDENT INVESTIGATIONS

AUDITS

INVENTORY/CAPACITY REDUCTIONS

EMPLOYEE SAFETY TRAINING

STANDARD OPERATING PROCEDURES

EMERGENCY RESPONSE TRAINING

New training, procedures, and management used after this release-

PREVENTIVE MAINTENANCE/INSPECTIONS

AUDITS

INVENTORY/CAPACITY REDUCTIONS

EMPLOYEE SAFETY TRAINING

Engineering systems or controls used before this release-

CONTROLS FOR OPERATIONS MONITORING AND WARNING

NONE

New engineering systems or controls used after this release-

MONITORING EQUIPMENT: INSPECTION/REPAIR/REPLACEMENT/INSTALL

EQUIPMENT: UPGRADE/REFINE/REPAIR/REPLACEMENT/INSTALL

REVIEW/CHANGE SOP

EQUIPMENT: INSPECTION

See also <http://rthk.net/E9722T128>

The Corporation of The District of North Vancouver

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V7N 2K6



Mailing Address
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Planning & Development Services

Telephone: 604-990-2387

Fax: 604-984-8664

FAX TRANSMISSION RECORD

Operator

March 9/98
Date

SEND:

TO:

FAX #:

ATTENTION:

MESSAGE:

*Corrie: I have attached the
questions & answers from Oct 30/97
meeting with Can Dry.*

REPLY:

District of North Vancouver
Planning Department

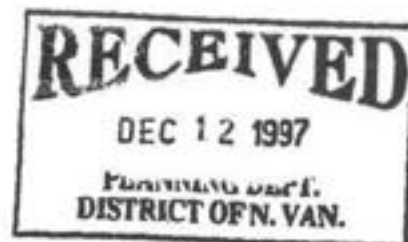
Telephone: 604-990-2____
Fax: 604-984-8664

Attention: _____

We are transmitting *4* pages (including cover sheet)

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SUMMARY OF QUESTIONS & ANSWERS**October 30, 1997****Information Meeting on the QRA****North Vancouver Plant**

The following is a list / summary of the questions and answers presented at an information meeting held at the North Vancouver plant of CXY Chemicals on October 30, 1997. Only those questions related to the QRA or plant operations are included. Other questions, such as those relating to plant operations, will be answered directly by the District.

Questions from Angela Trudeau**Q.1 Wind Direction**

I have recently spoken with two recreational sailors familiar with the area who state that the wind direction in this section of the narrows has two specific and different patterns, depending on the time of year and weather conditions. Also, that the wind patterns at the section of the site near the plant are different from that at the GVRD station, due to topography and second narrows wind-mixing dynamics.

Obviously, this is colloquial information. Does the available wind data rule this out or indicate that this could be an area for investigation? If so, would the plume modelling require redefinition (as a worst case) until such time as adequate site-specific data is compiled?

A. 1 The risk analysis included the review of data from both the bridge station and a meteorological station on site. The two sets of data were very similar, and the data set for the bridge was used as it was slightly more conservative for the area of particular concern to the north of the site. (The bridge data set showed a slightly higher chance that the wind would blow onshore). Many risk analysis must rely on data for a general area and do not have the advantage of two different weather stations in close proximity.

The risk analysis is not based on just one weather pattern. It uses data collected over a long period of time which means that a range of weather patterns will be included - from the dominant ones mentioned by the recreational sailors to those that only occur a very small percentage of the time.

Q.2 Planning Issues. Are you able to make recommendations to the following questions?

While the risk assessment does not consider other conditions in the

OCT 30/97 → MAR 9/98
TO GET A REPLY !!

community such as bridge and road access conditions, emergency response planning and response capability, should they be considered by the municipality in land-use planning?

Do you have any additional recommendations to make to the municipality

- other operations which may require risk assessment
- emergency response planning
- land use planning

MIACC does not define the recommended land uses precisely. Given what you know about the risks and the area, what additional limitations would you place on the land use designations within the MIACC definitions, ie.

- number of employees in industrial, commercial operations
- any specific operations to be avoided
- "low density" residential definition?

A.2 The risk analysis has taken no credit for community emergency response planning or various mitigation strategies (such as sheltering in place). If such factors were to be considered, they would reduce the risk levels from those depicted in the report. The municipality might want to consider such factors in its land use planning.

Trying to fill in the detail in MIACC's land use guidelines is subjective, but a comparison with guidelines established in the United Kingdom by the Health and Safety Executive (HSE) suggests that workplaces might be thought of as those containing less than 100 employees. They view the presence of small industrial developments, offices and warehouses near a facility as being reasonable. It would not make sense to add facilities with sensitive or immobile populations in the immediate vicinity of the plant. In terms of what "low density" residential means, little guidance is available. However, the HSE is currently leaning toward allowing small housing developments in some of the areas that commercial/industrial activities are allowed. Unfortunately, they do not define what they mean by small housing developments.

For the area to the west of the plant, it would be beneficial to ensure that they work closely with the plant in terms of training staff on emergency response and sheltering in place. They could also participate in some of the drills that the plant conducts. There should be an established communication plan for immediate notification by the plant in the event of a release, but this plan should not interfere with communications from the plant to the regional emergency response centre.

Questions from David Sadler

Q.1 I understand the MIACC guidelines consider multi-family condominiums as low density, while here in the District we regard such developments as medium density. You touched upon this fact when discussing the new proposed condo development at 1984, 1988 & 2012

Dollarton Highway. Please supply the range of population density figures for what the MIACC guidelines define for low, medium, high etc.

A.1 believe this has been answered in the response to Angela Trudeau.

Q.2 Seymour's 25,000 residents have only two roads in and out of the area (Dollarton and the Mount Seymour Parkway) and could be potentially trapped in the event of a major accident. Elsewhere, the residents surrounding a plant could probably escape in any number of directions. Has the Risk Assessment incorporated this factor into their calculations.

A.2 The Risk Assessment assumes no credit for evacuation or sheltering in place. The answer therefore is yes, this Assessment did account for this.

Q.3 Please identify other chlorine plants in North America which are located within city limits as I would like to contact them. I attempted to obtain this information from the Chlorine Institute in Washington. However, as I was not a member there is a charge. This information should be readily available to CanOxy since they are a member.

Q.3 Pamphlet has been ordered.

Q.4 What is the time frame in hours (minimum to maximum) that the public would be in danger from a major chlorine release?

A.4 In the event of a major release (worst case scenario) people would be exposed for less than 1 hour and should shelter in place for that period of time.

Q.5 How polluted is the CanOxy site? What are the major contaminants? When the plant closes, could residential housing be permitted on the site because of the pollution?

A.5 There is asbestos land filled on the plant site - this is a licensed waste site. Prior to 1974, chlorinated tars were buried in the same area but the precise location is not known.

Questions from Corrie Kost

Q.1 Since insufficient details were provided in any of the available documents in order for me to feel comfortable that the various chlorine release impacts have been done properly, I have requested that pamphlet 74 be made available. This pamphlet, estimating the area affected by a chlorine release provides colour graphs showing downstream chlorine plots at 25 and 10 parts per million (ppm) for 14 different scenarios. This would enable me to cross-check the validity and conclusions of the models which were reviewed in the report of July 4/97. I was informed that pamphlet 74 (currently in revision) would be sent to me in about 1 month. I trust I will be given the

appropriate time so that I can put forth an informed decision on the matter of the validity of the quoted risk assessment.

A.1 Pamphlet has been ordered.

Q.2 In conjunction with the above I should like to submit for the record (and have it verified by the appropriate experts in this field) the calculations submitted below. The question as to what was the maximum that could be covered by 300 tonnes of vapourized chlorine (say to a height of 3 meters above ground level) at the lethal dosage of 1000 ppm is one worthy of consideration. I have calculated this to be about 30 km². The calculation was done as follows:

300 tons = 3×10^8 gms

1 mole of Cl₂ (ie. 70 gms) occupies 22.4 litres in a gas state at STP

300 tons thus occupies a volume of $22.4 \times 3 \times 10^8 / 70$ litres

Diluted in volume to 1000 ppm would expand this by 1000 and since 1m³ = 1000 litres the two factors cancel nicely to give a volume of $22.4 \times 3 \times 10^8 / 70$ m³

Dividing by the height of 3 metres gives an area of $22.4 \times 10^8 / 70$ m² ie. 32 $\times 10^6$ ie. 32km²

Now one can readily generate the following areas for different densities (ppm)

Parts per Million	Height (meters)	Area (km ²)
1000	3	32
1000	10	9.6
1000	30	3.2
300	3	107
300	10	32
300	30	10.7
100	10	96
100	100	9.6
10	10	960
10	100	96

It would be informative to know the mortality rates/times for these proportions (ppm) as well.

A.2 Mr. Kost's estimate of plume extents assumes that the material is uniformly mixed within an enclosed, predefined volume and that no material leaves the cloud. The dispersion models used in this assessment attempt to model turbulent diffusion under specified atmospheric conditions which results in a distribution of concentrations over the area affected by the plume. This distribution is typically characterized by higher concentrations at the

plume centreline and closer to the source of the release, and with concentration dropping off as one moves off centreline and away from the source. Some of the factors the model attempts to account for are as follows:

- The effects of turbulence generated by the interaction of the wind with obstructions on the surface
- The effects of increased turbulence generated by daytime heating of the ground and the suppression of turbulence resulting from nighttime cooling of the ground
- The enhanced mixing clouded by gravity spreading of a dense gas cloud
- The reduced dispersion that results when the cloud is heavier than the ambient air.

The dispersion model SLAB was used to estimate the maximum area within which the concentration will meet or exceed 1000 ppm over the duration of the release taking into account the factors listed above. The release considered was a 289 tonne release from the 300 tonne storage tank. This is a conservative scenario as normal operation does not permit the storage tank to contain that mass. In addition, all of the mass was assumed to go into the plume rather than forming a pool at the release site which increases the cloud area extents. Under poor dispersion conditions (stable atmosphere low wind speed) the cloud area was estimated as approximately 4.5 km.

The table below provides an estimate of the exposure times required to provide a given lethality probability for a specified concentration level.

Concentration (PPM)	Time to a given lethality probability	
	50% lethality	10% lethality
1000	2 seconds <i>min</i>	1 second <i>min</i>
300	20 minutes	5 minutes
100	190 minutes	46 minutes
10	312 hours	70 hours

*see also
page 4 of
"Document Two"
Issues of Question*

The above results are based on the implementation of the probit equation which reflects the dose response relationship of humans to chlorine gas. As noted earlier, very few releases will pose exposure times of 1 hour; most will be of much shorter duration than this.

Q.3 In attempting to understand the factor of 10 reduction in the risk assessment from the previous report I have come to the conclusion that since the earthquake risk multiplied by the volume of chlorine stored on site form by far the major risk components, and that since the earthquake risk remains unchanged, and the volume has been reduced by a factor of only 5, I am

unable to understand where the additional factor of two (to account for the 10) came from. Could I have a simple explanation for this please.

A.3 Some factors other than storage volume that could result in reduced individual risk contours when comparing the 1994 and 1997 assessments can be summarized as follows:

- Release was not assumed to be contained by a dyke in the 1994 report. An unconfined release results in higher consequences and risk.
- In the 1997 report the release physics were modified to reflect Chlorine Institute experiments. The modifications result in a reduced initial fraction of chlorine going into a cloud which reduces the consequence and risk.
- The plant operation of the large storage tank was defined more carefully in the 1997 report in order to refine estimates of the fraction of time that the tank was in a certain fill condition. This impacts the susceptibility of the tank to earthquake damage. The 300 tonne tank also has a lower earthquake risk than the 600 tonne one.

Letters from Cas Bohlken

October 23 Letter

Q.1 In the 1994 QRA, the "Maximum Downwind Extent of 1% Probability of Death" at wind speed of 2 meters/sec. is about 6 km. (figure 6.4). In the 1997 updated report the distance is about the same at this wind speed. However, the 1994 report shows a down wind range of about 8 km at a wind speed of 1m/sec., and the 1994 report shows a range of over 14 km for a wind speed of 1.5 m/s. For comparison purposes what would the 1997 "Maximum Downwind Extent of 1% Probability of Death" be with a 1 m/s wind and why such a large difference between the 199 and 1997 reports?

A.1 Figure 6.4 (1994 QRA) shows the results for a confined release (dyke integrity maintained) under D stability 2 m/s wind speed and E stability 1 m/s wind speed. The 1997 QRA shows unconfined and confined results under C stability 2m/s wind speed and F stability 1.5 m/s wind speed. Both stability and wind speed influence the the downwind distance. In addition to depicting the model results under different weather conditions in the figures presented in the 1994 and 1997 QRAs different storage conditions have also been addressed. Due to the different weather, confinement and storage conditions, care must be taken in comparing results.

The table below summarizes a comparison of results from the 1994 and 1997 QRAs for dispersion over sea of a large storage tank release.

Stability	wind speed m/s	Downwind distance to 1% lethality (km)			
		1994	1997		
			confined	unconfined	confined (full)
		289 tonnes	225 tonnes	225 tonnes	289 tonnes
C	2		3.4	4.8	7.4
D	2	6.2	4.3	6.1	9.2
E	1	8.0	5.5	8.0	12.3
F	1.5		7.6	11.1	16.6

It can be seen from the table that the 1994 and 1997 unconfined results are very similar due to similar release and storage conditions. The capacity release has very different storage conditions which result in the entire mass of chlorine forming a dense vapour/mist cloud (ie. no rain out and no pool formation). As can be seen from the table the consequences resulting from this release are significantly higher than previously analyzed.

The tank is not operated at a capacity greater than 225 tonnes. Routine conditions limit the storage volume to 225 tonnes, and it is often run at volumes considerably lower than this.

Q.2 The 1997 Updated Report did not include the "Worst Case Probability of Death Contour" for 1 m/s winds (see 1994 QRA, Figure 6.6). Other wind directions should also be included eg. west, south-west, south and south-east.

A.2 In the 1997 report the intent was not to show worst-case probability of lethality contours but rather to present a selected release under selected weather conditions as an example of the extents of the probability of lethality contours given a release occurs. Wind direction information is handled implicitly in the derivation of risk contours and is considered in the presentation of consequence contours only to show the difference resulting from land and sea dispersions. Normally the contours are independent of wind direction but in this specific case dispersion varies because of the different surfaces the wind flows over as it approached the source.

Q.3 Since the prevailing winds at the CXY plant are easterly, it seems that even a relative minor spill at the plant would affect traffic at the Second narrows bridge and connecting highways. Driving into a minor cloud at speeds over 80 km/h could temporarily blind drivers which would create a traffic nightmare. Has this scenario been considered in the Risk Assessment calculations?

A.3 The consequences of an individual release are more the domain of an emergency response plan rather than a QRA which combines frequency and consequence information. For illustration purposes, a relatively high

frequency release scenario (hose break release scenario 7a in the 1997 QRA) was examined in the context of a nuisance release to determine what the impact might be on visibility on the Second Narrows bridge. A chlorine plume can be seen at a concentration of about 20 ppm. Figure 1 (attached) shows the extent of the 20 ppm contour as a result of a chlorine release from a hose break for several selected weather conditions.

It can be seen from Figure 1 that the extent of the 20 ppm contour reaches a maximum elevation of approximately 20 m at a downwind distance of about 200 m for the conditions of C stability/ 2 m/s wind speed. The maximum extent of the 20 ppm contour at ground level is about 550 m as shown.

Given that the Second Narrows Bridge is approximately 800 m from the plant, the impact on the bridge in terms of reduced visibility should be minimal.

Q.4 What are the suggested population densities in the MIACC guidelines for the 10-5 to 10-6 risk zone (commercial, offices and low density residential)?

A.4 The MIACC guidelines do not include population densities.

Q.5 There was a lot of discussion at the September 23 public meeting (afternoon session) of taking shelter at home during a chlorine spill. Apparently one has a good chance of surviving a chlorine release by staying at home. This was confirmed by different experts present. It was also suggested that a large breach of the 300 tonne storage tank would probably only occur during a large earthquake. It is also well known that the home is not a safe place to be after a large earthquake (gas leaks, falling beams, after shocks etc.). A home without windows wouldn't provide much of a shelter from the chlorine cloud anyway. Was the above considered when calculating the Risk Assessment?

A.5 Yes, all of the risk calculations were performed assuming no one would seek shelter or evacuate from the path of the plume. If sheltering or evacuation were considered the extent of the predicted risk contours would be reduced.

Q.6 Calculations on the "Estimated Consequences" of a chlorine spill would be more useful than Risk Contours. Estimated casualties from chlorine inhalation under different scenarios considering the populations residing in the affected areas and the atmospheric conditions at the time, eg. large breach of the 300 tonne storage tank, a 1 m/s south-west wind, large earthquake (most homes would be damaged) the estimated casualties will be x. Repeat the exercise for a large breach without damage to homes etc. Different atmospheric conditions should also be considered eg. wind directions and wind speed. It could also include a scenario projecting estimated population in the effected areas in the area 2012 (in 15 years).

A.6 The suggested approach, consideration of the chance that a certain number of casualties occurs or the expected number of casualties over a

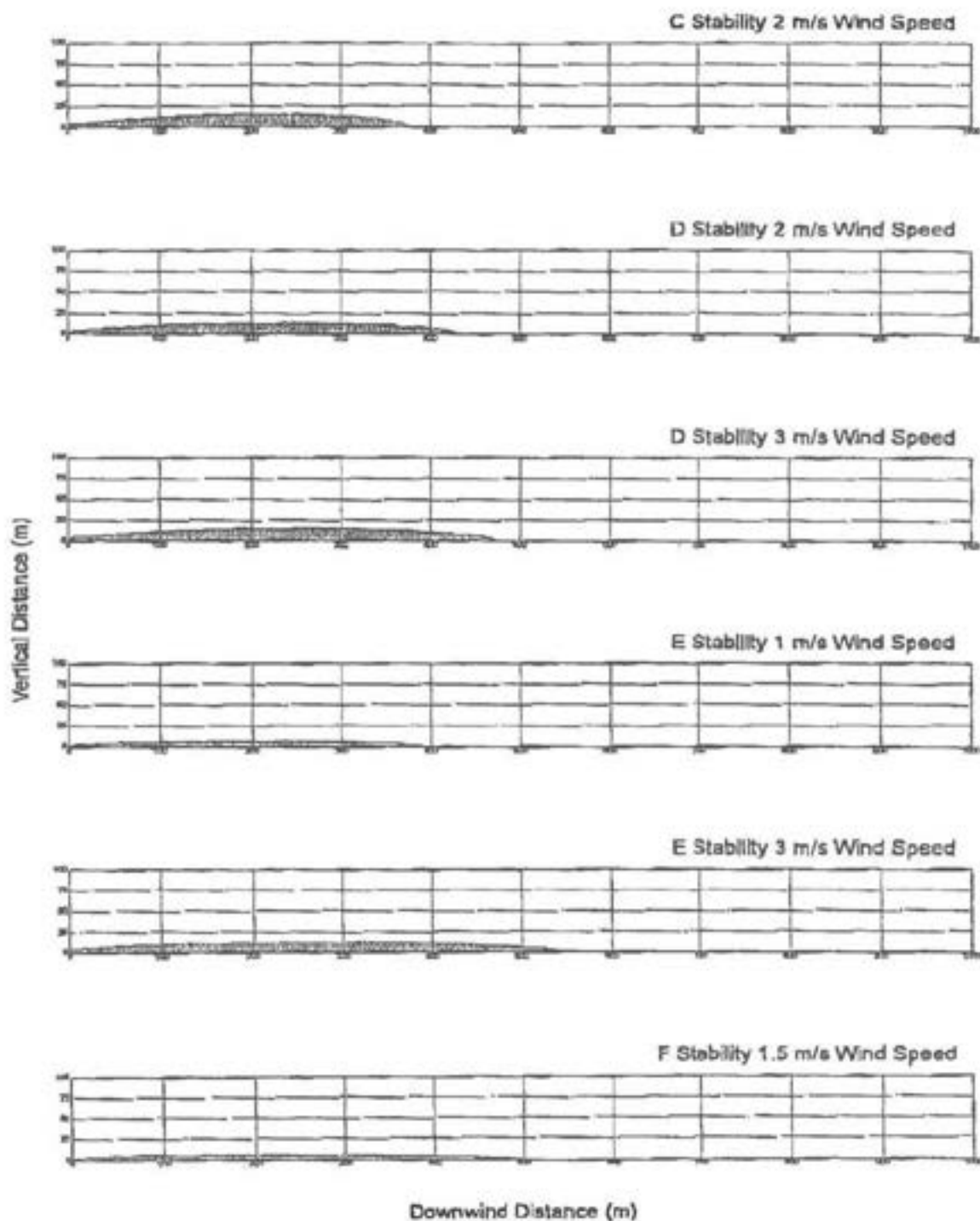


Figure 1. The extents of the 20 ppm chlorine concentration contour resulting from a line break release under selected weather conditions.

certain timeframe, is part of the estimate of societal risk. Societal risk involves the consideration of the chance that a certain number of casualties occurs or the expected number of casualties over certain time frame results in an estimate of the societal risk due to a facility. This was not the focus of this assessment as societal risk is not commonly used for land use planning or setback determination. Future population growth can be important in a societal risk context.

Q.7 If a chlorine spill could be attributed to an act of God (eg. a large earthquake) who will be held responsible to pay for damages, clean-up etc.?

A.7 Refer to the District solicitor.

Q.8 The Bovar report on Risk Assessment is impossible to evaluate without some understanding of what risks were identified and also the estimated frequency of occurrences and estimated consequences. Could these figures be presented in a condensed format?

A.8 The frequencies and consequences of all the release scenarios are presented in the 1997 PHA report. Additional data on consequence distances is provided in the responses to other questions raised by the public.

November 1 Letter

Q.1 The answer to my first question was vague and I am still puzzled why there is such a large difference in "Downwind Probability of Death" estimates. Both 1994 and 1997 reports deal with capacity release of the 300 tonne tank. The 1997 figure at 1.5 m/s wind speed is 14.7 km or 83% larger than the 1994 total of 8 km at 1 m/s. wind speed. The 1997 distance would even have been larger if a 1 m/s wind speed had been used as in 1994. I would like to see this graph redrawn comparing 2 m/s and 1 m/s wind speeds.

A.1 In the 1997 report all of the release material was assumed to go into the plume for the capacity release. This results in a more conservative estimate of the consequences, and as a result cannot be compared directly to the 1994 capacity release which assumed that some of the release would go to a pool.

The table below summarizes a comparison of results from the 1994 and 1997 QRA for dispersion over sea of a large storage tank release. The numbers that can be compared are shown in bold type.

Stability	wind speed m/s	Downwind distance to 1% PD (km)			
		1994	1997		
			confined	unconfined	capacity
C	2		3.4	4.8	7.4
D	2	6.2	4.3	6.1	9.2
E	1	8.0	5.5	8.0	12.3
F	1.5		7.6	11.1	16.6

In the 1994 report the capacity release was modelled as an unconfined release and as such produces quite comparable results to the unconfined 1997 release for similar meteorological conditions.

The table below shows a comparison of the extents of the 1% probability of death contour for the capacity release over land, with 1997 modelling assumptions under 1 and 2 m/s wind speed, E and F stability meteorological conditions.

Stability	Wind speed	Downwind distance to 1% Probability of lethality
	m/s	(km)
E	1	9.8
E	2	9.8
F	1	14.5
F	2	14.9

The table shows that the 2 m/s wind speed provides greater downwind extents to the 1% probability of lethality contour. For the purposes of a risk assessment a decision must be made on how to discretize the continuum that exists in nature; to this end a selected set of meteorological conditions was chosen based on the frequency of occurrence. For very stable conditions (F stability) a wind speed of 1.5 m/s was chosen to represent the range of wind speeds that may occur.

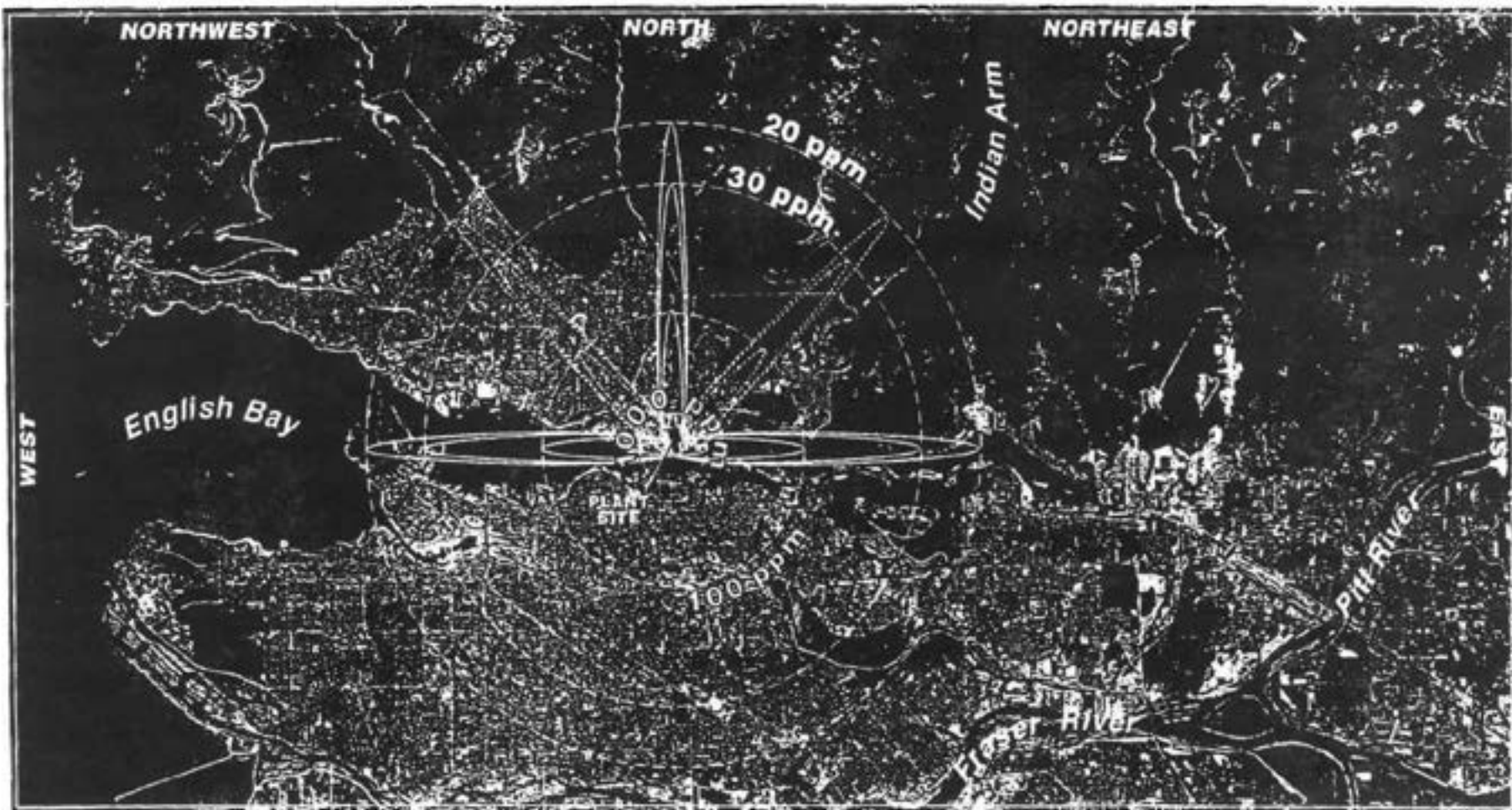
Q.2 My second question dealt with the "Worst Case Probability Contours" for 1 m/s winds (see 1994 QRA, Figure 6.6). This graph was not re-issued in the 1997 report although there should have been some large differences (see 1 above).

A.2 The above table indicates that when considering downwind extents, the worst case contours may not be for 1 m/s. The graph issued for the 1997 report was for a medium release of the storage tank under F stability and 1.5 m/s wind speed, and was presented as an example of probability of death contours and was not intended to be a worst-case. While in actuality an absolute worst-case is difficult to obtain, the risk assessment has accounted for the consequences of a wide range of probable and possible meteorological conditions and release scenarios. The figure attached shows a representation of cloud travel for a 225 tonne chlorine release under typical daytime weather conditions. This scenario is estimated to occur once in 750,000 years.

Q.9 It also occurred to me after the meeting that using a cigar shape to represent the plume might work over water or flat terrain, but since most of the community north of the plant is located on a mountain slope the cloud would be more like the shape of a mushroom with higher concentrations and lateral spread at the base of the mountain. This will add to the risk in those areas eg. Maplewood and should have been considered in the model.

A.9 Terrain effects are not typically considered in a risk assessment and in general, other than the case of narrow valleys that can contain a plume's spread, or direct plume impingement, terrain effects tend to enhance turbulence which actually results in reduced concentrations. Wind tunnel studies have shown that in the case of direct plume impingement on a ridge, the concentrations can range from 1.2 to 1.8 times as high as flat terrain predictions within a very short distance (ie. a fraction of the ridge height) from the ridge base.

If all other factors are considered equal this could raise the individual risk to receptors in a very localized region at the base of the ridge. As the predicted risk at the base of the ridge is less than 1 chance in a million this increase should not result in "intolerable" risks at the base of the ridge.



Representation of cloud travel for 225 tonne chlorine release

Worst Case Scenario



MUCH WORSE IS AT NIGHT!

Under typical daytime weather conditions
Estimated to occur once in 750,000 years

Lack of diligence to prevent spill costs MB \$100,000 fine

Resulting cloud of toxic chlorine dioxide gas narrowly missed residents near Powell River.

GORDON HAMILTON
and SEAN PERCY
VANCOUVER SUN

POWELL RIVER — MacMillan Bloedel has been fined \$100,000 in provincial court for a huge chemical spill that came dangerously close to gassing residents living near the coastal community.

In sentencing MB for the Oct. 17, 1994 chlorine dioxide spill, Judge Fred Green said the company did not show due diligence in trying to prevent the accident, the largest of its kind in British Columbia history.

The company was found guilty last July on three charges under the provincial Waste Management Act and federal Fisheries Act: permitting waste to escape into the ocean and into the air and introducing a deleterious substance into the ocean.

It was acquitted on another

five similar charges relating to the fact the spill occurred over two days. The judge ruled that MB was attempting to clean up the spill on the second day.

The sentencing hearing was not held until this week.

The spill occurred when an aging wooden pulp storage tank at the company's paper mill burst, sending a shower of timbers and pulp on to two chlorine dioxide storage tanks containing 600,000 litres of toxic liquid.

Chlorine dioxide is used in bleaching paper.

Both tanks ruptured and the chemical escaped, flowing into Malaspina Strait and turning into a gas cloud that drifted northwest of Powell River, narrowly missing the Indian village of Sliammon.

Two years earlier, MB had received a consultant's report stating that the iron bands hold-

ing the pulp tank together were corroded and needed replacing.

During the trial, MB's lawyer Ross Clark argued the company understood that the repairs did not need to be done for two years.

"If the company had any idea that [the accident] was a potential result, it would have acted long before," Clark said in an interview Tuesday. "But it was missed."

"Mercifully, the extent of the damage was minor," Judge Green said in assessing the fine. Had circumstances been different, people may have been injured, he said.

The prevailing winds the night of the accident carried the chlorine dioxide cloud off the coast, rather than onshore.

Green also said the company showed remorse and did not make any money from the offence, both factors in setting the fine.

MB has 30 days to appeal, but the company has made no decision on an appeal yet, Clark

said.

Crown counsel John Barkwell, who sought a fine in the \$250,000 to \$500,000 range, said it is "certainly towards the high end" of waste discharge fines but it is not the highest. In 1990 Cariboo Pulp and Paper was fined \$275,000 for discharging turpentine and white liquor into the Fraser River.

MB has since spent \$5 million to build new concrete pulp storage tanks away from the chlorine dioxide tanks, Clark said.

The judge agreed with an MB submission that most of the money go toward enhancing salmon stocks in the Powell River area, near where the spill occurred.

Of the \$100,000 MB was ordered to pay, \$35,000 will go to general provincial revenue, while \$27,500 will go to the Powell River Salmon Society, and \$27,500 to the Sliammon salmon hatchery. The local Provincial Emergency Program gets \$10,000 to upgrade search and rescue equipment.

Community Advisory Panel (CAP)

of CXY Chemicals Canada Ltd. and Sterling Pulp Chemicals Ltd.

c/o CAP Facilitator
Lori Walker
444 Fader Street
New Westminster, B.C.
V3L 3T3
(ph .515-0115)

January 5, 1997

Community Advisory Panels (CAPs) offer the chemical industry, emergency responders, and community members living near these facilities the opportunity to better understand the concerns, risks, and benefits they share.

CXY Chemicals and Sterling Pulp Chemicals, with the North and West Vancouver Emergency Program (representing the three North Shore municipalities) initiated the formation of a CAP in December, 1995 to begin a broader discussion of community and industry concerns in North Vancouver.

The enclosed CAP Report for periods September to June 1995/96 and 1996/97 documents the formation, activities and discussions of the CAP members as it moves toward its objective of identifying and sharing information about the risks and benefits of CXY and Sterling Pulp Chemicals. Discussions of the rezoning of CXY Chemicals and the Dollarton realignment have been initiated in CAP meetings, but are not included in the report due to the timing of the peer review of CXY's quantitative risk assessment. We look forward to discussing future CAP involvement in issues such as these.

We hope that this report sparks interest and debate that will result in a broader understanding of safety issues associated with these two companies and the need to prepare for emergencies in this area.

Please get in touch with us with your questions, concerns, and suggestions.

Sincerely,
Members and Sponsors of the
Community Advisory Panel (CAP) of CXY Chemicals Canada Ltd. and
Sterling Pulp Chemicals Ltd.

Community Advisory Panel (CAP)
to CXY Chemicals Canada Ltd. and
Sterling Pulp Chemicals Ltd.

DOCUMENT ONE: Background

report for periods
September to June
1995/96 and 1996/97

Compiled by Lori Walker
CAP Facilitator
Summer 1997

DOCUMENT ONE: Background

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Community Advisory Panel (CAP)

of CXY Chemicals Canada Ltd. and Sterling Pulp Chemicals Ltd.
Report for periods September to June 1995/96 & 1996/97

Document One: CAP Background

Introduction

Why Community Advisory Panels?

Industrial progress contributes countless benefits to our lives. While we take many of these benefits for granted, they do come with significant costs—and periodic high-profile, chemically related incidents justify community concern about potentially negative impacts. Difficulties in understanding the risks compound this community concern.

Scientists and experts in the chemical industry have developed technical terms and assumptions to address the risks and benefits associated with their work. While these terms and assumptions address health and safety, the technical language does not, and cannot, always address the more straight forward concerns of the public. Risk estimates and probabilities can only partly satisfy the community's main questions: "Are we safe?" and "Are the benefits worth the risks?" Only the public itself can judge whether these concerns are addressed; and to do so they will require comprehensive technical information from industry and government.

Understanding this information requires that the public have a seat at the table when the topic of health and safety for their families and the environment is under discussion.

Community Advisory Panels in Canada

Community Advisory Panels (CAPs) were first initiated in Canada in the late 1970s as a tool to help the chemical industry better understand the concerns of people living and working near their facilities and to use community insight to manage risk more effectively. The joint CXY Chemicals Canada Ltd. (CXY) and Sterling Pulp Chemicals Ltd. (Sterling) CAP is among the first initiated by industry in British Columbia's Lower Mainland.

The Purpose of This Report

The purpose of this report is to outline CXY/Sterling CAP activities over the last two years and to share with community members the questions CAP members have asked about the risks and benefits of having CXY and Sterling operations in the community.

As individuals, CAP members have different ideas about how risks and benefits associated with industry on the North Shore are best balanced. However, we also share the two companies' belief that open communication among industry, government, and residents is the best place to start in determining this balance.

Together, we identified the need to (1) open communication channels, and (2) to identify our primary concerns.

We decided to begin by simply posing our initial questions about health and safety issues to appropriate CXY and Sterling representatives (who in many cases were plant managers Brian Thornton [year one] and John Billham [year two] of CXY, and Roger Thomey of Sterling), municipal representative Ross Peterson of the North and West Vancouver Emergency Program, and other experts. Once we had their answers, the next step would be to share those responses with you.

For the convenience of readers, this report is presented as two documents:

Document One describes the CAP—its background, structure, membership, and objectives. This document also provides information about the background of CXY and Sterling, and their objectives for participating in the CAP.

Document Two lists a chronology of CAP meetings and topics over the last two years. This document also provides questions and answers explored during this time.

More Community Involvement Needed

We fully expect that the CAP and its objectives will evolve. We hope that this report sparks interest and debate that will result in a broader understanding of safety issues associated with these two companies and the need to prepare for emergencies in this area.

If you are interested in becoming involved in CAP, or have questions please call:

- CAP Facilitator Lori Walker (515-0115—leave a message)
- John Billham, Plant Manager of CXY Chemicals (929-3441)
- Bob MacLeod, Plant Manager of Sterling Pulp Chemicals (929-3002)
- Ross Peterson, Co-ordinator, North and West Vancouver Emergency Response (983-7440)

Origin of the CXY/Sterling Chemicals Community Advisory Panel

As members of the Canadian Chemical Producers Association, CXY Chemicals and Sterling Pulp Chemicals abide by a set of industry guidelines called "Responsible Care." These guidelines define responsible conduct in the following areas:

- community awareness and emergency response
- research and development
- manufacturing
- transportation
- distribution
- hazardous waste management

As part of their commitment to the CAP program, the companies recognized a need for dialogue with community members regarding potential risks and to share ideas about managing the risks.

In 1994, CXY undertook a scientifically based study (Quantitative Risk Assessment or QRA) to assess the possible consequences of a major incident at the North Shore plant. The results of the study made apparent the need to establish a CAP. The two companies proposed establishing a CAP and met with the North and West Vancouver Emergency Program (representing the three North Shore municipalities) to discuss their possible involvement. The companies appointed Lori Walker, a Simon Fraser University doctoral student studying communication about environmental and health risk, as a neutral resource to attract and select CAP members and to facilitate the process.

In October, 1995 CXY Chemicals and Sterling Pulp Chemicals ran the following advertisement in the North Shore News to identify members for the CAP.

We'd like your advice...

CXY Chemicals and Sterling Pulp Chemicals of North Vancouver are looking for 12 volunteer members to participate in a Community Advisory Panel (CAP). If you are a local resident who is interested in ensuring our community remains a good place to live, we ask you to consider helping us out.

The CAP will provide a regular forum where community members, local business, and the municipality can exchange information with CXY and

Sterling about plant operations and activities. While the CAP will not serve as a decision making body for the two plants, it will be a forum where the panel members' concerns and points of view are respected and taken into consideration by CXY, Sterling, and the municipality when decisions are made.

The CAP will meet 3 to 4 times a year, 2 to 3 hours in the evening. The members will establish other meeting logistics to meet their needs.

Fifty-four people responded to the advertisement. Many were people with chemical industry experience or who could provide technical assistance. In selecting members, however, Lori Walker believed that the first priority was to identify the immediate concerns and criticisms of community members. It was also thought that CAP members should represent a variety of interests and community groups, including Maplewood School, First Nations groups, local business, and community associations.

Charter members had a variety of reasons for wanting to get involved. Some felt that companies were often arrogant and purposefully neglectful of community concerns. Several were concerned about the safety of their children in the event of an emergency. Many were unclear about what to do in an emergency situation, and wanted to identify what to worry about and what to do if an alarm was sounded. Others were concerned about environmental impacts of an incident. All expressed the need to share what they learned with the community.

This report is the initial step in addressing these concerns and in sharing our findings with you.

Charter members of the CXY/Sterling CAP include the following individuals:

- Nachiko Yokota, Resident and former member of Chemical Hazard Alert Committee
- Ellen Riley, Resident
- Pat Neufeld, Resident and President, Lynmour & InterRiver Assoc. (year one)
- Rob Bengough, Resident (former Manger of Health and Safety, TOLKO Industries)
- Cas Bohlken, Resident
- Capt. Dennis Burg, Resident and representative of Ship Safety, Transport Canada
- Nancy Dale, Resident, teacher, and representative of Maplewood School (year one)
- Salim Ledak, Resident
- Neil McManus, Resident
- George MacPherson, President MWBMU (year one)
- Neil Mort, Director of Campus Operations, Canadian International College
- Ross Muirhead, Resident and representative of Friends of the Watershed
- Tony Webb, Resident & representative, Maplewood Flats Bird Sanctuary (Wild Bird Trust of British Columbia)
- Gail Weimer, ICBC Community Relations
- Ross Peterson, North and West Vancouver Emergency Program
- Brian Thornton, Manager of Community Relations, CXY Chemicals Ltd. (year one)
- John Billham, Plant Manager, CXY Chemicals Ltd. (year two)
- Roger Thomey, Plant Manager, Sterling Pulp Chemicals

CAP Objectives

The following terms of reference were identified at the CAP's inaugural meeting, held December 5, 1995:

Mission Statement

The CXY/ Sterling CAP (the CAP) is a forum for the open, frank, and mutual exchange of ideas and concerns of both industry and citizens. Comprised of representatives of the local community, the industry sponsors, and the municipality, the group works to develop an understanding of these industries as they relate to the neighbouring area for the purpose of mutual education. The CAP serves as a resource to industry and the community at large on issues including safety, health, environment, and economy.

Objectives

1. To address issues that are important to the community and industry.
2. To provide the community with input from the plants about facility operations.
3. To provide feedback from the community about plant operations and concerns, and to identify ways to improve communications with the community.
4. To provide a mechanism for the plants to discuss community response to the plants' ideas and plans.
5. To provide a means to educate the plants and their corporate management about the community.

Scope

The CAP does not usurp regulatory functions, local government controls, or other government procedures that are in place for public safety, health and environmental protection.

Decision-Making Process

If required, Robert's Rules are used informally. When voting, 50% plus 1 constitutes a majority.

CAP Size

The CAP consists of no more than 20 people with membership reflecting the community. Individuals with expertise in specific areas will be invited to present to the group as required.

Expenses

The cost of facilitation, meeting space, and refreshments are paid by CXY and Sterling. Compensation for direct expenses paid by the sponsors will be reviewed by the CAP.

Meeting Dates

These are established by the facilitator with CAP members over the telephone. The meetings are held every six weeks, from September to June.

Agenda

When possible, the agenda for the next meeting will be set before the end of each meeting. If necessary, a committee of interested members will establish the topic for the next meeting. Every Agenda will include updates from CXY, Sterling, and the North and West Vancouver Emergency Program, and will provide opportunity for participants to identify new issues for discussion.

Original CAP Issues and Concerns

1. Emergency Response and Evacuation
 - warning systems (how does notification happen?)
 - access to information in emergency
 - role of first responders
 - sheltering vs. evacuation
2. Information Needs
 - what information is available?
 - what information can the community access?
 - how effective is available information?

3. Risk and Health Concerns

- smells, air quality
- health effects
- what areas are most at risk?
- regulations, standards, monitoring, content of emissions
- company response to regulations
- company steps to risk reduction
- recovery, reclamation
- potential risk, probability of accidents, probable accidents
- dispersion of gas
- threat of quake/crisis
- railcar safety/mischief
- location, relocation, long-term plans

4. Development Issues

- MacKenzie Barge, other
- Dollarton Realignment

5. Benefits

- employment, products

CXY and Sterling Objectives for CAP

Roger Thomey of Sterling and Randy Gossen of CXY articulated their own objectives for participation in the CAP. They are as follows:

CXY's Principles of Community Affairs

- No sacred cows; all issues raised by the public will be addressed fully and openly.
- The public has a legitimate right to participate in the decision making for issues that affect them.
- Input from the public is "value added" to our business.
- Seek issue resolution through consensus.
- Acknowledge that the public must decide what constitutes an acceptable level of risk.

CXY accepts the responsibility to put these principles into practice. The community will be the judge as to how well this is accomplished.

Sterling's Objectives for CAP Participation

It's interest in participating in a CAP also stems from their involvement in the "Responsible Care" program. In addition, when they began operating under new ownership, in 1992, they wanted to introduce their operations to the community. They also wished to identify any issues, questions or perceptions that local residents may have had about their operations and to seek a means of communicating that would lead to resolution.

It is important to Sterling that neighbours know Sterling has an open-door policy and an environmental objective of "zero impact on the environment."

Background on CXY and Sterling Facilities

*CXY Chemicals Canada Limited Partnership
(formerly Canadian Oxy Industrial Chemicals Limited Partnership, and Hooker
Chemicals)*

CXY Chemicals is a joint venture between Canadian Occidental Petroleum Ltd. (Canadian Oxy) and Occidental Chemical Corporation. The North Vancouver facility was established in 1957 and subsequently purchased by Occidental Petroleum in 1968. It came under the management of Canadian Oxy in 1971. In 1995, Canadian Oxy established a new chemical partnership with Occidental Chemical Corporation, which combined Canadian Oxy's industrial bleaching chemicals business with Occidental's sodium chlorate production facility at Taft, Louisiana. At the time that this partnership was formed, the name was changed to CXY Chemicals.

When it was first opened, the plant had a capacity to produce 109 tonnes of chlorine per day. Currently, the North Vancouver plant has a production capacity of 435 tonnes per day of chlorine. Other chemicals produced at CXY include: caustic soda; muriatic acid; hydrogen gas (some of which is transferred by pipeline directly to the neighbouring Mohawk Oil Co. Ltd. recycling facility); and sodium chloride products such as brine, salt slurry, and bulk salt.

To produce its products, CXY annually consumes 250,000 tonnes of common salt, 460 million kilowatt hours of power, 1.87 billion litres of water, and 1.2 million gigajoules of natural gas. The products produced at CXY are used by the BC pulp and paper industry, by the US Gulf petrochemicals industry in the production of plastics, by the oil and gas industry in Western Canada, and by the steel industry. These products are also used for water chlorinating, bottle washing, effluent treatment and wire pickling.

Products are transported via tank truck, bulk barge and rail barge, railcar, fixed pipeline (H₂ and brine) and deep sea vessels.

CXY's North Vancouver site employs 173 people with 30% of those living on the North Shore. The company's site payroll and benefits equal \$10 million per year, and it pays \$1.3 million in annual municipal taxes.

Sterling Pulp Chemicals Ltd.

Sterling Pulp Chemicals, Ltd. (formerly Albright & Wilson) was purchased in 1992 by a Texas company, Sterling Chemicals Inc.

Sterling employs 510 people in its six manufacturing facilities across North America (located in Valdosta, Georgia; North Vancouver, BC; Grande Prairie, Alberta; Saskatoon, Saskatchewan; Thunder Bay Ontario; and Buckingham, Quebec).

The company produces two primary products: sodium chlorate and sodium chlorite. At its newly acquired Saskatoon site, in addition to sodium chlorate, chlorine, caustic, muriatic acid, hypochlorite and calcium are produced. Chlorate is an industrial salt used primarily in the bleaching of pulp. It is the only product manufactured at the North Vancouver site. Using a large quantity of power, it is produced by the electrolysis of salt and water. To manufacture its single product, the North Vancouver plant uses approximately 500,000 kilowatt hours and 45,000 tonnes of brine solution annually.

The North Vancouver plant was first commissioned in May 1957. It has a current capacity of 92,000 tonnes and ships its product by truck, ocean going barge, railcar and export containers. With annual sales in excess of \$40 million dollars, it has a direct site payroll of \$3 million, locally purchases \$15 million in goods and services, and pays approximately \$1 million in property taxes to the District of North Vancouver. The site employs 40 full-time employees of whom 28% live on the North Shore and over 50% have greater than 20 years of service.

Since 1987, production has been increased by 50%, while raw material usage has been reduced by 47%. Environmental performance (i.e. reductions of air emissions, effluent, solid wastes) has been improved by 87% (relative to 1987). Current air emissions from the plant measure approximately 2.5 parts per million (ppm) of chlorine (0.63 tonnes annually), and the annual disposal of hazardous brine and acid wash mud to a secure landfill measures approximately 325 tonnes. (The material is considered hazardous because of the small amount of chromium present.)

Chronology

The current CXY/Sterling CAP is not the first group formed to address concerns about possible health and safety risks associated with the CXY plant; nor is CXY Chemical's Quantitative Risk Assessment the first technical study of possible risks. The following chronology acknowledges the efforts of others in bringing attention to chemical hazards in the municipality.

- September 1978—Beak Report, (commissioned by North Vancouver District Council) examining risk associated with earthquake and railcar transport of chemicals.

- November 1979—The Mississauga Spill of 10 tonnes of chlorine from a tanker car.
- February 1980—The District established Chemical Hazards Action Committee (later Alert Committee/Community Hazards Task Force [CHAC]).
- March 1980—North Vancouver begins review and update of emergency plan.
- May 1980—Report commissioned from special ad hoc committee to evaluate Beak Report and role of municipal and governments in minimizing risk.
- November 1980—Community Hazards Task Force Report submitted to council.
- June 1983—Community Hazards Action Committee established subcommittees to explore North Shore emergency plans; marine, road and rail transport of hazardous goods; off-site health hazards; district plans for future industry; and cost-benefit analysis of Hooker facility to the North Shore.
- May 1993—The Community Alert Network was established by the North and West Vancouver Emergency Program and paid for by Canadian Occidental.
- May 1995—CXY Chemicals Quantitative Risk Assessment released.
- December 1995—Established CXY-Sterling Pulp Chemicals Community Advisory Committee.
- August 1997—CXY Chemical's updated Quantitative Risk Assessment was released.
- August 1997—Peer Review of Quantitative Risk Assessment done for the District of North Vancouver by A.D. Little was released.

Reports and newspaper clippings covering the issues that have arisen with regard to chemical and chlorine risk on the North Shore are available in the North Vancouver Public Library.

Community Advisory Panel (CAP)
to CXY Chemicals Canada Ltd. and
Sterling Pulp Chemicals Ltd.

DOCUMENT TWO: Issues and Questions

**report for periods
September to June
1995/96 and 1996/97**

**Compiled by Lori Walker
CAP Facilitator
Summer 1997**

DOCUMENT TWO: Issues and Questions

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Community Advisory Panel (CAP)

of CXY Chemicals Canada Ltd. and Sterling Pulp Chemicals Ltd.
Report for periods September to June 1995/96 & 1996/97

Document Two: Issues and Questions

Introduction

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Issues and Topics Addressed

- December 5/95 Established Terms of Reference and issues to be examined.
- February 6/96 Presentation by Brian Thornton, CXY and Roger Thomey, Sterling.
- March 5/96 CXY Presentation continued; presentation from Ross Peterson, North and West Vancouver Emergency Program.
- May 7/96 Emergency Program presentation continued.
- May 14/96 Tour of Sterling Pulp Chemicals.
- June 4/96 Presentation by CXY on Dollarton Highway Realignment and Rezoning, Quantitative Risk Assessment .
- June 19/96 Tour of CXY Chemicals.
- October 23/96 Planning Session; Updates.
- November 27/96 Final Report; Planning Session; and Sheltering vs. Evacuation.
- January 8/97 *Chlorine and Health* presentation by Dr. Neva Hilliard; Technical discussion of Material Safety Data Sheets with Neil McManus.
- February 19/97 Discussion of video dealing with CXY disposal practices
- April 3/97 *Regulations and Standards for Emissions and Waste Disposal* presentation by Ken Stubbs; GVRD Air Quality; and *Pollution Prevention* presentation by Ray Robb, BC Ministry of the Environment.
- May 14/97 Emergency Planning and Response.
- June 25/97 Report Discussion and CAP planning for next year.

N.B.: Minutes of these meetings are available from CAP Facilitator, Lori Walker.

The following were identified as issues to be addressed (listed in priority order as established by CAP members). The questions below are samples of those posed by CAP members. Also included are any answers collected by the CAP. We selected these because we think they best address general concerns about health and safety.

All questions asked at CAP meetings have been recorded and are available through the CAP facilitator, Lori Walker.

Health effects of chlorine – Long- and short-term exposure in "Plain English"

(Responses provided by Dr. Neva Hilliard, Occupational Medicine Consultant and Clinical Associate Professor Department of Health Care and Epidemiology, University of British Columbia and from "Chlorine/Chlorine Dioxide: Review of Health Effects" (February, 1997) prepared for the Pulp and Paper Advisory Committee Forest Industry Health Research Program by the Occupational and Environmental risk Management Group of the BC Research Institute).

Q. What amount of chlorine is dangerous to humans? Are small amounts very hazardous?

A. Both chlorine and chlorine dioxide are highly corrosive to tissues of the eyes, nose and mouth. The Chlorine Institute and the National Institute for Occupational Safety and Health classified exposures as follows:

0.2 - 0.3 parts per million (ppm)	odour perception
3 - 5 ppm	Slight irritation nose and throat
5 - 8 ppm	Irritation of the respiratory tract and eyes
14 - 21 ppm	Respiratory injury within 30-60 min.
30 ppm	Intense coughing
40-60 ppm	Serious respiratory damage in 30-60 min.
34-51 ppm	Death in 60-90 min.

pointing?
over

→ The chlorine monitor alarms at CXY are set to go off at 0.15 ppm; which is less than the odour concentration.

Both occupational human studies and animal studies have been conducted to look at chronic health effects following low-level exposure, either as a result of long-term, low-level exposures, or from one or more episodes of acute exposure. Exposures to chlorine in these studies were far greater than exposures that would result from any small accidental releases from the CXY plant (for example a continuous exposure to 0.5 ppm over an 8-hour period). Long-term effects of exposures to small amounts of chlorine in occupational settings have been studied, but no studies have been conducted on the general population's exposure to small amounts, such as takes place when using hot tubs or swimming pools.

Q. What is the concentration of the gas off the top of a bleach bottle? What's the concentration in a swimming pool?

A. The concentration off the top of a bleach bottle is 0.2 ppm, the level at which chlorine can be smelled. The concentration of 3 ppm chlorine is generally recommended for swimming pools.

Q. What about the chlorine that is vented out from the CXY plant?

A. NERM Data (National Emission Reduction Masterplan) submitted by the plant to the Canadian Chemical Producers Association shows an amount of 300 kg a year as the chlorine released through routine venting. Chlorine is very reactive, so it will

react with moisture to form weak hydrochloric acid—long before it would react to such chemicals as PCB's.

Q. What are the effects of hydrochloric acid? When you breath chlorine, does it become hydrochloric acid?

A. Yes. This can result in irritation (depending on the concentration and the duration of the exposure).

Q. How are exposures of 15-30 ppm treated? Do you have to go to the hospital?

A. Best treatment is fresh air, away from exposure and other lung irritants (cigarette smoke), lots of liquids. Individuals could be treated with oxygen while they are being transported to a clean environment.

Q. Can you see chlorine gas at 30 ppm?

A. Yes, you can see it at 10 ppm. It is a yellowy green colour.

Q. Could chlorine have more of an affect on children?

A. Kids have a higher respiratory rate, so the dose or the amount they breath in will be slightly higher. Some people with pre-existing respiratory problems (the elderly for example) may be more sensitive.

Q. If chlorine is at the 0.3 ppm level exposure will it damage the olfactory nerve?

A. No. Although it will fatigue the nerve, the nerve won't be damaged long term.

Q. The cancer connection still bothers me...

A. Research examining both acute, high levels of exposure and chronic, low levels of exposure have not identified cancer as a health effect. Several of the studies included follow-up studies on long-term health effects over a 6-12 year period. To date, there is no medical evidence to show there is a link between elemental chlorine and cancer.

Q. If there are no linkages, why do Canadian drinking water guidelines exist?

A. Standards are established for a variety of reasons, including the establishment of environmental and occupational health and safety measures, and risk assessment. These types of standards (indicating, for example, what amount of chlorine is added to drinking water) refer to how decisions should be made, not simply the levels of risk that are judged to be acceptable. Standards provide measures that reduce possible risks, but they also provide a process for making decisions about risks and environmental pollutants in the future.

Q. How much spill would it take for it to move out of the area toward the school etc.?

A. How chlorine disperses depends on a number of factors. Chlorine gas will tend to stay at low elevations, but concentrations depend on the wind speed, therefore dilution in the air. This question was examined in the Quantitative Risk Assessment that CXY conducted.

Q. How is information about the possible risks of a chemical shared between the people who produce, transport, and use them?

A. The Material Safety Data Sheet (MSDS) is a concise source of information about the chemical, physical, toxicological and fire properties of a product or substance. It provides information that an educated user can utilize to protect his/her health and safety. It also provides information for handling, storage, use, spill clean-up, fire fighting, emergency first aid, and disposal. MSDSs are part of a broader program called the Workplace Hazardous Materials Information System (WHMIS).

Q. What kind of enforcement is there for WHMIS guidelines?

A. WHMIS is a Federal regulation (not a guideline) and therefore is a legal requirement. It is administered in British Columbia by the Workers Compensation Board (WCB), which means it is part of a WCB workplace inspection and is enforced as any other safety regulation by that agency.

Accidental releases —causes, nature, incident investigation, odour, and community warning system

Q. Why do accidental releases typically occur?

- A. Of the eight reportable incidents over the last three-and-a-half years, all but one are related to equipment failures; for example power failures, small leaks from valves or line flanges. The one exception was considered as human error.

Q. How much chlorine in (ppm) is typically released?

- A. There have been 19 reportable incidents since 1990. Fifteen of those incidents involved releases of less than 5 kg.

Q. How long does it typically take to identify a leak?

- A. The plant has an exterior grid of 39 monitors that give operators immediate warning of chlorine releases. They can identify and react to a release in 1 or 2 minutes.

Q. Who do you report leaks to?

- A. We are required by law to report leaks greater than 5 kg to the GVRD, BC Ministry of Environment, and District of North Vancouver Fire Department. However, we also report any leak that we think will have an odor impact on neighbours or when we get an outside complaint to the GVRD and the Fire Department.

Q. If a leak is detected, then what?

- A. The source is identified and immediate steps are taken to stop the leak.

Q. Is it at that point that you shut the windows and turn off the air conditioner?

- A. Yes, individuals can take their own protective actions. The Municipality will also advise residents through the Community Alert Network, an automatic phone-dialing service (more information on this to follow).

Q. What is secondary containment in case of leaks?

- A. The chlorine storage tank is surrounded by a concrete pad and containment wall.

Q. How does CXY estimate the volume of chlorine spilled, and how accurate are these estimates?

- A. Releases to the air are usually very small so the amount is quoted at "less than 5 kg", the legal reporting level. Accurate measurement at such low levels is very difficult.

Q. What do we do when we hear a horn coming from the plant?

- A. 1) Stay in your house or apartment
 2) Close the windows and shut off air conditioners
 3) Seal any door or window gaps with wet towels
 4) Turn on radio (CBC AM) or TV (Rogers Community Cable).
 Advice will also come through CAN ALERT phone system.

Land issues: Dollarton, Rezoning, Redevelopment and Quantitative Risk Assessment—storage, what does it mean in plain English?

Note:

As noted in the introduction, a study was undertaken to assess the possible consequences of a worst-case incident at CXY. This study, called a Quantitative Risk Assessment (or QRA) would also indicate appropriate land uses near the plant. The question of land use in the area has arisen because the District of North Vancouver wishes to realign the Dollarton Highway and then allow development of a land in the vicinity. The new Dollarton Highway will provide access both to land owned by Canadian Occidental Petroleum and land owned by the district.

As a result of a public hearing on June 11, 1996, the District requested that the study be reviewed by an independent company for its accuracy and limitations. A.D. Little, an environmental, health, and safety consulting company was hired by the Municipality to do that review, and the results of the review were received by municipal council in a public meeting August 12, 1997. On August 13, 1997 CXY Plant Manager John Billham, and Jane Fleming, Manager of Land Development for Canadian Occidental Petroleum, and Ross Peterson of the North and West Vancouver Emergency Program met with members of the Maplewood Community Association to answer other questions arising from the council meeting.

In September, the Municipal Council will hold a public meeting to discuss the latest results of the QRA and their plans for rezoning. Following this meeting, the Municipal Council will hold a formal public hearing on the rezoning application.

For more information on the Quantitative Risk Assessment (QRA), the peer review of the QRA, or future rezoning contact John Billham, CXY Plant Manager at 929-3441 or Jane Fleming, Manager, Land Development, Canadian Occidental Petroleum Ltd. at 924-2923.

Emergency response

Q. When is the public notified about accidents?

A. When a significant public risk is perceived (by the Fire Department mainly).

Q. Is a Mississauga-type situation (spill resulting in mass evacuation) possible here?

A. Yes. The Mississauga spill involved a railcar carrying chlorine in 1979 and resulted in new standards for transport of dangerous substances and improved emergency planning procedures (including those in North Vancouver). In addition, the Canadian Chemical Producers' Association have also put into place a new code of practice called "Responsible Care." The code includes specific requirements to visit communities through which their products are shipped, in order to assess risks and make improvements. Unfortunately, despite planning, accidents can still happen.

Q. Who is responsible for notifying residents?

A. The municipality.

Q. Who is responsible for chlorine after a spill?

A. The company.

Q. What would happen in the case of a derailment in North Vancouver?

A. Responsibility would be jointly shared by industry, railroad, and the municipality.

Q. What would happen to the Lion's Gate and Second Narrows Bridge commuters?

A. If necessary, bridges would be closed.

Q. Don't you communicate by news media? Who decides what to do in an emergency? Can you interrupt radio as you do to report a news bulletin?

A. The municipality decides. Radio and TV would be interrupted if required.

Q. Who are the people getting information that they are giving out to others—who is behind the spokesperson?

A. Combination of company, health and municipality officials.

Q. Who are the people who have responsibility for public safety and emergency planning?

A. Municipal fire, police, health departments. Also provincial ambulance service.

Q. What role do the municipality and industry play in the event of an emergency? What is the chain of command?

A. It is the municipality's responsibility to protect public safety outside the plant gate. The municipality and company will work cooperatively.

Q. Do you tell people to turn off gas furnaces and heaters etc.

A. Yes, we would and did in 1994.

- Q. Is the Community Alert Network operator or computer activated?**
A. The North Shore's Community Alert Network is paid for by CXY Chemicals and owned by North and West Van Emergency Response. It has been used three times since 1994. The system is activated by municipal officials. A computer system does the dialing and plays a recorded message.
- Q. There needs to be more information on the Community Alert Network pamphlet. It is as simple as answering your telephone, but the pamphlet doesn't say that. I had to read to end of the first paragraph before I started to clue in that I didn't need to do anything. I was looking for what I had to do.**
A. Perhaps the next version can include improvements.
- Q. Would the phone system work in the case of earthquake?**
A. It may not work for some hours.
- Q. What if people don't answer or don't hear phones at night?**
A. The message would include a request for people to please alert their neighbour.
- Q. What about unlisted numbers or numbers that people take with them when they move?**
A. Residents with unlisted numbers must call the North and West Vancouver Emergency Program at 983-7440 to add themselves to the list. The annual update will provide corrected numbers for those who have moved.
- Q. Maplewood Flats and the Wild Bird Trust area— how to deal with people wandering to the west of the Flats? We thought signs might be put up explaining what the whistle is for and what to do?**
A. The company will work with you on signs.
- Q. What is the emergency response plan in this community?**
A. A specific response plan with CXY is in place and is being updated with new organizational procedures.
- Q. What constitutes first aid?**
A. Depends on concentration and damage. Fresh air or oxygen may be adequate. Hospitalization for severe cases may be necessary.
- Q. How familiar are workers with site-specific contingency plans—other than having to pull a manual off the shelf? When there is an earthquake, you don't have time. Are there drills?**
A. The company has education programs, in-house drills, and exercises with the municipality.

- Q. At Maplewood School, we are advised to go to a higher place. The highest place is on the stage in the gym. There isn't room for all the kids there. How would you get all those kids to the hospital?
- A. Moving the students to the stage isn't the answer. The emergency program would like to meet and discuss a suitable plan with the school this fall. A scenario in which we would have to transport "all those kids to the hospital" is very remote. But the issue of harmful inhalation should be discussed with the school.

Note:

The CXY Plant Manager, John Billham and Plant Safety Co-ordinator Peter Graveson met with the Maplewood Parent's Council in April 1997 to begin discussing emergency response options for fire, earthquake, and chlorine scenarios. Future meetings with the Parents Council are anticipated.

Court Case: CXY and Environment Canada

Q. Just what is going on anyway?

A. On October 13, 1994 there was a total power failure in the BC Hydro "feeders" to the CXY plant. The loss of power resulted in the plant having to undertake emergency shutdown. A valve designed to close in such circumstances did not fully close and allowed cooling water in the process to continue to contact chlorine. Plant cooling water containing a chlorine concentration above permit levels was discharged for several minutes into Burrard Inlet. Monitors at the plant were rendered inactive due to the total power failure. Charges were laid under the Federal Fisheries Act by Environment Canada and the Provincial Ministry of Environment also charged CXY for exceeding its permit.

As part of the regulatory investigation and notwithstanding CXY's cooperation, CXY offices were searched and documents seized. The company has argued that the documents were not obtained through a lawful search. The B.C. courts have twice ruled that the documents were unlawfully seized. Environment Canada has appealed these decisions to the Supreme Court of Canada. The decision whether the Supreme Court will hear the appeal is expected in October 1997.

The equipment malfunction resulting in the permit exceedence has been repaired. In addition, in accordance with new regulatory requirements and at a projected cost of over \$2 million, CXY is studying a process that would divert and treat the plant's water discharge before it goes into Burrard Inlet.

On-site disposal, waste management—historical background and current practices

Q. What is solid waste? Where does it go?

A. Waste asbestos goes to an approved landfill in Surrey (Port Mann) or Delta. Salt sludge is landfilled on site. General garbage goes to the municipal landfill, scrap metal, paper and cardboard is recycled.

Q. How often are your air emissions tested?

A. We run tests once per year and submit data to the GVRD.

Q. What do operators test for in emissions?

A. The plant water discharges are tested continuously for pH and chlorine. There are no ongoing air tests done by operations. Chlorine at trace levels would be obvious by smell and picked up by monitors on the CXY site.

Q. What could we smell in discharges?

A. Chlorine at trace levels would be obvious by smell.

Q. What is in your raw sludge?

A. It is approximately 75% salt. The rest is calcium carbonate, magnesium hydroxide and natural compounds like sand.

Q. Loading—do you ever lose a bit there?

A. The loading is done through hoses which are connected and disconnected each time a car is loaded (approximately five times a day). The hoses are blown out with air to a vessel before they are disconnected. Monitors are located in the loading area to warn if chlorine is released.

Q. I've called the municipality because I thought there was a spill. I don't know if it was you or someone else. I've smelled acid so strongly on the air while washing my car that I've had to go inside.

A. If the smell is acidic, it is probably sulphur dioxide. If we receive such a call, we would pass it on to the GVRD. We check our plant and report back to the caller and the GVRD.

Q. If there was a pipe break what would be a reasonable estimate of the amount of solution lost?

A. The size of the leak would depend on pipe length, diameter and on the time taken to isolate the line that is leaking. Fifteen of the Nineteen reportable accidents we have had since 1990 have involved amounts less than 5 kgs.

Q. If a spill takes place loading cars, how quickly does that disperse?

A. Dispersion would depend on wind velocity and obstructions (for example, buildings in the path of the cloud).

Q. Could the flushing sludge that is still being buried at the CXY site slowly seep back into the inlet, create an increase of salinity in the inlet of the Seymour River?

A. Ground water flows in the direction of the inlet, not towards the Seymour River, so the river should not be affected.

Q. When you had a spill at the end of May, how much was spilled?

A. Less than 5 kilograms, the spill was noted by the smell along the west fence of the plant.

Q. At what point does someone push the alarm?

A. At 0.15 parts per million, the monitors set off an alarm in the control room. The emergency horn is sounded if the spill is of a magnitude that people on the plant site should evacuate.

Q. Who is involved in pulling the alarm? How many people could be involved?

A. The alarm is set off by the stationary engineer (the person operating the control in the steam plant). Any employee can contact him to identify a problem.

Q. What is the height of the sensors?

A. They are at a variety of elevations in the plant process and loading area; Ground level monitors are generally 5 feet off the ground.

Q. How many levels of spills are there (minor, major)?

A. Three: non reportable, reportables-minor, reportables-major.

Q. Is the sludge (buried on the site) contaminating the land?

A. No. Components are all naturally occurring in sea water.

Q. Are chlorinated hydrocarbons still part of the sludge buried at CXY?

A. No. None have been produced since the plant was converted to metal anodes in 1974.

Q. What are you allowed to dispose of on site?

A. Our permit allows the disposal of waste asbestos and salt sludge on site.

Q. What is in your effluent— 25 million gallons per day?

A. Effluent is limited to heat removal exchangers and is pumped through cooling exchanges from the inlet and then returned to the inlet.

Q. How is this monitored? How often is it tested? By what company?

A. Continuous analyzers for chlorine and pH. Daily "grab samples" are also taken and results reported quarterly to BC Ministry of Environment.

Q. Has any analysis of sludge been done for minor components?

A. Trace metal analysis was done and found to be very low. Metals mainly originate

from sea salt so they are naturally occurring.

Q. Is asbestos still dumped?

A. Not at the plant site. It goes to an approved industrial landfill site in Delta or Surrey.

Q. How much asbestos is still on site? How is it stored? Does it pose a risk?

A. Asbestos is still used on site. It is a health risk to the employees if not handled properly.

Q. How often does the salt sludge get dumped?

A. Every 3-5 years, one of the 3 tanks are cleaned.

Regulations—how do they happen and by whom?

Q Emissions are checked 4 times a day? By whom?

A. The Water effluent is analyzed continuously for pH and chlorine. Otherwise, grab samples are taken daily for reporting purposes.

Q On operating permit from the Ministry of Environment—do you have to be tested once a year for safety, environmental or regulatory issues?

A. The Ministry can sample any time they want. There is no set time or frequency for this to happen.

Q To whom do you send data on effluent monitoring?

A. The data for the water effluent is noted daily and submitted quarterly to the BC Ministry of Environment.

Q Is monitoring through stack or in the water?

A. Water samples are taken directly from the effluent pipe.

Q Is effluent tested in tube or out in water? Are fish tested?

A. Continuous monitoring is conducted in the pipe. Grab samples are analyzed in the CXY laboratory and also for specific items at an outside lab. Fish testing is done quarterly under contract.

Q Who monitors your monitoring? How often does that happen? Can you cheat if it is only quarterly?

A. The BC Ministry of Environment receive compiled daily results at the end of each quarter. Is it possible to fudge the numbers? Yes, but this is not only illegal but unethical and would not be supported by any Canadian Chemical Producers Association member company under "Responsible Care" guidelines.

Q How often do monitors go off?

A. The fence line monitors go off about 2 to 3 times per year. The monitors are activated at 0.15 parts per million which is below the odour level of 0.2-0.3 parts per million.

Q Under what circumstances would someone smell chlorine? Would these be picked up by a monitor? Could the smell go as far as Second Narrows?

A. The monitor alarms go off at 0.15 ppm. A large release could be obvious by smell at the Second Narrows.

Sterling— "Realistic Worst Case Scenario"

Q. How are the chemicals you produce used?

A. We produce an industrial salt known as sodium chlorate that is used primarily in the pulp and paper industry as a bleaching agent. To a much lesser extent, it is used as a herbicide and in the processing of ore.

Q. What would be your worst-case scenario?

A. From our 150 years of operating four plants in Canada, we believe that we have had no adverse effects or impact on any of our neighbours or their property. As part of our commitment to Responsible Care and our belief that everyone has a right to know what we do, how we do it, and why we do it, we will, over the next six months, be performing our most likely and most credible scenario. The results of these reports and consulting studies will be available to the general public.

Q. Does [the product produced] taste like salt such that animals may ingest it? Is it more dangerous to spill onto the ground or into the ocean?

A. Sodium chlorate has a taste similar to that of common table salt. It is suggested that chlorate not be ingested. It may cause nausea, vomiting, abdominal pain, diarrhea, cyanosis and/or anuria (urine shutdown). Chlorate may be fatal if ingested in significant amounts (10 to 30 grams have been reported as being fatal in humans). Sodium chlorate released into the ground has the potential to mix with combustible materials and burn when ignited.

Q. Is it not a fire hazard? What if there was a fire at the plant?

A. To start a fire, three conditions are required: fuel, a source of ignition, and oxygen. Sodium chlorate has oxygen and while burning will produce oxygen. It is only a hazard if the other two conditions are present. In the unlikely event of a fire at the Sterling plant, there is a documented and tested emergency plan which includes the North Vancouver District Fire Department.

Q. Have the shutdown systems been tested?

A. All shutdown systems in the plant are tested regularly and, as a minimum, are required to be tested at least once per year as per our corporate safety manual.

Q. Do you record incidents?

A. Yes, we investigate all safety and environmental incidents that occur at the site. All such incidents are reported to senior management. If they exceed regulatory requirements, they are reported to the various agencies.

Q. How many trucks of hydrogen peroxide per year will you use?

A. Two per month.

Q. What happens if it spills?

A. Hydrogen peroxide will react with organic material and dirt and decompose rapidly.

Q. Is hydrogen peroxide dangerous?

A. Hydrogen peroxide is a strong oxidizer and corrosive. This product is non-combustible, however it can cause ignition of combustible materials on contact.

Long-term plans and benefits of CXY

Q. What are the long-term plans for the plant?

A. The plant will operate as long as it is profitable. There are no plans at this point in time to shut it down.

Q. There was an article in the Vancouver Sun saying MacMillan Bloedel stopped using chlorine. What is the future of chlorine products, and how will that affect the manufacture of chlorine on the North Shore?

A. Very little of our chlorine goes into pulp and paper. Approximately 90% goes to US customers for plastic products, water treatment, and bleach.

Q. What is chlorine used to produce?

A. Chlorine and the related alkali chemicals are ingredients in foods (additives, processing, soft drinks), health care products (anesthetics, artificial joints, bactericides, medications), consumer goods (antifreeze, ceramics, cosmetics, deodorant, detergents, dyes, floor covering, perfumes, toys), to name just a few of its uses.

Transport

Transport issues to be addressed in the Fall of 1997.

NOT FOR
DISTRIBUTION

**CXY-Sterling Pulp Chemicals Advisory Panel
Minutes Meeting #17 - December 3, 1997
Canadian International College
2420 Dollarton Highway, North Vancouver**

In Attendance:

Ellen Riley, John Billham, Neil McManus, Lori Walker, Ross Peterson, Neil Mort, Mike Riley, Bob McLeod, Nachiko Yokota, Jane Dixon (taking minutes)

2. Approval of Agenda - approved.

3. Approval of Minutes -September 17, 1997 minutes approved

4. CAP Member Update

(Note - Let's add to the update a brief "preview" of the topic for the next meeting to identify what information we want and suggest other resources.)

Gail suggested that we revisit our original plan for CAP members to serve two year terms. This would be discussed further on in the meeting. Ross Muirhead inquired if Cas had officially resigned from the CAP. Lori replied that it was her understanding that Cas was limiting his involvement due to other commitments but still wished to be involved in some meetings and "kept in the loop."

A copy of the Chlorine Institute's pamphlet #74 on chlorine dispersion has been ordered and an updated version should be available in the new year. John will supply and discuss overheads on dispersion prepared for a presentation to the Roche Pointe Community Association. Pamphlet #64 "Emergency Response Plans for Chlorine Facilities" is available from Lori. Ross Muirhead inquired if the testing of sour gas dispersion in Alberta was based on modeling (it was). Ross Peterson mentioned that there was a Ph.D. student at UBC who attempted to model actual dispersion of released gases in the atmosphere using the Maplewood area of North Vancouver but found it difficult due to the complex micro-climate of this area. Neil McManus asked about studies on carbon dioxide in the area and the migration of exhaust gasses. Ross P. suggested Ken Stubbs from the GVRD would have that information if it were available.

Future topics - please think about questions and possible speakers

- 1) chemical facilities on the North Shore and risks in conjunction with other facilities (including risks associated with fires).
- 2) Personal emergency preparedness
- 3) More information on emergency response and sheltering eg. chlorine exposure to individuals in cars and on the street, high pressure gas mains.
- 4) Municipal Plans, Official Community Plans and plant
- 5) Responsible Care - What is it all about?
- 6) other CAPs - how do they work?

5. CXY Chemicals Update

There was no new information on CXY's court case which is waiting for a preliminary hearing in the Supreme Court of Canada. Regarding rezoning, the district staff are putting together a report for council which will include the questions and answers to inquiries made at public and community meetings. A public meeting is expected in late February. Ross P. said that staff preparing the report are currently awaiting answers to some questions from the consultants involved (Bovar, A.D. Little). Report will cover QRA, rezoning, bridge use, and Tolko site. The decision may be referred to the Seymour official Community Plan Review. John stated that CXY may step out of the rezoning/realignment if this occurs because such a referral could delay the decision by another two years. The process began six years ago.

6. Sterling Pulp Chemicals Update

Sterling has undertaken a risk assessment which is being coordinated by JBF. Bob is awaiting the results (the author has been ill).

7. N&W Van Emergency Program Update

Ross Peterson attended the annual MIACC (Major Industrial Accidents Council of Canada) meeting in Toronto and wished us to know that there is a growing dissatisfaction with risk assessment procedures which do not accommodate the views and concerns of the public. Ross wrote a briefing paper discussing the need to address this omission in a formal way, which could form the nucleus of future risk assessments. In general, there is some shift in attention away from mathematical modeling approaches more towards qualitative approaches. For example, This could mean an expanding or formal role of CAPs. Tools such as fatality contours, while useful in planning for emergencies and understanding risk, are not necessarily what the public want. Other expressions or ways of understanding of risk are often sought. Quantitative risk assessments (QRA's) alone can put municipal councils in a difficult position. Results of QRA's may fit MIACC's guidelines for risk acceptability but not necessarily the public's'.

Ross has also made a request to MIACC for any research or information they may have regarding the use of general alert siren systems and telephone and siren systems used in tandem. Ross will pass this onto CAP.

Ross Muirhead asked Ross if there were Answers to the Questions (from the public information meeting on CXY's QRA) he forwarded with the last set of minutes. Ross stated that those would be included in a report to council and shared... Ross M. also inquired if the approval of rezoning meant the approval of the risk assessment. Ross P. responded not necessarily. For example, zoning could still be based on more conservative criteria than those used in the MIACC guidelines.

7. Discussion - Action Items for CAP: Achieving our objectives

Lori initiated a discussion of how CAP members wished to proceed in achieving the objectives we originally set out for ourselves. We started by looking at the objectives and discussing if they still fit. We discussed whether we wished to try to achieve group consensus on issues arising in discussions, and offer recommendation or be primarily a vehicle for information exchange. The importance of having different perspectives, representing the perspectives of the community was recognized.

The mission of CAP was identified as follows:

1. Identify issues of concern and importance to the community
2. Provide information to the community
3. Provide information to the company sponsors and municipality
4. Improve community safety/ emergency preparedness
5. Represent community

With respect to accomplishing these goals, other issues were identified. We re-evaluated the need for the two year term that we had originally set for members and decided that given the amount of time and effort that it has taken to acquire the background knowledge we have, it would be unfortunate to start from the beginning with a new group. The need to stay fresh, relevant, and representative was also recognized. It was felt that this could be accomplished by welcoming new people into CAP as we went along. Individual members may decide to step aside when they see fit. Another reality is that there are a limited number of people interested in participating. A discussion of our representativeness led to the identification of a youth member, Ports Canada rep, city planning rep, and OCP rep as possible new members. Lori will follow up with the principal of Windsor High School for a youth member. We should consider how to assess how well we are representing the interests of other community groups.

We discussed the need to recognize the role members wished to play on CAP. While some view their role as encouraging the exchange of information among involved parties, others see their role as "watchdog". Both roles are essential. We also act as advocates for public involvement processes. The need to make time for CAP members to discuss issues was identified as important, as is the need to discuss possible resource people and the issues and questions we want them to address.

John and Bob were asked if the CAP is fulfilling their information needs. Bob stated that Sterling is there to identify what the community wants to know. John shared this position, and said that CAP members should be the ones to identify the issues to be addressed.

In considering the task of getting information out to the community, we talked about the need to identify who it is we are communicating with and the special challenges of reaching particular groups. For example, Lori said that she was initially unsure about how to involve First Nations people close to the plant.

Ross P. suggested reaching the "uninterested" was a huge challenge, but nonetheless an important step if CAP is to truly be representative of the community. Gail suggested we may have to think of different ways to reach different groups. (Suggestions are noted on the "Achieving Objectives" work sheets following the minutes).

During a discussion of how CXY communicated with its neighbours, Nachiko asked about Neil Mort's experience at Canadian International College. Neil said that instructions about what to do in the event of a leak were designed and are included in the yearly orientation and in the handbook. Instructions are also reviewed with students. While initially uncomfortable about a possible accident, a "matter-of-fact", a proactive approach has been taken by the college and has been received fairly positively.

The issue of liability when/ if CAP members do presentations was raised. It was agreed that we would design communication material together to assure accuracy, beginning with a "homework assignment" to identify what should be communicated (please see page following "Achieving Objectives").

There was also an inquiry about why other North Shore chemical companies are not participating in the CAP. John responded that only Dow is a member of the Canadian Chemical Producers association and are not involved in the Responsible Care. Ross suggested that broadening scope may be beneficial to the municipality. John also said that the Mohawk plant manager had offered in the past to speak to the CAP whenever requested.

8. Next Meeting

Transportation of Hazardous Products - With Terry Litchfield, Manager, Transportation Logistics, Jim Muirhead, Sterling Pulp Chemicals, Ross Peterson, North and West Vancouver Emergency Program and Doug Kittle, Transport Canada Hazardous Goods Officer

Date - **FEBRUARY 4, 1998** 5:30 PM Canadian International College

NB Please contact Lori with specific questions or other suggestions for speakers.

9. Meeting Adjourned at 9:00 PM

north shore news
MAIL BOX

Gas plant could be good for H. Sound

Dear Editor:

Re: B.C. Gas Southern Crossing Hearing

It is distressing for our association to read the comments of the mayor of Lions Bay in our local media which, in our opinion, grossly misrepresent the West Coast LNG storage facility proposed for McNab Creek and the conduct of the Sunshine Coast Regional District. It is our understanding that Lions Bay has made similar representations to the commission at the above hearing.

It is equally distressing to learn that this hearing has become, not just an evaluation of the Southern Crossing proposal, but rather an evaluation of all proposals to supply natural gas to the Lower Mainland.

Had our association been aware of the reality of this situation, we would have participated as an intervenor in the process and made a significant presentation. Perhaps it is our inexperience with regard to the B.C. Utilities Commission that is to blame.

West Coast Gas has recently made a major presentation on their project to our association. They have answered every one of our questions in a forthright and honest manner. They have provided detailed technical information with respect to earthquakes attributed to the proposed site which has revealed that none of the recent quakes were remotely near the proposed site.

West Coast Gas needs approvals and zoning changes from the Sunshine Coast Regional District. Even though this is at a very preliminary stage, West Coast Gas has demonstrated that it wishes to become a responsible partner in our community. None of the other competing projects, or indeed the original applicant itself, B.C. Gas, has even bothered to contact our association, let alone provide us with any information or background on their proposal.

Our firm position on this hearing can be summed up thus: if the commission is to allow the evidence or representations of Lions Bay to remain on the record, then we should be allowed to make a presentation, and that we

should be given the time and funding necessary to properly prepare this presentation.

The West Coast Gas LNG storage proposal will generate immediate construction jobs for the community, create a limited number of long-term, good-paying, operating jobs, and most importantly provide significant new tax revenues to our local governments.

To have the decision-making process tainted by the ranting of Lions Bay's mayor is inexcusable and in our opinion, indefensible.

The issue of Lions Bay's mayor misleading the public as to the project's safety, when her only real concern is that her view may change, is a matter that she will be publicly held accountable for.

We have not interfered in Lions Bay affairs when they constructed the grossest of all public eyesores, clearly visible from the Sunshine Coast, which significantly destroys the spectacular scenic beauty of Howe Sound because we realize this is a very significant part of their community's flood protection infrastructure.

Regrettably the mayor of Lions Bay has not taken the time, as we have, to learn the facts of the project. If she had bothered to do so she would discover that while there are concerns with regards to the project, the long-term financial benefits and related positive community impact far outweigh those concerns, and thus the project should be allowed to proceed through the next level of the regulatory processes.

We would respectfully suggest that the commission has two alternatives: either declare a mistrial, and hold a new hearing properly informing the public what is to be discussed and what is at stake; or suspend the current hearing and allow us, and indeed I suspect, many other groups, the opportunity to properly participate in the hearing.

We would respectfully ask that the commission rule on our request forthwith.

Bob Jones
Elphinstone Community Association
Gibsons

GVRD criticized for opposing gas tank

Residents of the Sunshine Coast aren't "a bunch of hillbillies" and know how to decide what constitutes a safety hazard to the public.

With those words, Patricia Baldwin, chairman of the Sunshine Coast regional district chastised GVRD officials for opposing construction of a liquefied natural gas tank at McNab Creek in Howe Sound.

Baldwin said the GVRD jumped the gun in opposing the tank farm, which is being proposed by Westcoast Energy as an addition to the Vancouver Island natural gas pipeline.

The storage facility, which would be located in SCR D territory, still needs provincial regulatory approval.

DEC 15/97

Sound test

AT first glance the testiness in Lions Bay and vicinity over plans to build a large Liquefied Natural Gas (LNG) storage plant across the way on Howe Sound smacks of the old NIMBY syndrome.

Westcoast Gas Services Inc. proposes the largest such facility in North America on a site approximately 7.5 kilometres inland from Howe Sound at McNab Creek.

Subject to government approval, the storage plant will be designed to liquefy up to 16 million cubic feet of gas per day. Up to three billion cubic feet of gas could be stored at the site.

The storage tank will be 74 metres wide and 52 metres tall — a massive structure. LNG stored at the site will be taken from gas fields in northeastern B.C. Westcoast's intention is to provide a competitive alternative to the BC Gas

Southern Crossing project, a pipeline hook-up to Alberta gas for B.C. customers.

On the Sunshine Coast the Westcoast development would be a good thing in some quarters. The project would realize hundreds of construction jobs and an eventual 14 full-time jobs once completed.

Across the water, however, there's concern about visual pollution, earthquake hazard and questionable development thrust for the region.

This issue is a test. The good folks in Lions Bay are right to raise a ruckus. The heat will bring to life a process that should be taking place at the grassroots level. The future of the Howe Sound region is being determined now. Is it a leisure playground? Is it an industrial breadbasket? Can it be both?

Spill actions blasted

Robert Gabriel

News Reporter robert.gabriel@times.com

DEC 11/97

CHERYL Tront says Lionsdale Recreation Centre staff bungled their handling of an ammonia spill that emptied the centre, an elementary school and several businesses in the area two weeks ago.

Tront, 32, was unaware of the Nov. 27 spill when her Thursday she went to the centre's pool for a swim. "I often go swimming at that pool... when I got in the water, right off the bat it was different because it burnt," recalled Tront. Initially she said the burning was centered around her legs and eyes, but when her tongue started to swell, she panicked and decided to get out of the pool.

Rec centre user claims ill affects after using pool following ammonia leak

Once she was on the pool deck, she started to feel woozy and managed to reach a poolside bench before she passed out. Although there were two lifeguards in the vicinity, Tront said neither one approached her. When she approached them and asked what was wrong with the water, they told her about the ammonia spill earlier that day.

Her North Vancouver Recreation Commission Director Gary Young said the entire facility was checked for ammonia levels following the spill before it was reopened to the public.

"All the tests said that the ammonia was at a safe level includ-

ing (in) the pool," said Young. He said pool staff performed a chlorine burn at the facility following the incident. Tront attended as part of a regular cleaning schedule.

A chlorine burn is a common procedure at public swimming pools and involves significantly raising the chlorine level in the water and letting it dissipate overnight.

Young said pool staff found the chlorine levels to be still too high Friday morning and decided against opening the pool that day. Young said pool staff performed a second chlorine burn that morning.

"As soon as you cancel classes you might as well go all out," said Young.

However, North Shore Health's Rick Kwan said he received a complaint about the pool's water quality Friday morning. Kwan

See Commission Page 3

Commission guards water tests

From page 1

said one of his staff members checked over the facility and checked the pool's recent water quality tests as a result of the complaint.

Kwan said the water's chlorine count was high. The pool was then closed for the remainder of Friday.

Meanwhile Tront's problems were just beginning. Upon coming home after her dip she took another shower, but her discomfort was not easing up and she also started sneezing.

"It got progressively worse with my tongue and my legs; there was a constant pain on my legs," said Tront.

The next morning, she awoke to the same discomfort and after driving her boyfriend to work she returned home. Tront called her mother who subsequently drove her to Lions Gate Hospital.

"Basically I just had a really bad allergic reaction to the whole thing," said Tront, who stayed in bed for three days following the incident.

Tront has since contacted a lawyer and is contemplating legal action against the North Vancouver Recreation Commission.

"My lawyer just can't believe they had that pool open," said Tront. "It's sheer negligence. They should have had it closed and it's lucky I'm as healthy as I am."

When Young was contacted again last Wednesday he confirmed the pool was opened briefly on Friday morning, but said he would not discuss nor would he release the specific results of the water tests performed on the water on Nov. 27 and 28 because there is a claim against the facility.

Young said recreation commission staff have contacted Tront and will have their insurance agents evaluate it.

"We'll look at her claim, and if it's an appropriate claim we'll honor it," said Young. "We're also talking about making sure the taxpayer is protected."

Young added "not many" claims are filed against the North Vancouver recreation facilities even though they have 2.5 million visitors annually.



NEWS photo Mike Winkler
CHERYL Tront claims she was overcome by high levels of ammonia as she swam at Lionsdale Rec Centre on the day of the leak.

Ammonia actions appreciated

Dear Editor:

DEC 12/97

On Thursday, Nov. 27, the North Vancouver Recreation Commission experienced an ammonia leak at the Lonsdale Recreation Centre.

The leak required us to evacuate the building just after 9 a.m. Approximately 300 of our clients, many in fitness apparel, were warmly welcomed at Silver Harbour Manor. As well, the children from Lonsdale elementary school, who were downwind of the leaking gas, were evacuated to our Delbrook Recreation Centre. The upper portion of the Lonsdale city corridor was closed for a couple of hours.

We offer our sincere apologies to all the citizens of North Vancouver who had their daily patterns disrupted.

We would also like to express our thanks to the staff and volunteers of Silver Harbour Manor, the RCMP, the City Fire Department, Emergency Social Services, City Staff, B.C. Transit, North Shore Health, B.C. Ambulance, Environment Canada, Lonsdale School and our own staff, all of whom responded magnificently to the emergency situation.

Maureen Curtis

Chairman

North Vancouver Recreation Commission

Gas debate heats up

Michael Becker

New Editor

michael@nsnews.com

DEC 3/97

WEST Vancouver Mayor Pat Boname and Lions Bay Mayor Brenda Broughton share a nightmare. The dark fear is this: an earthquake and a Hiroshima-scale natural gas explosion in the Howe Sound area.

The source of this hellish vision: Westcoast Gas Service Inc. proposes to construct and operate a liquefied natural gas (LNG) storage facility in the Sunshine Coast Regional District near the Vancouver Island Pipeline.

The 24-hectare McNab Creek site is located approximately 7.5 kilometres inland from Howe Sound, 20 kilometres across

War of words picks up steam over plans for LNG storage facility in H. Sound

the water and away from Lions Bay and approximately 30 kilometres from Sunset Beach in West Vancouver.

Westcoast would like to build an LNG storage tank 74 metres (243 feet) wide and no more than 52 metres (170 feet) tall. The tank may be fitted with four white aircraft warning strobe lights.

It would be used to store natural gas during spring, summer and fall months. In the winter, during peak demand, the facility would be able to supply up to 300 million cubic feet of gas daily, enough to meet the needs of 300,000 households.

Westcoast anticipates a construction start early next year to

open the facility by 2000. The project has yet to be approved. It must get the nod from the Sunshine Coast Regional District, the B.C. Environmental Assessment Office and the B.C. Utilities Commission. To jump through the regulatory hoops, Westcoast has thus far spent approximately \$1 million on third-party consultants for the project.

In the meantime, proponents and opponents wage a steady public relations war. Broughton and many of her constituents believe the Westcoast facility poses a serious risk to the well-being of Howe Sound residents.

Verkuil Communications Inc. spins Broughton's position to the media in terms of "the feisty volunteer mayor" engaging in a "David and Goliath-type battle" against big corporate agents of industrialization and purveyors of catastrophe.

On the other side of the issue, an information package pro-

See Energy page 3

Energy company answers critics of storage plan

From page 1

vided by Westcoast Energy's Wayne Soper, vice-president environment and government relations, includes color shots of scenic Howe Sound vistas. The LNG storage tank is invisible to the eye in photos identified as View from Lions Bay, Simulation of Proposed Tank from Highway 99 and Simulation of Proposed Tank from North Shore of Gambier Island.

Point by point, the hot-button issues — visual impact, noise, public health and safety, earthquakes, environmental concerns — are addressed.

Howe Sound politicians, including Boname and Broughton, met on Monday to discuss the Westcoast plan and grapple with the larger issue of planning for the region. Said Boname, "There's a fair portion of West Vancouver that fronts on Howe Sound. What started off as being a concern about the visual impact of the size of the storage tank has turned out to be the tip of the iceberg."

"It's not only a very large structure, but there's the earthquake chance that something might go wrong and there's the scenario of of Howe Sound going up in smoke if everything did go wrong.... And I guess a third concern is the future of Howe Sound. Will it be another False Creek at the turn of the century?"

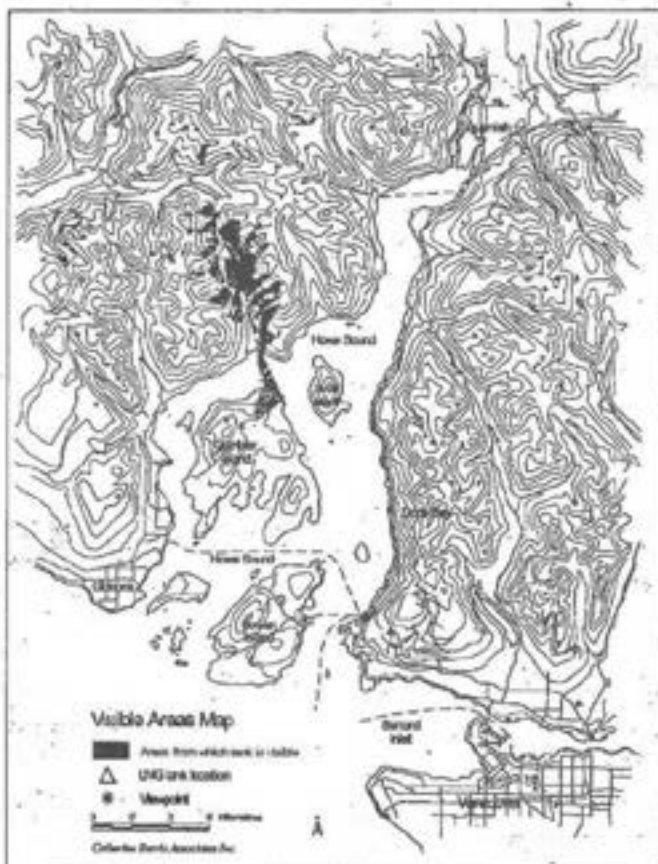
For the more immediate future the West Vancouver mayor is considering a public open house with Westcoast representatives some time in January.

Meanwhile Lions Bay's Broughton has taken heat from Sunshine Coast Regional District Chairman Patricia Baldwin for actions "that side-step the review process currently under way." The mayor made official representation on behalf of Lions Bay residents opposed to the LNG project to the B.C. Utilities Commission on Nov. 25. She will take her community's case to the environmental assessment office panel on Dec. 16.

Said Broughton of Baldwin's criticism: "There is a difference of opinion about the role of leaders. The Sunshine Coast believes that the rigor (of review process) is in the hands of these studies that are being conducted. (But) this is absolutely the public's time. The public needs to be alert to this issue, otherwise the public is asleep during a very critical period."

Westcoast's Soper doesn't want a sleeping public either. "I think we've been very forthright in terms of public consultation, being very open with the public in terms of what the LNG project means for the area."

"One of the things I think we've been very clear on is that it's important



Graphic submitted by Catherine Berris Associates Inc.

A proposed liquid natural gas storage tank will be visible from a 2.3 km stretch of coast north of Horseshoe Bay and south of Sunset Beach.

that we all stick to the facts. In the case of liquefied natural gas, it is a cold liquid stored at atmospheric pressure. It does not explode. The comparison to liquefied petroleum gas explosions is really not reasonable. It's a facility in conjunction with the pipeline. There's no linkage to other industrialization. There are no present plans, no future plan, no contemplation whatsoever of there being any shoreline facilities relating to LNG shipments or a port," he said.

Son poses as dad in scam

Anna Marie D'Angelo

News Reporter
dangelo@nsnews.com

FRANK Williams Junior used his father's name to rip off two mortgage companies of about \$47,000.

Williams, 27, was sentenced last month to a six-month conditional sentence and 12 months' probation for the crimes.

North Vancouver provincial court Judge Doug Moss ordered Williams to pay \$44,308.86 restitution to the L.S.B.C. Captive Insurance Corp and \$5,500 to Burnaby-based H.F. Heritage Financial.

Williams, a New Westminster resident, was required to perform 200 hours

NORTH & WEST VANCOUVER EMERGENCY PROGRAM

Memorandum

To: Irwin Torry – DNV
John Bellham – CXY
Terry Litchfield – CXY
Jane Flemming – Canadian Oxy
Elizabeth McDonald – ASL
Stewart Behie – Bovar
Bob Schubak – Hooley & Schubak
Norman Stowe – PACE Group
Brian Stegavig – DNV Fire
Lori Walker – CAP Facilitator

From: G. R. Peterson

Date: October 14, 1997

Re: Open House on Chemical Risk Assessment and Land Use Re-zoning

Overall, I don't think that we did as good a job as we should have in the area of chemical risk communication to the public.

I have since written to MIACC on the need to expand risk assessment procedures to incorporate more public involvement in the determination of public sensitivity and concerns, with the hope that in future, risk assessments can include or be directed towards those issues of concern to the public. I suppose a simple way to put my views is to say that risk assessment is not the same thing as risk communications and risk assessors are not necessarily risk communicators, although we often ask them to assume this role as what seems to be a logical extension of their assessment work. I contend that in some cases, this may not be appropriate or fair to the risk assessor.

These suggestions do not in any way criticise the good science that goes into quantitative risk assessment and other technical studies associated with risk, such as seismic engineering work, etc.

My suggestions refer instead to what I feel is a lack of follow through in risk assessment or what should follow the QRA or Responsible Care audit in terms of a meaningful discussion with the public. After all, much of the risk being calculated is public risk.

It seems clear that if one objective of risk assessment is public release of information to satisfy the principle of the public's right to know, then to make this most meaningful, the public should be asked what kinds of things it wants to know and this should ideally take place before the assessment in order that as many concerns as possible are addressed by the process.

This brings us back to the September open house.

There seems some unpreparedness to provide information on what some people wanted to know, even though some of these questions had been asked before. In other words, there were really no surprises at the open house, but the public didn't always get the kind of information they were asking for. For example, questions 10B, C and D and questions 20A, B and C refer to a public interest in simpler information such as plume size and direction, and gas concentrations. Also, questions 10A, 1 and 20A, B and C refer to the general issue of sub lethal effects.

I don't think the public was totally satisfied with the answers provided to these questions. Although Elizabeth McDonald provided useful information on levels of harm from chlorine, we weren't able to follow this up with plume figures or contours of projected concentrations showing where these harmful levels might be found. I acknowledge that there was a get together following the evening meeting where Stuart described some of the possible plume behaviours; but in my view, this should have been a central feature of the risk assessment description. In saying this, I acknowledge that the QRA itself was not designed to provide this type of information, but to satisfy the informational requirements for the MIACC land use guidelines. However, this guideline informational need is not the same as the public's need or desire for information. This is the whole point. Let's find a way to provide the information that the public wants and orient the whole process where necessary towards providing it.



CANOXY - Bylaw 6762
September 23, 1997 Public Information Meeting

PUBLIC QUESTIONS/COMMENTS	ANSWER
1. Measurement of chlorine emissions/spills (low level basis around plant) by GVRD a) why not put in monitor? b) concern with frequency of monitoring - regular vs. annual?	<i>Ken Stubbs</i>
2. Riverside intersection and one-way traffic flow proposal a) what about traffic by Maplewood Pub, etc. - affect on patrons? b) how does traffic interact with CXY, recycling depot, etc.? c) what about railroad tracks? d) Maplewood not in favour of one-way; prefer to keep Riverside open.	<i>Berry Carlson</i>
3. Concern with CXY reporting spills a) what are the requirements/regulations? b) who is responsible for damages resulting from spill - CXY or District? c) what about effects of spill on other side of inlet; specifically, systems for alerting residents?	<i>John Gillham</i>

4. In the event of a chlorine release a) how should the public react in event of a chlorine release, i.e. what about sheltering, those in vehicles, best advice? b) if concentration of gas does get high (in your 'shelter'), how do you protect yourself? c) what is the responsibility of other employers in the area (other than CXY) for training employees for an emergency?	<i>Ross Peterson</i> <i>ROSS</i>
5. Dollarton realignment a) what is the benefit? b) why not expropriate CXY land for the highway? c) what came first - business park or realignment?	<i>Ivan Jarry</i>
6. How safe are the valves on the rail cars?	<i>Greg Litchfield</i>
7. a) are the two 600 ton tanks still in place and still in use? b) would the tanks be used again & why? c) what would be the risk?	<i>John Dickson / P.O. Hirdack</i>
8. We should develop better egress into the area before more development, such as another Seymour Crossing, 3rd crossing, dedicated lanes into Cove to avoid bridge line ups. Is there residential development planned for this area?	<i>Greg Carlson</i>

9.	a) what is the present zoning for CANOXY? b) would a business license be approved today for this plant?	Irwin Terry
10.	a) what are the health effects of exposure to chlorine? b) why have we not studied (and presented) information on how chlorine would disperse in a release and what would be the concentrations in different areas (as identified on the map)? c) can that be depicted and illustrated clearly? d) why is that not here tonight? e) what goes on down at the plant during an incident? f) what is the Corporate response?	Elizabeth McDonald Stuart Bellis John Billham
11.	Has risk assessment included a scenario involving explosion from a propane storage on a neighbouring site or in transit through the area?	John Billham / Stuart Bellis
12.	Concern with integrity of workers. All industrial users could get out of the area and leave residents in peace. It would make a great park.	John Billham / Paul Fleming
13.	Safe workplace - worker feels safer in the plant than driving down Mt. Seymour Parkway.	this area is a commercial area as well as a residential facility.
14.	a) what to do when there is a chemical spill? b) what about an earthquake scenario - when windows may be blown out?	Mr. Peterson ROSS

15.	a) who will benefit from the business park? b) are there disadvantages? c) has it been taken into consideration that new businesses will bring existing staff from outside the community? d) how much more development can we take?	Irwin Perry
16.	a) how do risk assessments differ from this community and, for example, Seattle? b) what about the role of the EPA or other regulatory bodies?	Lisa Bendisen
17.	a) what is the difference between public meetings/hearing? b) is Council here to make a decision on anything tonight?	Irwin Perry
18.	Would the District expropriate private residential lands to make way for Business Park/realignment?	Irwin Perry
19.	a) what is the cost of realignment? b) have options been considered, such as overpass and make improvements to the existing Dollarton?	Gerry Carlson
20.	a) what is the ratio of fatalities to injuries in chemical exposure incidents? b) what are the different effects of injuries and the costs of medical care? c) are the effects permanent or irreversible requiring expensive treatments?	Elizabeth McDonald

27. a) public process for rezoning has been undermined by work to date on realignment. b) need for improvements to transportation routes, but phase it as follows: phase 1 - bridge; phase 2 - realignment; phase 3 development of Business Park/CXY site.	<i>These are statements and opinions expressed by an individual at the meeting.</i>
28. a) what is proposed for CXY if rezoning does not proceed? b) what are the differences between existing and proposed zonings for CXY land?	<i>Irvin Terry</i>
29. a) what are the factors around risk contours ending at rail line? b) would staff approve the set up of this operation today? c) why not work with CXY to phase out operations?	<i>John Bellham, Dave Kearney / Stuart Bell</i>

21.	How could the District spend money on the realignment before the public hearing?	<i>Larry Carlson</i>
22.	a) in what form are the results of the Quantitative Risk Assessment? b) are summaries available? c) what does it mean in a nutshell?	<i>Stuart Belie / Hans Fleming</i>
23.	a) would staff recommend use of MIACC guidelines in future land use planning? b) is there a frame of reference for "low density"?	<i>Irwin Perry</i>
24.	a) chlorine is net benefit to society, but why ship it? Produce and use on same site, as in Europe. b) don't see margin of error confidence identified in report. Have obscured risks (helicopter crash, sabotage) been considered? c) is community comfortable with these risks? d) would you put a plant such as this in this location today?	<i>Stuart Belie / Hans Fleming</i>
25.	a) how many people were laid off when Squamish plant closed? b) why not keep it open and close North Vancouver?	<i>Hans Fleming</i>
26.	a) what are the long term plans for the surrounding areas (Port lands, International College, etc.) east and west of the CXY site? b) All will produce traffic.	<i>Irwin Perry</i>

OCT 31/77

Last great quake hit B.C. 300 years ago

Scientists find proof in the stumps
of dead cedar trees along the
Copalis River near Olympia, Wash.

LARRY PYNN
VANCOUVER SUN

COPALIS BEACH, Wash. — After a decade of research, scientists say they've found confirmation on this side of the Pacific that the last great earthquake to strike B.C. and parts of the U.S. West Coast occurred almost 300 years ago.

The proof lies in an innocuous patch of tree stumps on the Copalis River — a brackish slough feeding the Pacific Ocean about 100 kilometres west of Olympia, Wash.

Japanese researchers reported in 1996 in the journal *Nature* that they'd calculated, with the help of tidal-wave records, that the quake occurred at 9 p.m. on Jan. 26, 1700.

But until recently, there was no proof in North America that supported their theory.

Then, on the Copalis River, just one kilometre upstream of what is today the quiet community of Copalis Beach, researchers found a place where old-growth western red cedars and Sitka spruce once thrived on rich riverbanks.

They also found that as the land collapsed by about a metre during the last great quake, the ancient trees became submerged in tidal saltwater and died.

Although the spruce trees have largely rotted away, the cedars have proven far more resistant to the natural elements, especially the root system, neatly preserved by three centuries of tidal mud.

"What makes this place so graphic is that the forest is still sticking up," said Brian Atwater, a geologist with the U.S. Geological Survey and an affiliate professor at the University of Washington in Seattle. "That almost never happens."

Donning bright-yellow waterproof gear, Atwater waded chest-deep into history, lowering himself into a coffin-sized hole in the ground next to a 20-metre-high cedar stump. Using a small chainsaw, he cut off a chunk of root the size of a Presto-Log.

"There you have it," he beamed. "You can see how well it is preserved."

Using the growth rings still visible in the roots, scientists have been able to determine that the cedars died shortly after the fall of 1699, which, supported by radio-carbon dating, proved a match to separate research into an equally mysterious phenomenon that took Japan by surprise in 1700.

Ancient records obtained by the Geological Survey of Japan and the Earthquake Research Institute of the University of Tokyo showed a tsunami, or tidal wave, struck at least five villages during that period.

But there was no similar evidence of an earthquake in Japan, suggesting the tsunami had originated across the Pacific.

The Japanese calculated the tsunami originated in the Cascadia subduction zone some 10 hours before the villages were hit — and therefore were able to pinpoint the time of the quake on the other side of the Pacific.

The quake was huge — lasting a minute or longer and registering in the range of 9 on the Richter scale, almost 100 times more powerful than the 1989 San Francisco quake, which hit 7.1 and caused \$7 billion US damage.

It didn't have an epicentre as we know it, but ruptured the entire length of the Cascadia subduction zone — the point on the ocean floor at which the Juan de Fuca plate descends beneath the North American plate, stretching some 1,000 kilometres from the west coast of Vancouver Island to northern California.

Along with the rumbling and creaking of the earth's surface, the earthquake created the tsunamis, powerful waves, that rushed east and west across the Pacific Ocean at the speed of a passenger jet.

While it was the earthquake, not the tsunami, that caused the land to drop and kill off the cedar trees on the Copalis River, there's evidence there, too, of the great mountain of water that briefly inundated the land.

Chewing into the bank with a small army shovel, Atwater held out a sample that clearly displayed three neat layers: Brown organic earth in which the cedar trees once grew; a layer of grey sand deposited at the moment of the tsunami, and a final layer of olive-colored mud deposited by the tidal forces over the past 300 years.

While no such spectacular evidence of the great quake as the Copalis cedars has been found in B.C., Canadian researchers have found similar soil layers at Tofino and Ucluelet, as well as sand volcanoes — thin vertical veins of sand, up to five metres deep — on exposed soils in drainage ditches on the Fraser River delta.

The sand volcanoes indicate a violent shaking of the earth.

As well, aboriginal people on Vancouver Island have supplemented the pure science with an extensive oral history, telling of a giant and terrifying shaking of the earth one winter night long ago.

For geologists such as Clague, the big problem remains that of forecasting the next megathrust quake.

"They don't go off like clockwork," he said. "For some reason, they don't have that regularity, and that's what makes it difficult."

Corrie Kost

October 28, 1997

Mr. Irwin Torry
Manager of Planning
District of North Vancouver
355 West Queens Rd.
North Vancouver, BC, V7N2K6

Dear Mr. Torry,

Re: Question about CXY's QRA & Arthur D. Little Report

There are a number of issues that still concern me about the risks associated with the operation of this Chlorine plant.

1. Since insufficient details were provided in any of the available documents in order for me to feel comfortable that the various chlorine release impacts have been done properly, I have requested that Pamphlet 74 be made available. This pamphlet, estimating the area affected by a Chlorine release, provides colour graphs showing downstream chlorine plots at 25 and 10 parts-per-million (ppm) for 14 different scenarios. This would enable me to cross-check the validity and conclusions of the models which were reviewed in the report of July 4/97. I was informed that Pamphlet 74 (currently in revision) would be sent to me in about a month. I trust I will be given the appropriate time so that I can put forth an informed decision on the matter of the validity of the quoted risk assessment.

2. In conjunction with the above I should like to submit for the record (and have it verified by the appropriate experts in this field) the calculations illustrated below. The question as to what was the maximum area that could be covered by 300 tons of vaporized chlorine (say to a height of 3 meters above ground level) at the lethal dosage of 1000 ppm is one worthy of consideration. I have calculated this to be about 30 km². The calculation was done as follows:

300Tons $\sim 3 \times 10^8$ gms

1 mole of Cl₂ (ie. ~ 70 gms) occupies 22.4 litres in a gas state at STP

300Tons thus occupies a volume of $22.4 \times 3 \times 10^8 / 70$ litres

Diluted in volume to 1000ppm would expand this by 1000 and since 1m³ = 1000 litres the two factors cancel nicely to give a volume of $22.4 \times 3 \times 10^8 / 70$ m³

Dividing by the height of 3 meters gives an area of $22.4 \times 10^8 / 70$ m² ie. 32×10^6 m² ie. 32km²

*Note - immediate danger to life was given as 25 ppm in reference
<http://rth.net/15922128>*

Now one can readily generate the following areas for different densities (ppm)

Parts-Per-Million	HEIGHT (meters)	Area (km ²)
1000	3	32
1000	10	9.6
1000	30	3.2
300	3	107
300	10	32
300	30	10.7
100	10	96
100	100	9.6
10	10	960
10	100	96

It would be informative to know the mortality rates/times for these proportions(ppm) as well. If you need further clarifications on these calculations please don't hesitate to give me a phone call.

3. In attempting to understand the factor of 10 reduction in the risk assessment from the previous report I have come to the conclusion that, since the earthquake risk multiplied by the volume of Chlorine stored on site form by far the major risk components, and that since the Earthquake risk remains unchanged, and the volume has been reduced by a factor only of 5, I am unable to understand where the additional factor of two (to account for the 10) came from? Could I have a SIMPLE explanation for this please?

I trust the answers to the above will help the public understand the risks associated with this plant and allow for an informed debate on the matter when it is brought before Council.

Yours truly,



Corrie Kost

..\district\canoxy\lc281097.sam

October 23, 1997

Mr. J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver
355 West Queens Road
North Vancouver, BC
V7N 2K6

Re: Additional questions on CXY Chemicals' QRA.

Dear Mr. Torry

I understand that on October 30th, the District has organized another public meeting to discuss outstanding questions on the QRA with representatives of BOVAR Environmental, CXY Chemical and Arthur D. Little.

Please submit the following questions to the parties concerned.

1. In the 1994 QRA, the "Maximum Downwind Extent of 1% Probability of Death" at wind speed of 2 meter/sec. is about 6 km (figure 6-4). In the 1997 updated report the distance is about the same at this wind speed. However the 1994 report shows a downwind range of about 8 km at a wind speed of 1 m/s, and the 1997 report shown a range of over 14 Km for a wind speed of 1.5 m/s.
For comparison purposes what would the 1997 "Maximum Downwind Extent of 1% Probability of Death" be with a 1 meter/sec. wind and why such a large difference between the 1994 and 1997 reports?
Could BOVAR also produce figures for 50% and 100% Probability of Death?
2. The 1997 Updated Report did not include the "Worse-Case Probability Death Contours" for 1 m/s winds (see 1994 QRA, Figure 6.6). Other wind directions should also be included e.g. West, South-West, South and South East.
3. Since the prevailing winds at the CXY plant are easterly, it seems that even a relative minor chlorine spill at the plant would affect traffic at the Second Narrows bridge and connecting highways. Driving into a minor chlorine cloud at speeds over 80 km/h could temporarily blind drivers which would create a traffic nightmare. Has this scenario been considered in the Risk Assessment calculations?
4. What are the suggested population densities in the MIACC guidelines for the 10^{-5} to 10^{-6} risk zone (Commercial, offices and low-density residential)?

5. There was a lot of discussion at the September 23rd Public Meeting (in the afternoon) of taking shelter at home during a chlorine spill. Apparently one has a good chance surviving a chlorine release by staying at home. This was confirmed by the different experts present.
It was also suggested that a large breach of the 300 ton storage tank would probably only occur during a large earthquake. It is also well known that the home is often not a safe place to be after a large earthquake (gas leaks, falling beams, after shocks etc.). A home without windows wouldn't provide much of a shelter from the chlorine cloud anyway.
Was the above considered when calculating the Risk Assessments?
6. Calculations on the "Estimated Consequences" of a chlorine spill would be more useful than the Risk Contours. Estimated casualties from chlorine inhalation under different scenarios considering the populations residing in the effected areas and the atmospheric conditions at the time, e.g. Large breach of the 300 ton storage tank, a 1 m/s South-West wind, large earthquake (most homes would be damaged) the estimated casualties will be x.
Repeat the exercise for a large breach without damage to homes, etc.
Different atmospheric conditions should also be considered e.g. wind directions and wind speed.
It could also include a scenario projecting estimated population in the effected areas in the year 2012 (in 15 years).
7. If a chlorine spill could be attributed to an act of God (e.g. a large earth quake) who will be held responsible to pay for the damages, clean-up, etc.?
8. The BOVAR report on Risk Assessment is impossible to evaluate without some understanding of what risks were identified and also the estimated frequency of occurrences and estimated consequences. Could these figures be presented in a condensed format?

Yours



Cas Bohlken

cc. Ross Peterson, North and West Vancouver Emergency Coordinator.
cc. Corrie Kost, FONVCA

EMERGENCY PLANNING AND RESPONSE

Pamphlet 63	First Aid and Medical Management of Chlorine Exposures, Edition 5, May 1993. Gives recommendations on first aid and medical management of chlorine exposures. (6 pages)
	Members \$2.50 Non-members \$5.00
Pamphlet 64	Emergency Response Plans for Chlorine Facilities, Edition 4, November 1995. Includes information essential to the preparation or updating of formal, written emergency control plans applicable to chlorine-producing, chlorine-packaging, and chlorine-consuming facilities. (41 pages)
	Members \$12.50 Non-members \$25.00
Pamphlet 65	Personal Protective Equipment for Chlorine and Sodium Hydroxide, Edition 3, November 1995. Provides information pertaining to certain personal protective equipment used in the manufacture or handling of chlorine and sodium hydroxide. (34 pages)
	Members \$12.50 Non-members \$25.00
Pamphlet 73	Atmospheric Monitoring Equipment for Chlorine, Edition 5, May 1991. Discusses experiences of CI members with monitors and techniques involved in installing a successful chlorine monitoring system. Provides listing of known monitoring equipment vendors. (41 pages)
	Members \$15.00 Non-members \$30.00
UNDER REVISION (Edition 2 available for sale) Pamphlet 74	Estimating the Area Affected by a Chlorine Release, Edition 2, February 1991. Provides color graphs showing downstream chlorine plots at 25 and 10 ppm for 14 different scenarios. Useful for small producers, users and local emergency planning committees for planning purposes. Three atmospheric conditions are shown for each scenario. (32 pages)
	Members \$17.50 Non-members \$35.00
CHLR-1 CHLOREP	Flyer: How to Get Help in Chlorine Emergencies. Card outlining the CHLOREP program and giving telephone contacts for the CHEMTREC (US) and CANUTEC (Canada) summoning systems. (Available in French upon request)
	Free

CHLR-2 CHLOREP	Flyer: What is CHLOREP?
	Free
IB/A	Instruction Booklet: Chlorine Institute Emergency Kit "A" for 100-lb. and 150-lb. Chlorine Cylinders, Edition 8, June 1996. Provides instructions and illustrates the use of Chlorine Institute Emergency Kit "A." Includes complete parts list. (12 pages)
	Members \$5.00 Non-members \$10.00
IB/B	Instruction Booklet: Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers, Edition 8, June 1996. Provides instructions and illustrates the use of Chlorine Institute Emergency Kit "B." Includes complete parts list. (12 pages)
	Members \$5.00 Non-members \$10.00
REVISED IB/C	Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks, Edition 8, December 1996. Provides instructions and illustrates the use of Chlorine Institute Emergency Kit "C." Includes complete parts list. (12 pages)
	Members \$5.00 Non-members \$10.00
IB/RV	Instruction Booklet: CI Recovery Vessel for 100-lb. and 150-lb. Chlorine Cylinders, Edition 1, July 1992. Includes complete parts list. (12 pages)
	Members \$5.00 Non-members \$10.00
REVISED PUBLIC	Chlorine Institute Public Information Handbook for Emergency Planning and Community Right-to-Know, 1997. Collection of eight CI publications covering entire emergency planning process. Includes the Chlorine Manual, #63, #64, #73, #74, HEALTH, CHLR-1 and SNAPSHOT (150 pages)
	Members \$25.00 Non-members \$50.00

THE CHLORINE INSTITUTE, INC.

CI PUBLICATIONS ORDER FORM

THE CHLORINE INSTITUTE, INC.
2001 "L" Street, N.W.
Suite 506
Washington, D.C. 20036
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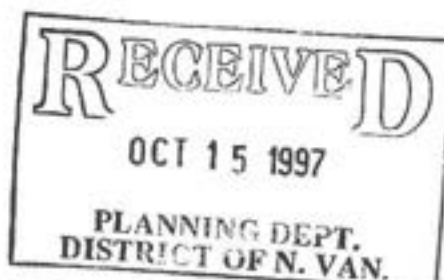
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EMERGENCY PLANNING AND RESPONSE

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Pamphlet 73	Atmospheric Monitoring Equipment for Chlorine, Edition 5, May 1991. Discusses experiences of CI members with monitors and techniques involved in installing a successful chlorine monitoring system. Provides listing of known monitoring equipment vendors. (41 pages)
	Members \$15.00 Non-members \$30.00
UNDER REVISION (Edition 2 available for sale) Pamphlet 74	Estimating the Area Affected by a Chlorine Release, Edition 2, February 1991. Provides color graphs showing downstream chlorine plots at 25 and 10 ppm for 14 different scenarios. Useful for small producers, users and local emergency planning committees for planning purposes. Three atmospheric conditions are shown for each scenario. (32 pages) <i>email [REDACTED]</i>
	Members \$17.50 Non-members \$35.00
CHLR-1 CHLOREP	Flyer: How to Get Help in Chlorine Emergencies. Card outlining the CHLOREP program and giving telephone contacts for the CHEMTREC (US) and CANUTEC (Canada) summoning systems. (Available in French upon request)
	Free
CHLR-2 CHLOREP	Flyer: What is CHLOREP?
	Free

Arthur D Little**Environmental, Health, and Safety**

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Fax Transmittal**To:** Irwin Torry**Company:**

District of North Vancouver

Date: October 15, 1997**Fax Number:**

604-984-8664

From: [REDACTED]**Location:** [REDACTED]**Total number of pages (including cover):**

1

Irwin –

Here are my responses to the two questions you sent.

Corrie Kost

I am not aware of any failures of similar tanks in recent time. Historically, there have been reported losses from chlorine storage tanks, although without specification of tank design or size. For example, there were incidents in France (1926), in New York (1929), in Romania (1939), and in Finland (1947) that all reportedly involved 25 to 30 tonnes of material. There was a release in Louisiana in 1976 following an explosion, but no quantity was provided. The design, size and condition of these tanks is not discussed in the data tabulation.

north shore news

MAIL BOX

Bad for business

Dear Editor:

No heed is being paid by local politicians to the North Shore winning a contest as the least desirable place in Canada to own a business.

The Oct 5 issue demonstrates why West Vancouver came in at below zero in attractiveness. A simple business licence application to open a bed and breakfast in a home has activated the bureaucracy into advertising a public hearing to investigate the matter thoroughly.

This is a concrete example of one of the thousand pins and needles that the three North Shore municipalities stick into the back of free enterprise.

It's also an example of why our taxes are so high. It costs a lot of money to hold these impromptu soirees so that neighborhood busy bodies can cluck about someone's effort to create employment.

I wonder if West Vancouverites know that they are being laughed at, not with.

John Edwards
North Vancouver
edwards@direct.ca

Chemical queries unanswered

Dear Editor:

Re: Article on CanOxy redevelopment plans, North Shore News Sept. 28.

The recent News article that covered the open house meeting on the proposed redevelopment plan by local chlorine producers CanOxy did not tell the whole story.

Your writer summarized the plant's redevelopment plans and risk assessment very well, yet failed to document how the public responded to the plans at the open house.

As the article pointed out there was approximately 50 people at the meeting, yet what was not covered was the fact that every speaker had important questions for plant operators and the assorted cast of technical experts, with regards to how safe the plant's redevelopment plans and operations are for the community.

The following are some of the issues raised by the public and from what I observed, were not properly addressed by

plant officials and experts:

■ In the case of a major earthquake, most windows of surrounding houses would be blown open. To that end, how do they expect residents to shelter themselves from winds that could direct chlorine gas their way?

■ Since the plant manufactures a hazardous substance close to a community, with resultant negative impressions (smell and risk) to incoming residents, has CanOxy done a study to see if its operations affect property values in the surrounding neighborhoods of Maplewood and Seymour? Will they compensate homeowners if property values are proved to be diminished because of their operations?

■ Because there is no protective buffer zone around the plant (ie: no development), surrounding industries, ie: Allied Shipyards and others west of the plant), would be subject to a risk that is higher than acceptable. Canadian

guidelines, how is this reconcilable with CanOxy's current operations?

■ Since the amount of chlorine stored on site has changed, when can the public see revised plume maps that will indicate how a full chlorine release will be affected by northerly wind conditions directed at our neighborhoods?

■ If the CanOxy plant was to start up operations today in the North Vancouver District, they would be denied a business licence because the manufacturing of toxic chemicals is not accepted by today's zoning standards. To that end, how can the plant ethically and responsibly continue to push its operations as a viable member of the business community and not accept a phase-out plan?

■ Based on the fact that 99% of the questions at the open house were probing and negative, I think it is fair to say that the public is still not comfortable with CanOxy's operation

and the information that the plant is supplying to the public.
Ross Muirhead
Director, Friends of The

Watersheds and a member of CanOxy's Community Advisory Panel

Seek new voices and ye shall find them

Dear Editor:

Seek And Ye Shall Find Department.

I love it: on page 9 of the Oct.10 North Shore News there's Stephen Aberle fulminating that your letters to the editor pages should demonstrate "free speech" by giving

space to "screaming queers, bleeding heart minority lovers, militant feminists and the angry poor." On page 10 there's contributing columnist Sandra McKenzie wringing her politically correct hands about the emerging strength of the Promise Keepers movement

across North America.

Stephen Aberle: meet Sandra McKenzie!
Andris Neimars
Bowen Island
102345.310@compuserve.com

Chlorine plant meeting draws 50

Sparse crowd raises plant safety issues

By Robert Galster

News Reporter
robert@nshnews.com

A North Vancouver District-sponsored public information meeting last Wednesday evening drew 50 concerned citizens to hear expert opinion on the effects of chlorine production in their community.

But some left the meeting less than satisfied with what they heard.

"A lot of people wanted to hear a closing date," said Coun. Trevor Carolan, who attended the evening session. "But they didn't get one."

What they got was the reiteration of an independent review contracted to Arthur D. Little of Canada Ltd. The study took more than a year to complete and was first presented Aug. 12.

At issue is the viable public safety of lands located to the north of the Canadian National Railway (CNR) right-of-way and owned by Canadian Occidental Petroleum Limited (CanadianOxy).

The land is unused and lies both inside and outside of a plant operated by CanadianOxy at 100 Amherst Ave. that produces mainly chlorine as well as caustic soda and



CXY Chemicals worker Kym Kostluk is one of 170 employees at the North Vancouver company's plant. A recent public meeting gave the area's residents a chance to ask questions of both company executives and local politicians.

NEWS photo Mike Wakefield

marianic acid.

Under an agreement negotiated with the district, a proposed realignment of the Dollarton Highway would place it on CanadianOxy land and allow the district to make better use of its adjacent land holdings for a long-proposed business park.

If proposed zoning changes were to be approved, CanadianOxy would be able to sell or develop its lands for light

industrial and commercial use.

At a June 11, 1996, public hearing Bover Environmental presented the original assessment of chlorine safety risk to the public on behalf of CXY.

On Tuesday night, council was told Bover had updated that risk assessment based on input from Arthur Little's independent review but that it had reached the same conclusion: ■ manufacturing and open-space development would be

acceptable in the north outside plant boundaries;

■ commercial and low-density residential development could proceed beyond the rail line north of the plant;

■ unrestricted land use would be acceptable beyond approximately 600 to 700 metres north of the rail line.

Bovar's risk assessment notes three recent improvements to plant safety:

■ reducing plant inventory of

liquefied chlorine gas to one 300-tonne storage tank from three tanks storing a total of 1,500 tonnes;

■ discontinuing the use of a barge with three, 300-tonne fixed tanks for shipping chlorine;

■ moving a propane storage tank to a more remote location on the site.

Little's independent review of Bover's updated risk assessment was presented by Lisa

Bendixen.

Bendixen summed up her review of Bover's conclusions by saying that some of the hazard frequencies may have been underestimated while consequences may have been overestimated.

"Taking them together, bringing it into a risk assessment, that risk estimate is judged to be a reasonable representation of the risk associated with the chlorine operations at the Maplewood chlorine plant," concluded Bendixen. However, Bendixen's written report also notes that the area to the west of the CXY Chemicals plant is at a higher risk level than might be desired.

"This is a very critical issue and has to be handled correctly," said Carolan.

Wednesday's meeting featured representatives of CXY Chemicals and various emergency services employees in addition to the district's staff members.

"Here is a plant that produces toxic materials," added Carolan. "How do we live with a dragon in the neighborhood? You live cautiously."

"Complicating the issue is that the dragon was here before most of us," said Carolan, referring to the plant's opening in 1957.

A public hearing on the possible rezoning of the lands adjacent to the plant has yet to be set. In addition to Carolan, councillors Lisa Muri and Ernie Crist were also at the Wednesday night meeting.

— with Yolanda Watkins and Martin Millership



CHANGES TO PLANT OPERATIONS CXY CHEMICALS, NORTH VANCOUVER

On-going Improvements as Part of Responsible Care 1994-1997

1. Significantly reduced (75%) chlorine stored in fixed tanks on site.
— From 3 tanks to 1 tank.
2. Relocated propane storage away from operating plant.
3. Stopped shipping chlorine in fixed tanks on the barge.
4. Introduced a more accurate method of forecasting distance and concentration of a chlorine plume if a leak occurs (SAFER System).
5. Increased the number of chlorine monitors on site.
6. Added a back-up generator for monitors to ensure emergency systems work during a power failure.
7. Donated Community Alert Network System to the District of North Vancouver.
8. Upgraded chlorine piping – shorter runs.

Resource People for "Question and Answer" Period

Irwin Torry	Manager of Planning, District of North Vancouver - provides planning advice to council on land use and zoning issues.
Ross Peterson	Coordinator, North & West Vancouver Emergency Program - Undertakes planning with the municipality and provides municipal emergency response to accidents, including the Community Alert Network.
John Billham	Plant Manager - CXY Chemicals, North Vancouver - Responsible for plant operations, in particular, plant improvements since the 1994 Bovar QRA study.
Jane Fleming	Land Manager for Canadian Occidental (CanOxy) - Managing CanOxy's rezoning application.
Stuart Behie	Bovar Environmental - Operations and Safety Management - Responsible for risk assessment group that conducted the Quantitative Risk Assessment (QRA) and update.
Lisa Bendixon	Principal, Safety and Risk - Arthur D. Little Consulting - Responsible for the peer review of Bovar Environmental's Quantitative Risk Assessment.
Terry Litchfield	Transportation Manager - CXY Chemicals - Responsible for transportation of chlorine and rail car safety.
Gerry Carlson	District of North Vancouver - Undertaking planning of Dollarton Highway, Bridge, and Riverside Drive Intersection improvement.
Bob Shuback	Structural Engineer - Hooley & Shuback Ltd. - Conducted structural assessment of chlorine storage tank under earthquake (seismic) loading.
Elizabeth McDonald	Manager, Occupational Hygiene, Analytical Services Laboratories (ASL) Ltd. - Works in area of health effects of exposure to chlorine.
Ken Stubbs	Administrator, Monitoring & Assessment, Air Quality Department Greater Vancouver Regional District (GVRD)
Nimet Alibhai	Officer - Air Quality Control - Responsible for regulation of CXY air emissions

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October 16, 1996

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver
355 West Queens Road
North Vancouver
British Columbia
V7N 2K6

Re: ADL Reference No. 30728

Dear Mr. Torry:

Arthur D. Little of Canada Limited is pleased to submit this summary of our independent review of *Canadian Oxy North Vancouver Plant Quantitative Assessment of Safety Risks*, prepared by BOVAR-CONCORD Environmental, and submitted in August 1994. The District of North Vancouver requested this independent review of this risk assessment report in part because important distinctions in zoning will be based in large part on the coincident placement of the risk contours and the proposed realignment of the Dollarton Highway. Therefore, it is particularly important that the Council be comfortable with the accuracy of the current study's findings and understand its limitations.

This review was performed based on the report presented as well as additional appendices and addenda forwarded to us by BOVAR-CONCORD Environmental. Specifically, these were Appendix A3: Technical Descriptions for Release Events, an August 1994 addendum on Alternative Operations with the Barge, and a May 1995 addendum on the 1995 Operations. We did not conduct site visits to audit the accuracy of the report and attachments, but rather reviewed the information as presented. We also conducted several telephone conversations with Canadian Oxy personnel as well as with BOVAR-CONCORD Environmental staff. A series of questions were provided in writing to BOVAR-CONCORD Environmental following our conversations and their answers were received several weeks later. Our efforts focused on the soundness of the methodologies and the reasonableness of simplifications and assumptions, in order to identify inconsistencies, gaps or limitations in the analysis.

The material in this letter reflects Arthur D. Little's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this letter, or any reliance on or decisions to be made based on it, are the responsibility of such third party. Arthur D. Little accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on the information contained in this letter.

Our review covered:

- the identification of hazards—what can go wrong?
- the frequency analysis—how likely is it to happen?

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J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

- the consequence analysis—*what happens if the undesired event occurs?*
- the overall estimation of risks—which pulls all the previous items together to develop an estimate of the risk to the affected community.

The methodology for each step was reviewed along with the assumptions made under each of the two operational scenarios included in the report. We evaluated: the approach and assumptions used in the consequence modeling, including the credibility/applicability of the selected meteorological conditions; the completeness and soundness of the frequency analysis/approach; the rationale for the frequency values taken directly from historical data; and the way in which the seismic risk analyses conducted by Failure Analysis Associates and Hooley & Schubak Ltd. were taken into account in the overall frequency analysis. The implications of our findings in each area on the overall risk estimates were also determined to the extent possible without recreating the entire analysis.

General Comment

As we examined these various areas, we paid particular attention to the two scenarios that were identified as the primary contributors to risk:

- the earthquake-induced failure of a storage tank, and
- a barge tank marine accident.

The importance of these two scenarios led us to one overall observation on the reports prepared by BOVAR-CONCORD Environmental. The base case and the alternatives have not been conducted to equivalent levels of detail, making comparisons quite difficult. The inconsistencies in approach relate largely to the treatment of failures of the storage tanks. In the analysis of the base case, the tanks have been assumed to always be full, while in the analysis of the alternatives several different fill levels have been considered in both the frequency and consequence analyses. In discussions with BOVAR-CONCORD Environmental it was pointed out that it is common to start with a simpler set of assumptions for a base case and then to increase the level of detail for the alternatives. This is true if the alternatives are to be compared to each other and the preferred alternative selected, but causes difficulties when comparisons are to be made between an alternative and the base case.

To illustrate this point, assume that the analysis was conducted two ways, with no changes in actual operations and therefore no changes in the frequencies of the identified hazards. In the first case all three storage tanks would be assumed to always be full, meaning that they would be assumed to release their full contents (either 600 or 270 tonnes depending on the tank size) in the event of a major failure. In the second case, the actual history of fill levels would be used to determine the fraction of the time that the tanks were at about 90-95% of capacity versus 75% full versus 45% full versus 15% full or less. This second case would produce smaller risk contours than the first, and these contours could potentially be significantly smaller.

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J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

While the distribution for the current scenario (base case) was not provided and might be somewhat different, it is interesting to note that the distribution of fill levels assumed for the 300-tonne tank in the alternative with the continued barge operations showed that 94% of the time the tank was less than half full. Thus, the frequency of a very large spill (75% or more of the capacity) would be multiplied by 0.06 (6%), giving an answer more than a factor of 10 lower than in the analysis of the base case as a result of the fill level alone. If this same sort of distribution held true for the 600-tonne tanks, the risk contours could decrease significantly.

Hazard Identification

The hazard identification approach used in the report was based on the knowledge of incidents that have occurred in the chlorine industry in the past. This approach gives a general indication of the range of hazards associated with a particular type of operation, but is not particularly helpful in accounting for site-specific design features that make one location more or less hazardous than another—including consideration of such simple things as the number of loading or unloading operations, the length of piping, etc. It also cannot reflect the benefits associated with various risk reduction strategies.

Given that the emphasis of this report was on low frequency/high consequence events rather than all events which could have offsite impacts (per BOVAR-CONCORD Environmental, but not stated as explicitly in the report), some of these factors may not be that significant, but there should at least be a discussion of the relative position of this operation vis-à-vis industry as a whole. Is it newer or older technology? Simpler or more complex operations? Is the equipment more or less vulnerable to fires and explosions?

The report also focuses on chlorine releases, not potential propane or hydrogen releases or the damage caused by subsequent fires or explosions. In the case of hydrogen, BOVAR-CONCORD Environmental indicated that they believed that any chlorine releases which could result from hydrogen explosions would be included in the historical data set. Arthur D. Little believes that this is one area where site-specific design and layout would play an important role.

These are all differences in approach that lessen our confidence in the results, as they are not based on the actual plant design and operation to the extent that we believe is important. Also, this approach might not necessarily meet the requirements of a process hazards analysis in the United States as required by OSHA.

Frequency Analysis

The report appeared to be more concerned about the statistical significance of the overall data set than its relevance to this particular operation, and no detailed explanation was provided for the derivation of most the frequencies. For those

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Manager of Planning
The Corporation of The District of North Vancouver

frequencies which have been estimated to be greater than 0.05 per year (once in 20 years) it would have been beneficial to compare the number with actual plant experience. This would at least have provided a calibration or test of realism of the external data set.

For example, for the liquid lines to the barge, a frequency based on the number of piping releases per producer per year was determined. This does not consider the differences between process piping and loading lines, or the relative lengths of line at one producer versus another. However, the rate used is thought to be very conservative, based on typically pipe failure rates. Thus the risk from this event is more likely to be over rather than underestimated, which is generally good, but which further distorts the comparison of the base case with the alternative. (The risk could be underestimated if there are specific scenarios, such as failing the line as a result of a surge overpressure from the sudden closure of a valve, that have a high frequency. The present analysis does not consider such events.) This same historical piping failure rate has also been applied to a failure in the liquefier outlet piping, without any real basis of scaling for the amount of piping involved.

Many of the smaller release scenarios have also been omitted from further consideration. This means that the risk contours close to the site boundaries may have been underestimated, particularly if the consequence distances have been underestimated.

For the storage tanks, the greatest concern was seismic damage and this was looked at in much greater detail than the other modes of failure. Given the predicted failure rates, this focus on a single cause of failure is thought to have been reasonable. The application of the predicted rates merits some discussion, however. For the 600-tonne tanks, a design basis earthquake frequency was determined (0.0021 per year) and then the chance of both tanks failing given exposure to this earthquake was assumed separately by BOVAR-CONCORD Environmental to be 10%. Given that it is also possible for only one tank to fail, it would seem more logical to also assume that the overall frequency of one of the two tanks failing is 0.0021/year times some value between 0.1 and 1.

The analysis of the 600-tonne tanks also indicated that there may have been a number of errors and omissions in the original design calculations. Several of these were thought to make the design more conservative, but one was pointed out as potentially leading to a greater level of risk. No indication of a follow-up on these points is presented in the report, perhaps because BOVAR-CONCORD Environmental believed that these tanks were to be taken out of service. This still poses difficulty in making comparisons to the base case, however.

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Manager of Planning
The Corporation of The District of North Vancouver

A separate analysis has been done of the 300-tonne storage tank. This analysis explicitly considered different fill levels and analyzed the response of the tanks at each level. The estimates given were for failing the tank in each state, so it was not necessary for BOVAR-CONCORD Environmental to determine a separate release probability. The value calculated for the at-capacity level was used in the base case analysis. This once again points out a difference between the approach used for the base case versus that for the alternative.

Another observation on the frequency analysis is the tendency to discount those events which also require a secondary failure, such as an excess flow valve failure. In many cases this seems to be because the resulting frequency is so much lower than that for the original event even though the consequences are higher. For those events which do not have significant offsite impact, the more serious event might actually be a concern, even at its lower frequency. In response to one of our questions on rail loading scenarios, BOVAR-CONCORD Environmental stated that the emergency shut down system would limit the amount of chlorine released and that failures of these systems would be a "double-fault with correspondingly lower frequencies". However, it must be recognized that with some 1735 or more loading operations, there is a multiplier effect from the number of operations (1735) that can more than offset a failure probability of 0.001 per demand on an emergency shut down system, for instance.

The conservatism inherent throughout the base case was reinforced by the response to another of our questions. Noting that Event 5.1 (rail car breach) had the same value in both the base case and alternative analysis, we asked why this was so as the number of rail cars would increase from 1600 to 1735. We were informed that the analysis of existing operations used 1735, not 1600 rail cars. Given the low level of contribution made by these events, BOVAR-CONCORD Environmental did not feel that more precision was warranted. As presently analyzed, this is a reasonable conclusion, but in actuality these events could be more significant if a more consistent level of detail were applied throughout the analysis.

Consequence Analysis

The consequence modeling has been performed using COBRA, which is a proprietary model based on a well known and documented public-domain model known as SLAB. Most of the dispersion models in use today (including SLAB, but excluding hydrodynamic codes) are not suitable for performing dispersion calculations at low wind speeds. This is especially true when the surface roughness of the ground (i.e., the irregularities in the surface—picture a smooth surface of a pond versus a gravel driveway) is high enough that it effectively blocks the wind and contains the vapors emitted from liquid pools of materials that are in a cryogenic state or which are heavier than air, limiting further dispersion. The use of D-stability with a low wind speed of 2 meters per second and E-stability with an even lower wind speed of 1 meter per second in models such as COBRA is expected to significantly overpredict the dispersion

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Manager of Planning
The Corporation of The District of North Vancouver

distances. The effect on the calculated hazard areas is thought to be an overprediction by a factor of two or three.

The most significant concern we have about the consequence modeling is the approach used to estimate the amount of mass in the cloud, particularly for the large releases from the storage tanks and the barge. The approach used (assuming a multiplier of the flash fraction to represent the amount of entrained aerosols) is extremely out-dated and has no scientific basis. More importantly, this approach is very non-conservative for materials such as chlorine as it underestimates the amount of material in the cloud. The correct approach is to base the aerosol fraction on the actual breakup mechanism, which for chlorine is thermal breakup, i.e., flash atomization.

The attached table shows the results of a number of large-scale tests of chlorine releases, as collected by the Center for Chemical Process Safety at the Nevada Test Site. For a storage temperature of about 14° C (287 K) the table shows roughly 15% flash (F_0) and only 5% or less of the material captured in the pool (C%). This is much lower than the report's assumption of 62% in the pool in the alternative case. In discussions with the plant, we were told that present storage temperatures were about -22° C (251 K). According to the table, this would give a flash fraction of about 5%, as assumed in the report, but the amount of material in the pool would be roughly 17 to 20%, not the 80% assumed in the report.

A more reasonable assumption would have been to assume that 80% (not 20%) of the mass is airborne in the cloud instead of raining out and forming a pool. This would be true for both continuous and instantaneous releases, and even more significant for any release from a height of one meter or more as droplet evaporation then becomes significant as well. This difference in mass in the cloud could lead to a significant underprediction of hazard distances and areas that could more than offset the conservatism of the selected meteorological conditions.

It is considered very optimistic to assume that an earthquake that is capable of failing both tanks does not fail the dike around them. However, given the other comments made above on the amount of material in the initial cloud, this is not a significant issue.

Risk Estimation

The basic process used appears to be sound, and the development of risk contours is the most meaningful measure for land-use planning purposes. Given the relatively limited distances for the risk contours, it is also reasonable to not take credit for evacuating any of the exposed population.

Since the same approach seems to have been used in each addendum, no additional comments have been made on these various documents.

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J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

Overall Conclusions

The representativeness of the results for both the base case and the alternative where tank levels are kept below 500-tonnes is very difficult to determine given the competing over and under predictions of frequencies and consequences, especially for events contributing to the 10^{-4} per year contour. Our best judgment is that the 10^{-6} and 10^{-5} per year contours have been under estimated, i.e., they are larger than has been shown. Comparisons of these two cases with any of the other alternatives must also be made with extreme caution as there are so many differences in the level of detail considered in the various analyses, and because of all the uncertainty around the modeling of the large releases.

For those alternatives without barge operations, the primary uncertainty for the 10^{-6} and 10^{-5} per year contours is associated with the chlorining consequence modeling. We believe that these contours are also somewhat under predicted, and would not recommend using the existing report as the sole basis of a planning decision.

Please let me know if I can clarify any of these points or if you have additional questions.

Sincerely,

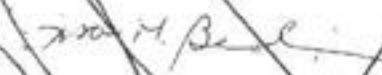

Lisa M. Bendixen
Principal, Safety and Risk

Table 20.6: CCPS Chlorine Data

T_0 K	P_0 kPa	D_0 mm	F_0	M kg/s	P_a kPa	T_a K	G %	T_{min} K	X_{min}	RH %	U_w m/s
247.4	147.2	6.35	0.035	0.31	90	303.3	23.4	204.5	1.52	8.6	6.8
256.4	257.0	6.35	0.064	0.49	90	303.6	21.5	204.9	1.52	8.9	7.7
250.9	215.5	6.35	0.046	0.44	90	301.2	20.2	205.2	1.52	10.6	6.0
247.1	178.9	6.35	0.034	0.38	90	304.3	18.9	206.1	1.52	23.6	5.8
261.8	303.3	6.35	0.080	0.55	90	300.7	18.1	202.5	3.04	14.1	6.0
251.5	225.9	6.35	0.048	0.44	90	305.8	17.1	204.6	1.52	8.9	4.9
258.1	258.5	6.35	0.069	0.48	90	304.0	16.6	205.4	1.52	23.4	5.3
272.8	362.2	6.35	0.115	0.51	90	304.3	16.6	205.4	1.52	10.9	10.8
245.4	183.7	6.35	0.028	0.39	90	300.5	16.5	206.3	1.52	11.9	6.1
267.4	388.6	6.35	0.098	0.60	90	303.5	16.2	204.0	3.04	14.0	9.9
272.4	420.8	6.35	0.114	0.64	90	302.9	15.2	203.4	3.04	8.0	7.2
267.6	295.9	6.35	0.099	0.45	90	303.9	13.2	204.6	1.52	11.7	8.8
261.3	586.0	6.35	0.079	0.81	90	300.9	11.7	202.2	1.52	10.8	6.4
273.3	433.9	6.35	0.117	0.65	90	304.3	9.6	206.5	1.52	22.0	4.9
267.1	639.1	6.35	0.097	0.84	90	303.8	9.2	203.4	3.04	15.0	7.6
277.9	482.3	6.35	0.131	0.70	90	304.8	9.0	204.6	1.52	15.1	6.1
278.1	417.5	6.35	0.132	0.54	90	305.3	8.1	205.4	1.52	14.3	6.1
261.8	922.5	6.35	0.080	1.05	90	300.5	6.8	202.5	3.04	10.7	6.9
283.7	558.9	6.35	0.149	0.74	90	305.8	5.3	204.9	1.52	15.3	7.1
267.1	979.1	6.35	0.097	1.07	90	303.3	4.1	203.1	3.04	13.4	10.0
283.6	567.2	6.35	0.149	0.75	90	303.5	3.9	203.7	1.52	7.2	7.5
289.2	661.1	6.35	0.167	0.83	90	303.3	1.3	205.4	1.52	26.4	5.2

**The Corporation of
District of North Vancouver**

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North Vancouver
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V7N 2K6



District of North Vancouver

Mailing Address
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Director of Planning & Development Services, Richard Plunkett

Telephone 604 987 7131

Fax 984 8664

September 11, 1997

File: 3060-20/8.93

Mr. Corrie Kost
Federation of North Vancouver Community Associations



Dear Mr. Kost:

**Re: Public Meetings to Discuss and Review the Quantitative Risk Assessment
and Independent Peer Review prepared for the Can Oxy Chemical Plant**

Public meetings have been arranged for:

Tuesday, September 23
Jaycee House
1251 Lillooet Road
2:00 pm to 5:00 pm
and
7:00 pm to 10:00 pm

These public meetings are being held to share the research findings from the Quantitative Risk Assessment, the findings from the independent peer review and to answer your questions related to the Can Oxy chemical facility in Maplewood.

This discussion is taking place in light of the municipality's desire to realign the Dollarton Highway and, at the same, consider zoning changes for Can Oxy property to accommodate light industrial and limited commercial uses. At the present time the Can Oxy property is zoned for general manufacturing and industrial uses. Under either land use alternative the existing chemical facility will continue to operate.

In preparation for the possible zoning changes Can Oxy completed a Quantitative Assessment of Safety Risks in 1994. This assessment together with land use guidelines established by the Major Industrial Accidents Council of Canada (MIACC) were used to define permitted land uses on the Can Oxy property.



The following chronology outlines the events leading to this public meeting:

In June, 1996 Council adjourned the public hearing on the rezoning bylaw for Can Oxy property north of the rail line. Council instructed staff and Can Oxy to conduct a public information meeting in order to share research findings and clarify the chlorine risk to the public. At the same time Council requested staff to report back on the timing and process to obtain a peer review on the Bovar Concord study.

In July, 1996 Council approved the appointment of Arthur D. Little to complete an independent review of the QRA study prepared by Bovar Concord.

In October, 1996 Arthur D. Little submitted a summary of their review of the Quantitative Assessment of Safety Risks (1994) prepared by Bovar Concord. The review raised several questions which required responses from Bovar Concord.

From November, 1996 through until March, 1997 Bovar Concord and Arthur D. Little exchanged additional information.

In May, 1997 Can Oxy and Bovar Concord decided to update the 1994 Quantitative Assessment of Safety Risks to reflect the numerous design and operational changes instituted by Can Oxy.

In July, 1997 Arthur D. Little submitted their independent review of the updated assessment of chlorine safety risk to the public. The independent review covered:

- the identification of hazards - what can go wrong?
- the frequency analysis - how likely is it to happen?
- the consequence analysis - what happens if the undesired event occurs?
- the overall estimation of risks - which combines all the previous items together to develop an estimate of the risk to the affected community.

The findings from the independent review were presented to District Council on August 12, 1997.

The public meetings will include displays and provide an opportunity to discuss concerns with District, Can Oxy and consultant representatives. The open house portion of the meeting will be followed by a "Question and Answer" period. The questions and comments will be documented and forwarded to Council when they consider future land use alternatives in this area of Maplewood.

For your convenience two times have been arranged for September 23, 1997 at Jaycee House, 1251 Lillooet Road. The afternoon session will run from 2:00 - 5:00 pm and the evening session will last from 7:00 until 10:00 pm.

If you have any suggestions on forwarding information and material to other members of your organization, please contact Diana Nelson at 990-2459.

Should you wish to review the updated assessment of safety risks to the public or the independent review prepared by Arthur D. Little please contact me at 990-2317.

Yours truly,

A handwritten signature in dark ink, appearing to read "J. Irwin Torry", is written over the typed name and title.

J. Irwin Torry
Manager of Planning

JIT/lk



SEP 14/97

Public Meeting

- **CanOxy Risk Assessment**
- **Dollarton Hwy Realignment and Land Use Alternatives**

Join this open house to discuss the most up-to-date information on the recent Risk Assessment Report for CanOxy, a peer review and future land use issues on the CanOxy property. Bring your questions and concerns.

Tuesday, September 23

Jaycee House, 1251 Lillooet Rd.

2:00 p.m. to 5:00 p.m. & 7:00 to 10:00 p.m.

Drop in to review information displays on :

- the Risk Assessment report of the CanOxy Chemicals site, and peer review of the report
- improvements to CanOxy plant operations
- safety issues, including rail cars
- emergency response plan
- land use alternatives for CanOxy lands
- Dollarton Highway realignment

Discuss your questions or concerns with District and CanOxy staff and consultants during a Question and Comment period.

For your information

Issues and concerns raised at the meeting will be documented and provided to Council as they consider future land use alternatives in this area, including either :

1. Maintaining heavy industrial zoning or
2. Rezoning to accommodate light industrial and commercial uses.

The existing chemical plant will continue to operate under both scenarios.

*For more information, please contact
Planning at 990-2317*

www.district.north-van.bc.ca

Risk control revealed

AUG
15/97

THE risk management process used in assessing the CanOxy plant:

The process of estimating the risks of a facility, judging its safety, and development of risk control measures if required comprises the risk management process.

The components and operation of a facility are first understood, and an inventory of hazardous substances used, transported and manufactured is established along with an assessment of the surrounding area that might be affected by hazardous events in the facility.

Risk analysis helps to understand the risk of a hazardous facility and the reductions in risk achievable given certain risk control measures.

Hazard identification answers the question: What can go wrong? Potentially hazardous events are identified and defined.

Frequency analysis and consequence analysis answer the questions: How often is the event expected to occur? and: What are the consequences if it occurs?

Frequency analysis makes use of historical accident data in similar facilities. Consequence analysis consists of modeling the behavior of releases of hazardous substances.

Risk estimation is the process by which frequencies and consequences of events are combined to quantify risk.

Risk evaluation answers the questions: Is the risk judged to be acceptable? and Do we need to do anything about it?

The combined process of risk analysis and risk evaluation is usually called *risk assessment*.

The risk assessment is then compared with standard guidelines established by the Major Industrial Accidents Council of Canada (MIACC). *MIACC guidelines* suggest that above the risk factor of 100 chances of death in a million no land use other than the risk source should be used, but between 100 in a million and 10 in a million manufacturing and warehouse use of land could be allowed.

1985 statistics indicate there is 170 chances in a million of death from a motor vehicle accident in Canada.

Chlorine fallout feared

By Martin Millership

Contributing Writer
millers@suncom.com

ZONING amendments and community planning are not usually based on life or death parameters.

But North Vancouver District Council will soon have to grapple with zoning decisions in the Maplewood area that will be influenced by the ultimate of safety considerations.

The specter of chlorine clouds hovering above a re-aligned Dollarton Highway and its related commercial development so concerned council last year that it took the unusual step of adjourning a public hearing and requesting an independent review of the risk assess-

Public safety of lands near CanOxy plant assessed in NV review

ment. That review process, contracted to Arthur D. Little of Canada Ltd., has taken just over a year to complete and was presented to council on Tuesday at a thirdly attended public meeting.

At issue is the viable public safety of lands located to the north of the Canadian National Railway (CNR) right-of-way and owned by Canadian Occidental Petroleum Limited (CanOxy).

The land is unused and lies both inside and outside of a plant operated by CXY Chemicals at 100 Arbutus

Ave. that produces mainly chlorine as well as caustic soda and muriatic acid.

Under an agreement negotiated with the district, a proposed realignment of the Dollarton Highway would place it on CanOxy land and allow the district to make better use of its adjacent land holdings for a long-proposed business park.

If proposed zoning changes were to be approved, CanOxy would be able to sell or develop its lands for light industrial and commercial use.

At the June 11, 1996, public hearing, Bover Environmental presented an assessment of chlorine safety risk to the public on behalf of CXY.

On Tuesday night, council was told Bover had updated that risk assessment based on input from

See Gas page 3



LISA Bendixen ... presents risk assessment review.

Gas risks debated at meeting

From page 1

Arthur Little's independent review but that it had reached the same conclusion:

- manufacturing and open-space development would be acceptable in the north outside plant boundaries;
- commercial and low-density residential development could proceed beyond the rail line north of the plant;
- unrestricted land use would be acceptable beyond approximately 600 to 700 metres north of the rail line.

Bover's risk assessment notes three recent improvements to plant safety:

- reducing plant inventory of liquefied chlorine gas to one 300-tonne storage tank from three tanks storing a total of 1,500 tonnes;
- discontinuing the use of a barge with three, 300-tonne fixed tanks for shipping chlorine;

■ moving a propane storage tank to a more remote location on the site.

Little's independent review of Bover's updated risk assessment was presented by Lisa Bendixen.

Bendixen summed up her review of Bover's conclusions by saying that some of the hazard frequencies may have been underestimated while consequences may have been overestimated.

"Taking them together, bringing it into a risk assessment, that risk estimate is judged to be a reasonable representation of the risk associated with the chlorine operations at the Maplewood chlorine plant," concluded Bendixen. However, Bendixen's written report also notes that "the area to the west of the CXY Chemicals plant is at a higher risk level than might be desired. Several of the 30, or so in attendance at the hastily called meeting were still not convinced that all relevant questions had been considered."

Das Ellis, a chemical engineer who in the past has worked on B.C. Gas emergency plans, noted

that there were two types of earthquakes and asked whether the duration of shaking had been factored as a risk. Bover and Little agree that the worst-case scenario affecting risk assessment would be the rupture of the main 300-tonne chlorine storage tank from whatever cause, including earthquakes.

According to Bover "the total frequency of all such events is estimated to be very low — in the order of one occurrence in 16,000 years."

Conventional Ellis: "There's a fair body of expertise out there that this area gets the granddaddy of earthquakes every 400 years, plus or minus 200 years, and the last one was in 1761."

Bendixen also confirmed that rail cars on site hold approximately 90 tonnes of chlorine each.

The Little review concludes there are an average of 10 full cars on site every day of the year, or another 900 tonnes of chlorine in transit.

But Bendixen said she could not envisage catastrophic failure of multiple cars even in a worst-case scenario.

This Week section showcases local culture

Dear Readers:

This Week is the first week of the rest of your lives. Own too.

We intend to make it sing and dance and perhaps turn a few pirouettes. We intend to make it informative and entertaining and a big part of your week

every week. Starting today, Friday's This Week section in the North Shore News (see page 15) will present readers with a whole new package of features focusing on local personalities, music, theatre, book, video and other media reviews, advice, listings of events, social activities, things to do and a gener-

ous dose of irreverence tossed in free of charge.

To make room for this new package of local entertainment and information, the News will be dropping its television listings. We want to get you off the couch and into the community.

We want to make This Week the best part of your week. Every week it's This Week.

On the North Shore. And in the North Shore News.

Blaze destroys mill

By Robert Galster

News Reporter
rgalster@nshnews.com

A cutting torch sparked a blaze on the North Vancouver District waterfront Thursday evening sending flames shooting into the sky and producing a pall of smoke seen all over the Lower Mainland.

Waterfront inferno levels last NV mill, threatens bird sanctuary

Glen Sandulak, a member of a salvage crew working to prepare the old Tolko Industries cedar mill for demolition, was operating the torch. He had been working at the site for about three weeks.

"I was burning and a young fella was watering when some of the sawdust caught fire and all of a sudden, whoosh," said

Sandulak as he watched the building go up in flames. "We left the hoses on overnight, but you know how sawdust is with fire." Sandulak and several other men were using a torch to cut metal out of the structure when an errant spark got away from them at about 5:45 p.m.

Tolko Industries' site manager Vern Parkstrom attended the fire, which was fought by more than 20 North Vancouver District firefighters late into the night. He said the mill occupying the structure was shut down permanently last February and

See Torch page 3

Torch sparks mill's sawdust

From page 1

all equipment had been either sold or removed prior to the fire.

"It was just scrap metal that was being salvaged at this time," said Parkstrom. "We were going to start demolition of the building next week."

He said losses suffered by the company are insignificant. When asked about the identity of the salvage company performing demolition preparation on the building, he said "no comment."

About an hour after the start of the fire easterly winds threatened to spread the blaze as several grass fires sprung up on the grounds of the neighboring Maplewood Flats bird sanctuary, forcing firefighters and a Greater Vancouver Regional District fire crew away from the evening's main attraction.

A helicopter assisted in the battle to save the bird sanctuary by dropping loads of water onto the flare-ups. However, damage to the estuary was limited to a few scorched paths of grass.

Ernie Kennedy, one of the wardens working at the sanctuary, saw the blaze start and worked into the night putting out the flare-ups on the property's grass field.

"We could see the fire inside and it wasn't smoky yet and I thought, whoa," said Kennedy.

Together with a co-worker, Kennedy called the fire department.

The magnitude of the blaze also attracted spectators from far and wide, including North Vancouver District Mayor Don Bell.

"I was driving along Marine Drive and saw the smoke and was curious, so I called the fire department and came down," said Bell.

The mayor said he initially drove to the parking lot of the Canadian Occidental Petroleum Ltd. chemicals plant just west of the fire. "I thought it would be a safe place to watch it from after the review," said Bell.

He was referring to a public meeting last Tuesday, which focused on safety issues surrounding the CanOxy plant at 100 Ambert Ave. As chronicled in the Aug. 15 News, the reports presented at the meeting addressed various emergency scenarios, including fires, at the plant, which produces mainly chlorine as well as caustic soda and muriatic acid.

SHIRTSLEEVES SESSION

CAN OXY QRA STUDY-PEER REVIEW

Tuesday, August 12, 1997 - 7:30 p.m.
Council Chamber

1. **Welcome and Introduction - Mayor Bell**
2. **Presentation by Lisa Bendixen (AD Little Ltd.)**

Attachment:

- staff report dated August 8, 1997
- report by Arthur D. Little dated October 21, 1996 on Assessment of the 1978 Beak Report
- report by Arthur D. Little dated July 11, 1997
- report by BOVAR Environmental dated July 4, 1997

3. **Discussion by Council**

* * * * *

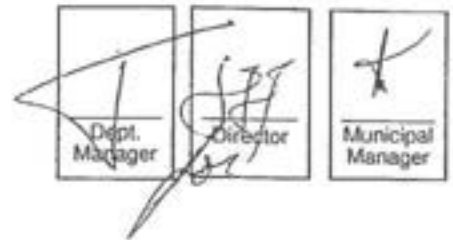
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COUNCIL AGENDA/INFORMATION

☐ In-Camera	Date: _____	Item # _____
☐ Regular	Date: _____	Item # _____
☐ Info Package	Date: _____	Item # _____
☐ Agenda Addendum	Date: _____	Item # _____



The Corporation of the District of North Vancouver

REPORT TO COUNCIL

August 08, 1997
File: 3060-20/8.93

AUTHOR: J. Irwin Torry, Manager of Planning

SUBJECT: Independent Review of the CXY Chemicals North Vancouver Plant
Assessment of Chlorine Safety Risk to the Public 1997 Update Report

RECOMMENDATION:

That this report be received as information.

REASON FOR REPORT:

To provide Council with a brief summary of the independent review of the CXY Chemicals Assessment of Chlorine Safety Risk to the Public, 1997 Update Report, the assessment of the 1978 Beak report, and an indication as to the next steps in the process.

SUMMARY:

The independent review conducted by Arthur D. Little concludes that "there are a number of factors which have been either over or underestimated for individual events; however, the overall results are judged to be reasonable representations of the public risk levels associated with current chlorine plant conditions and operations."

While not the focus of the current planning and land use decision, the consultant believed it was "important to note that the area to the west of the CXY Chemicals plant is at a higher risk level than might be desired. This is not at all surprising given the proximity of the western plant boundary to the storage tanks and rail car loading stations. This is an existing land use which has experienced a significant reduction in risk as a result of the recent changes in plant operations and the plant improvements. It will be important to maintain good communications with the operations to the west of the plant for the purpose of emergency response and proper action in the event of a release."

In the assessment of the 1978 Beak report Arthur D. Little concluded that the basic recommendations in the report still make sense and represent good management practices in the chemical industry. However, Arthur D. Little is of the opinion that the 1978 report has served its purpose, and that its continued use today would be inappropriate, except for some of the basic information on the chemicals and processes."

**SUBJECT: Independent Review of the CXY Chemicals North Vancouver Plant
Assessment of Chlorine Safety Risk to the Public 1997 Update Report**

August 08, 1997

Page 2

BACKGROUND:

On June 11, 1996, Council adjourned the public hearing on the rezoning bylaw for CXY Chemicals and instructed staff and CXY Chemicals to conduct a public information meeting, the purpose of which is to share research findings and clarify the chlorine risk to the public. At the same time Council requested staff to report back on the timing and process to obtain a peer report on the Bovar report.

On July 22, 1996, Council approved the appointment of Arthur D. Little Inc. to complete an independent review of the QRA Study prepared by Bovar-Concord. In addition the consultant was asked to assess the 1978 Beak report.

ANALYSIS:

On October 16, 1996, Arthur D. Little submitted a summary of their review of the Quantitative Assessment of Safety Risks (1994) prepared by Bovar-Concord Environmental. The review raised several questions which required responses from Bovar-Concord.

On October 21, 1996, Arthur D. Little submitted their independent assessment of the 1978 Beak report (Attachment A). In summary the consultant concluded that the basic recommendations in the report still make sense and represent good management practices in the chemical industry. However, the consultant is of the opinion that the report has served its purpose and that its continued use today would be inappropriate, except for some basic information on the chemicals and processes.

In November, 1996, staff authorized Arthur D. Little to release the preliminary findings of the independent review to CXY Chemicals and Bovar-Concord in order to continue the process of refining the identification of hazards, the frequency and consequence analysis and the overall estimation of risk.

From December, 1996 until March, 1997, Bovar-Concord Environmental and Arthur D. Little exchanged additional information as requested by Arthur D. Little.

In May, 1997 CXY Chemicals and Bovar-Concord decided to update the 1994 Quantitative Assessment of Safety Risks to reflect the numerous design and operational changes instituted by CXY Chemicals and to respond to items raised by Arthur D. Little Inc.

On July, 11, 1997, Arthur D. Little submitted their independent review (Attachment B) of the CXY Chemicals Assessment of Chlorine Safety Risk to the Public, 1997 Update Report (Attachment C).

The independent review covered:

- the identification of hazards - what can go wrong?
- the frequency analysis - how likely is it to happen?
- the consequence analysis - what happens if the undesired event occurs?

**SUBJECT: Independent Review of the CXY Chemicals North Vancouver Plant
Assessment of Chlorine Safety Risk to the Public 1997 Update Report**

August 08, 1997

Page 3

- the overall estimation of risks - which combines all the previous items together to develop an estimate of the risk to the affected community.

The review concludes that "there are a number of factors which have been either over or underestimated for individual events; however, the overall results are judged to be reasonable representations of the public risk levels associated with current chlorine plant conditions and operation.

While not the focus of the current planning and land use decision, the consultant believed it was "important to note that the area to the west of the CXY Chemicals plant is a higher risk level than might be desired. This is not at all surprising given the proximity of the western plant boundary to the storage tanks and rail car loading stations. This is an existing land use which has experienced a significant reduction in risk as a result of the recent changes in plant operations and the plant improvements. It will be important to maintain good communications with the operations to the west of the plant for the purpose of emergency response and proper action in the event of a release."

Following Arthur D. Little Inc.'s presentation to Council, District staff and CXY Chemicals representatives will be organizing a public information meeting in Maplewood sometime in September, to share information and to clarify the chlorine risk to the public. Following this meeting staff will report back to Council with recommendations concerning the reconvening of the public hearing in October.



J. Edwin Torry
Manager of Planning

JIT/tt/dw
Attach.

REVIEWED WITH: ☐ Communications ☐ Env. Protection ☐ Human Resources ☐ Eng. Public Works ☐ Eng. Admin. ☐ Eng. Parks	REVIEWED WITH: ☐ Finance ☐ Fire Services ☐ Legislative Services ☐ Land ☐ Permits & Licenses ☐ Planning ☐ Social Planning	REVIEWED WITH: External Agencies: ☐ Recreation Commission ☐ Library Board ☐ Health Dept. ☐ RCMP ☐ Other: _____	REVIEWED WITH: Advisory Committees: ☐ _____ ☐ _____ ☐ _____
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Arthur D Little

Arthur D. Little of Canada Limited

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Toronto, Ontario
M5E 1J8 Canada

Telephone (1) 416.361.1051
Fax (1) 416.361.1155

July 11, 1997

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver
355 West Queens Road
North Vancouver
British Columbia
V7N 2K6

Re: ADL Reference No. 30728

Dear Mr. Torry:

Arthur D. Little of Canada Limited is pleased to submit this summary of our independent review of *CXY Chemicals North Vancouver Plant Assessment of Chlorine Safety Risk, 1997 Update Report*, prepared by BOVAR Environmental and dated July 4, 1997. The District of North Vancouver requested an independent review of the risk analysis described in this report because a rezoning application for certain lands in the Maplewood area and future uses depend in part on the placement of the risk contours relative to these areas. Therefore, it is particularly important that the Council be comfortable with the accuracy of the current study's findings and understand its limitations.

The review process started last summer when we reviewed the August 1994 report, *Canadian Oxy North Vancouver Plant Quantitative Assessment of Safety Risks*, as well as additional appendices and addenda associated with that report. In October 1996 we submitted an initial set of detailed comments on the 1994 report. As a result of the numerous design and operational changes instituted by the plant as well as our comments, the 1994 report was updated and totally rewritten. Our latest review is based on that 1997 Update Report, numerous telephone conversations with CXY Chemicals and BOVAR Environmental personnel, and a site visit in early June 1997. These additional sources of information form an integral part of our review, as the 1997 Update Report is not intended to cover all the details of the risk analysis.

Our review efforts focused on the soundness of the methodologies and the reasonableness of simplifications and assumptions, in order to identify inconsistencies, gaps or limitations in the analysis. This also allowed us to comment on the overall results. In general, we have not commented on the text of the 1997 Update Report except for interpretations of the results of the risk analysis.

The material in this letter reflects Arthur D. Little's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this letter, or any reliance on or decisions to be made based on it, are the responsibility of such third party. Arthur D. Little accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on the information contained in this letter.

Arthur D Little

July 11, 1997 Page 2

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

Our review covered:

- the identification of hazards—*what can go wrong?*
- the frequency analysis—*how likely is it to happen?*
- the consequence analysis—*what happens if the undesired event occurs?*
- the overall estimation of risks—which pulls all the previous items together to develop an estimate of the risk to the affected community.

The methodology for each step was reviewed along with the assumptions made. We evaluated: the approach and assumptions used in the consequence modeling, including the credibility/applicability of the selected meteorological conditions; the completeness and soundness of the frequency analysis/approach; the rationale for the frequency values; and the way in which the seismic risk analysis conducted by Hooley & Schubak Ltd. in 1994 was taken into account in the overall frequency analysis. The implications of our findings in each area on the overall risk estimates were also determined to the extent possible without recreating the entire analysis.

Hazard Identification

The primary hazard identification approach used in the report was based on the knowledge of incidents that have occurred in the chlorine industry in the past. This approach gives a general indication of the range of hazards associated with a particular type of operation, but is not always helpful in accounting for site-specific design features that make one location more or less hazardous than another—including consideration of such simple things as the number of loading or unloading operations, the length of piping, etc. It also cannot reflect the risk reduction benefits associated with various modifications or improvements.

Given that the emphasis of this report was on low frequency/high consequence events rather than all events which could have off-site impacts, most of these site-specific factors will not have significant impacts on the overall risk levels. In addition, for newer facilities or those with extensive upgrades or relatively small operations—such as this plant, this approach will generally be conservative (i.e., it will lead to estimates for the frequencies of failure which are higher than would be determined by other approaches). BOVAR Environmental has also taken the scale and condition of the North Vancouver plant into account by adjusting some of the basic historical frequency values.

The 1997 Update Report focuses on the risk from chlorine releases, and does not address potential propane or hydrogen releases or the potential for associated fires or explosions to cause damage to chlorine-containing equipment. In the case of hydrogen, BOVAR Environmental indicated that they believed that any chlorine releases which could result from hydrogen explosions would be included in the historical data set. Given the relocation of the propane tank, it is unlikely that a propane release would lead to a chlorine release.

Arthur D Little

July 11, 1997 Page 3

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

The historic-incident-based hazard identification was supplemented with a detailed earthquake analysis for the storage tank and a consideration of other causes of tank failures. Thus, the largest releases have been examined in a more site-specific manner. The identification of those events with the potential to impact the areas of concern to the north of the site is judged to be reasonably comprehensive.

Frequency Analysis

The seismic analysis of the 300-tonne storage tank explicitly considered different fill levels and analyzed the response of the tanks at each level. A separate analysis of the dike indicated that it would be expected to remain intact in the same earthquake events that would fail the tank. Even if this assumption were not accurate, the analysis of other tank failure modes did assume that either the dike would fail or that the release would spew over the edge of the dike. Given the layout of the site, the assumption that such releases would be totally unconfined (that is, they could spread to their maximum extent) is considered very conservative.

The analysis of releases from the rail car based the failure frequency on a 1987 study for Transport Canada, which evaluated chemical transportation risks in rail yards in Toronto. While the results of this earlier study were scaled to account for the level of rail traffic on the site, the Transport Canada study did not include rail car failures which result from causes other than collision and derailment. Given that there are 1735 rail car movements of chlorine from the CXY Chemicals site each year, and that each car may remain on site for two or more days in a filled state, on average there are roughly ten rail cars on site in a full condition over the course of the year. These rail cars are susceptible to earthquakes, corrosion, fatigue, etc. We would have therefore expected a failure frequency at least an order of magnitude higher than was presented in the report. Both the frequency and consequences of rail car releases would still be dominated by the tank failure scenarios, but releases from the rail car would be expected to contribute slightly to the risk contours.

In the area of tank car loading, the report describes the new loading station and all its protective features. However, there has not been any indication that this station would be used either exclusively or preferentially. Thus, the accuracy of the frequency estimates for these loading-related releases is somewhat questionable as they appear to be based on the design of the new station. However, in terms of the overall risk results, these events are not significant.

Considering all of the above, it is possible that the risk in the immediate vicinity of the plant, particularly to the west, could be higher than indicated. No significant changes are expected in the areas of concern to the north of the plant, however.

Arthur D Little

July 11, 1997 Page 4

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

Consequence Analysis

The most significant concern we had about the consequence modeling was the original approach used to estimate the amount of mass in the cloud, particularly for the large releases from the storage tank. The approach used in the original analysis tended to underestimate the amount of material in the cloud. Arthur D. Little provided several release modeling results for use in the 1997 Update Report which determined the amount of mass in the cloud based on more realistic physical phenomena. This data was then used as input to BOVAR Environmental's consequence models to predict the dispersion distances and areas shown in the revised report.

The consequence modeling has been performed using COBRA, which is a BOVAR Environmental proprietary model based on a well known and documented public-domain model known as SLAB. Most of the dispersion models in use today (including SLAB, but excluding hydrodynamic codes) are not suitable for performing dispersion calculations at low wind speeds. This is especially true when the surface roughness of the ground (i.e., the irregularities in the surface—picture a smooth surface of a pond versus a gravel driveway) is high enough that it effectively blocks the wind and contains the vapors emitted from liquid pools of materials that are in a cryogenic state or which are heavier than air, limiting further dispersion. Therefore, to limit the conservatism associated with the use of these models at low wind speeds, the 1997 Update Report uses a more complete set of wind speeds and stability classes. However, since all the wind speeds considered are still very low (2 m/s or less), the dispersion model results are likely to be conservative, that is they will over predict the potential areas covered by a chlorine cloud.

Risk Estimation

The development of risk contours is the most meaningful measure for land-use planning purposes and the basic process used for calculating the risk levels appears to be sound. Given the relatively limited distances for the risk contours, a dispersing chlorine cloud would transit these distances in a manner of minutes, making it unlikely that anyone could be evacuated in the event of a release. Thus, it is reasonable to calculate the risk levels without any credit for evacuating portions of the exposed population.

The 1997 Update Report does state that the risk at any location could be expected to be less than indicated in Figure 4 due to the protection afforded by going or staying indoors to reduce one's chlorine exposure. Being indoors would actually reduce the risk to those persons who are indoors, but does not change the potential risk level at a particular location.

Arthur D Little

July 11, 1997 Page 5

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

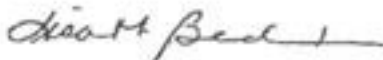
Overall Conclusions

There are a number of factors which have been either over- or underestimated for individual events; however, the overall results are judged to be reasonable representations of the public risk levels associated with current chlorine plant conditions and operations.

While not the focus of the current planning decision, we do believe that it is important to note that the area to the west of the CXY Chemicals plant is at a higher risk level than might be desired. This is not at all surprising given the proximity of the western plant boundary to the storage tanks and rail car loading stations. This is an existing land use which has experienced a significant reduction in risk as a result of the recent changes in plant operations and the plant improvements. It will be important to maintain good communications with the operations to the west of the plant for the purpose of emergency response and proper action in the event of a release.

Please let me know if I can clarify any of these points or if you have additional questions.

Sincerely,



Lisa M. Bendixen
Principal, Safety and Risk

Arthur D Little

Summary of the Independent Review of CXY Chemicals North Vancouver Plant Assessment of Chlorine Safety Risk, 1997 Update Report

Arthur D. Little of Canada Limited has conducted an independent review of *CXY Chemicals North Vancouver Plant Assessment of Chlorine Safety Risk, 1997 Update Report*, prepared by BOVAR Environmental and dated July 4, 1997. Our efforts focused on the soundness of the methodologies and the reasonableness of simplifications and assumptions, in order to identify inconsistencies, gaps or limitations in the analysis. This also allowed us to comment on the overall results. Our review covered:

- the identification of hazards – *what can go wrong?*
- the frequency analysis – *how likely is it to happen?*
- the consequence analysis – *what happens if the undesired event occurs?*
- the overall estimation of risks – which combines all the previous items together to develop an estimate of the risk to the affected community.

A summary of our findings in each area is given below.

Hazard Identification: The primary hazard identification approach used in the report was based on the knowledge of incidents that have occurred in the chlorine industry in the past. For newer facilities or those with extensive upgrades or relatively small operations—such as this plant, this approach will generally be conservative. BOVAR Environmental has also taken the scale and condition of the North Vancouver plant into account by adjusting some of the basic historical frequency values.

The historic-incident-based hazard identification was supplemented with a detailed earthquake analysis for the storage tank and a consideration of other causes of tank failures. The identification of those events with the potential to impact the areas of concern to the north of the site is judged to be reasonably comprehensive.

Frequency Analysis: For the storage tank, the greatest concern was seismic damage and this was looked at in much greater detail than the other potential failure events. The 1997 Update Report also considers other sources of tank failure and is more comprehensive in its treatment of other events than the 1994 report was. The rail car release frequencies given in the report are lower than expected, but should not influence the overall risk levels significantly as the frequency and consequences of such releases would still be dominated by the tank failure scenarios.

Consequence Analysis: The most significant concern we had about the consequence modeling was the original approach used to estimate the amount of mass in the cloud, particularly for the large releases from the storage tank. This has been improved in the 1997 Update Report. A more complete set of wind speed and stability classes has been used in the current report; however, since all the wind speeds considered are very low, the dispersion model results are likely to be conservative (that is they will over predict the potential areas covered by a chlorine cloud).

Risk Estimation: The development of risk contours is the most meaningful measure for land-use planning purposes and the basic process used for calculating the risk levels appears to be sound. Given the relatively limited distances for the risk contours, a dispersing chlorine cloud would transit these distances in a manner of minutes, making

Arthur D Little

it unlikely that anyone could be evacuated in the event of a release. Thus, it is reasonable to calculate the risk levels without any credit for evacuating portions of the exposed population.

There are a number of factors which have been either over- or underestimated for individual events; however, the overall results are judged to be reasonable representations of the public risk levels associated with current chlorine plant conditions and operations.

While not the focus of the current planning decision, we do believe that it is important to note that the area to the west of the CXY Chemicals plant is at a higher risk level than might be desired. This is not at all surprising given the proximity of the western plant boundary to the storage tanks and rail car loading stations. This is an existing land use which has experienced a significant reduction in risk as a result of the recent changes in plant operations and the plant improvements. It will be important to maintain good communications with the operations to the west of the plant for the purpose of emergency response and proper action in the event of a release.

July 11, 1997

The material in this summary statement reflects Arthur D. Little's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this statement, or any reliance on or decisions to be made based on it, are the responsibility of such third party. Arthur D. Little accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on the information contained in this statement.

Arthur D Little

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M5E 1J8 Canada

Telephone (1) 416.361.1051
Fax (1) 416.361.1155

October 21, 1996

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver
355 West Queens Road
North Vancouver
British Columbia
V7N 2K6

Re: ADL Reference No. 30728

Dear Mr. Torry:

Arthur D. Little of Canada Limited is pleased to submit this summary of our independent review of *Chemical Hazard Evaluation of the Maplewood Chemical Industry*, prepared by Beak Consultants, and submitted in June 1978. The District of North Vancouver requested this independent review to determine the overall usefulness and appropriateness of the 1978 report to present day decision-making needs.

This review was based on the report presented as well as several telephone conversations with Canadian Oxy personnel. We had initially planned to also conduct one or more telephone interviews with the Council or staff to better understand the purpose and proposed use of the report so that we would have a context in which to judge its relevance. However, based on our discussions with Canadian Oxy personnel, we no longer felt this was necessary.

The table below summarizes many of the factors that we evaluated during our telephone interviews and review. The effects and significance of the various factors were determined by reviewing the report and appendices in detail using our knowledge of current practices both in the chemical industry and in risk analysis methodology and assumptions, coupled with the results of our discussions with plant staff.

The material in this letter reflects Arthur D. Little's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this letter, or any reliance on or decisions to be made based on it, are the responsibility of such third party. Arthur D. Little accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on the information contained in this letter.

October 21, 1996 Page 2

J. Irwin Torry
 Manager of Planning
 The Corporation of The District of North Vancouver

Table 1: Relevancy of the 1978 Report

General Factors Influencing Relevance	1978 Study	Present Situation
scope of study	focus was on selected operations and chemicals, primarily chlorine and related products	materials other than toxics (e.g., propane) are also receiving attention
	risk of concern was acute risk to public; no discussion of environmental risks	environmental risks are of much greater concern, and could also be covered in a broad overview report such as this
	focus varied between Maplewood for fixed sites, general Vancouver area for transportation, and entire route for risks per shipment	report such as this would be expected to focus on a better defined area
surroundings/ external factors	1978 populations	encroaching residential and commercial populations
	considered local meteorology and terrain	still relevant
	some seismic analysis; general equipment response/failure predicted	more equipment-specific reviews and analyses conducted in interim
transportation	55-ton cars for chlorine	90-ton cars; rail car fleet has improved; release probabilities vary significantly for different types of rail cars (i.e., pressure versus non-pressure cars)
	used average accident rates for mid 1970's; data given on a per-shipment basis	major improvements to infrastructure have yielded significant reductions in rail accident rates since 1978; truck accident rates have not changed very much; marine rates are very location-specific, but the Port of Vancouver has undertaken a number of studies and initiatives to reduce risk so improvements would be expected; data is now generally expressed on a per-mile basis
	mid 1970's hazardous material shipment levels	significant increases in number of shipments at the site (about twice as many rail cars per year) and in Vancouver area in general; increased usage of intermodal containers (ISO-tainers)

Arthur D Little

October 21, 1996 Page 3

J. Irwin Torry
 Manager of Planning
 The Corporation of The District of North Vancouver

General Factors Influencing Relevance	1978 Study	Present Situation
operations	report did not take specifics of site and process into account, but rather relied on average industry experience; operation probably was fairly typical at this time	have improved procedures, quality programs and practices; less instrumentation and controls than might be found in a newer facility
	on-site inventory of up to 1780 tons of chlorine	total inventory limited to 550 tons of chlorine since 1995
	Chlorine Institute best practices	Responsible Care provides additional guidance
equipment age/ condition	20-year old operation	40-year old operation with few changes to physical plant, but well maintained and good attention to safety
	three 150-ton chlorine tanks; two 666-ton chlorine tanks	three 150-ton tanks removed; 318-ton chlorine tank added at some point in the past
		have added non-destructive testing of lines; do internal vessel inspections every 3 years instead of 5; more detection and automatic isolation; enhancements in earthquake resistance of equipment; adding motor-operated valve to rail car side of loading hose
		propane tanks moved further from chlorine operations
emergency response	concerned about both direct and secondary impacts	still relevant
	provided safety manuals and emergency response plans	out-of-date as there are more coordinated programs and site and local organizations have changed
	lack of coordinated response cited	much stronger and better coordinated emergency response programs/teams and better equipment available both locally and in the region
	concern over communication capabilities	much better and more reliable communication systems in place in the plants, the community, and the region
	most likely scenarios analyzed; maximum of 1000 pounds released	general practice is to evaluate a worst-credible release in addition to more likely (smaller) releases

Arthur D Little

October 21, 1996 Page 4

J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

General Factors Influencing Relevance	1978 Study	Present Situation
methodology	list of scenarios of concern	most are still relevant to some extent
	lists of incidents in industry and transportation	past events are generally still relevant, although many administrative controls and design improvements have been developed to limit the chance of them occurring again; more recent events could be added to lists
	used industry averages to give frequency ranges and release quantities	estimates are now out-of-date; industry-wide data is no more meaningful today than it was then as it does not indicate whether or not a given facility is better or worse than average and does not account for site-specific differences in activity levels, inventory, isolation capabilities, etc.; enough time has passed to know if some of the predicted frequencies were realistic; typical practice is to calculate flow rates based on the actual equipment and operating conditions
	coarse risk calculations	appropriate that they be coarse, but hard to accurately calculate estimates of individual risk when only considering the most likely events; low frequency/high consequence events must generally be considered
	simplified algorithms for consequence modeling predictions	significant improvements in consequence models
	concentrations of concern specified	minor, mostly insignificant changes

The 1978 report was intended to raise community awareness and help educate the interested reader. This need still remains, but today is more typically focused on the specific equipment, operations, and management systems of the industrial operations in a community than on the basic hazards of various chemicals. Without this degree of specificity, it is difficult to motivate improvements.

The 1978 report gave ideas on what it meant to classify Maplewood as an "active" chemical area and suggested that this characteristic must be factored into planning activities. However, it did not provide enough information on which to base such

Arthur D Little

October 21, 1996 Page 5

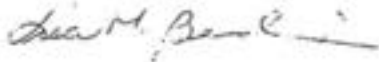
J. Irwin Torry
Manager of Planning
The Corporation of The District of North Vancouver

activities, other than to support the general need for strong emergency response planning and capabilities.

The basic recommendations of the 1978 report still make sense, and are typical of good management practices in the chemical industry today. However, we believe that the 1978 report has served its purpose, and that its continued use today would be inappropriate, except for some of the basic information on the chemicals and processes. Should you wish to update the report, there are numerous examples of community-wide reporting activities designed to address OSHA and EPA requirements that would help to structure your efforts. These reports are generally prepared by the operations of interest and then consolidated, rather than being prepared "externally" as the 1978 report was.

Please let me know if I can clarify any of these points or if you have additional questions.

Sincerely,



Lisa M. Bendixen
Principal, Safety and Risk

**The Corporation of
District of North Vancouver**

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British Columbia
V7N 2K6



District of North Vancouver

Mailing Address
P.O. Box 86218
North Vancouver
V7L 4K1

J. Murray Dykeman, Mayor

Telephone 604 987 7131

Fax 984 9637

**MEDIA RELEASE
Friday, May 5, 1995**

District of North Vancouver Mayor J. Murray Dykeman says that on Tuesday, May 2, Canadian Oxy Chemicals had a confidential meeting with District Council for the purpose of sharing the findings of the Quantitative Risk Assessment Study for their North Vancouver chlorine plant and how the Company proposed to make the information public.

This meeting was to advise Council on Can Oxy's process for public release of its risk information by June. "There was never any suggestion that the information presented would be withheld from the public," says Mayor Dykeman.

"It is regrettable that Councillor Crist chose to prematurely release selective information thus potentially causing much concern among members of the public who deserve to be fully informed about this complex issue."

District Council through its North and West Vancouver Emergency Program has stressed the importance of industries such as Can Oxy working with the community on issues such as risk assessment, risk reduction and risk communication. The study is one of the very few which has been undertaken in Canada to date and the procedure used includes a commitment of public disclosure.



MAYOR'S PERSONAL NOTES

Tues	May 2	Shirtsleeve meeting with Council and Can. Oxy to discuss public distribution of report. Material was "confidential" and slides of maps and charts were shown, not released. Meeting resolved 6 to max. 10 member committee be appointed by May 5 to finalize procedures for June publication to public.
Wed	May 3	Call from Vancouver Province reporter for comment of Can. Oxy report as a result of information provided by Coun. E. Crist. I returned and responded <i>"My only comment is if this information is published the article identifies Coun. Crist as the source of this confidential information that is before Council In-Camera"</i> . I demanded this be printed as the matter of confidentiality was extremely delicate and releasing such information was dealing with dynamite - but that he already had been told my only comment.
Thurs	May 4	Alerted Council to likelihood of publication of information.
Fri	May 5	Vancouver Province published article quoting Coun. Crist with the statement "information not classified" which is untrue. Press release prepared and distributed at 12:00 noon. Can. Oxy couriered copy of report to our Planner at 4:30 p.m. E-Mail to all Council and staff.
Sun	May 7	Vancouver Province editorial accusing the Mayor and The Corporation of the District of North Vancouver of preventing the release of information to the public. Another untruth and a further inaccuracy - directed citizens to contact 985-7761, the <u>City of North Vancouver</u> switchboard.

COUNCIL AGENDA/INFORMATION		
☐ In-Camera	Date: _____	Item # _____
☐ Regular	Date: _____	Item # _____
☐ Executive	Date: _____	Item # _____
☐ Info Package	Date: _____	Item # _____
☐ Agenda Addendum	Date: _____	Item # _____

Dept. Manager	Director	Municipal Manager
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The Corporation of the District of North Vancouver

REPORT TO COUNCIL

May 22, 1996
File: 3060-20/8.93

AUTHOR: Doug Allan, Senior Development Planner

SUBJECT: REZONING APPLICATION - CANADIAN OCCIDENTIAL PETROLEUM LTD.

RECOMMENDATION:

It is recommended that Council:

1. introduce Bylaw 6762 creating Comprehensive Development Zones 17, 18 and 19 and rezoning lands owned by Canadian Occidental Petroleum Ltd. and Imperial Oil Co. Ltd. from C3 and I2 to CD17, CD18 and CD19; and,
2. refer Bylaw 6762 to a Public Hearing on June 11, 1996.

REASON FOR REPORT:

As this application is an amendment to the Zoning Bylaw, Council's consideration is required.

SUMMARY:

In conjunction with the realignment of Dollarton Highway, Canadian Occidental Petroleum Ltd. (COPL) has applied to rezone its lands on either side of the new road to three new Comprehensive Development Zones. The former Esso service station site on Dollarton Highway at Riverside Drive which COPL has agreement to purchase is also included in the rezoning bylaw.

The Company undertook a Quantitative Risk Assessment of its plant to assess the risks of a major industrial accident under the current operational scenario and an alternate scenario. The two scenarios differ in terms of the volume and conditions of chlorine storage on-site. That QRA resulted in the development of a series of risk hazard contours around the plant which were used in conjunction with land use guidelines established by the Major Industrial

Accidents Council of Canada (MIACC) to define the permitted land uses within each zone based on the policy designations in the Maplewood OCP.

Notwithstanding the permitted uses which will be allowed in each zone, COPL will be prohibited by agreement from developing its lands until such time as the conditions of the alternate scenario are met. However, even when these conditions are met, some of the permitted uses within the CD Zones will be prohibited by covenant until further changes in plant storage are made, technology changes or the plant closes.

In order to achieve the objective of having the land uses reflect the conclusions of the QRA, COPL and the District must enter into an implementation agreement and a series of restrictive covenants to be registered on the title to the COPL lands. Consequently, staff recommend that Bylaw 6762 be held at third reading until COPL achieves the alternate scenario conditions and those conditions are verified by a qualified independent professional and all agreements are signed and ready for registration. COPL advises that the alternate scenario conditions are likely to be achieved by the end of the year.

BACKGROUND:

In order to facilitate the development of a municipal business park on lands north of Dollarton Highway east of Riverside Drive, COPL has agreed to dedicate a new road allowance through its lands which will permit the realignment of a portion of the existing Dollarton Highway and to contribute to the cost of construction. As the new road will facilitate improved access to their lands, COPL has applied to rezone its property on either side of the realigned roadway. The former Esso service station site on Dollarton Highway is also included in the rezoning (Attachment A).

EXISTING POLICY:

Under the Maplewood OCP, the subject lands are designated as "Commercial", "Light Industrial" and "Mixed Use" (Attachment B).

SITE AND SURROUNDING AREA:

The COPL lands are zoned General Industrial (I2) and are located between a rail spur line to the south, Front Street to the north, Amherst Avenue to the west and Forester Street to the east. The lands are presently vacant and heavily treed. The former Esso service station site (C3) on Dollarton Highway at Riverside Drive is vacant.

Surrounding land use consists of: a mix of light industrial (I3) uses, a neighbourhood pub (C6) and a paper recycling firm (I3) to the west; the waste transfer station (I2) to the southwest; other chemical industries and a lumber company (I1 and I2) to the east and southeast; and, commercial (C2), multi-family residential (RM3) and light industrial (I3) uses to the north.

Attachment C illustrates the proposed municipal business park in relation to the COPL and Imperial Oil lands.

QUANTITATIVE RISK ASSESSMENT:

COPL has undertaken a Quantitative Risk Assessment (QRA Study) as part of its long term risk management program to assess the public safety hazard associated with the operation of its plant and to assist in land use planning in the vicinity of the facility. A summary of the QRA Study is included as Attachment D.

ANALYSIS:

The Proposal: The proposal is to rezone the COPL lands on either side of the realigned Dollarton Highway from General Industrial I2 to three new Comprehensive Development Zones 17, 18 and 19. The bylaw will also rezone the former Esso service station site on Dollarton Highway from C3 to CD17 and 18. Bylaw 6762 (Attachment E) establishes principal and accessory uses; size, shape and siting regulations; landscaping regulations and parking requirements for each CD zone.

a) Permitted Uses:

1. **CD 17 Zone:** The CD17 Zone is intended to be a general commercial zone providing a range of services to complement the existing commercial uses for the benefit of the residents and employees in the general area.
2. **CD 18 Zone:** The intent of the CD18 Zone is to accommodate higher quality light manufacturing and warehousing uses which generally require larger sites which are augmented with a limited range of retail, wholesale and service-oriented uses consistent with the OCP.
3. **CD 19 Zone:** The intent of the CD 19 Zone is to accommodate uses which are appropriate in a business park setting with uses oriented to office and high quality light industrial and manufacturing uses which are environmentally safe and clean. A separate CD zone with very similar uses will eventually be placed upon the municipal lands to the north to regulate development within the future business park .

Notwithstanding the intent of each CD Zone relative to the OCP land use designations, the QRA risk contours and the MIACC guidelines will form the basis for the land use decisions within each zone. Since no uses would be permitted on the subject lands under the current operational scenario, the permitted uses in each zone represent the broadest range of allowable uses under the alternate operational scenario. However, even when the conditions of the alternate scenario are met within each of the three zones, there are some uses which would still conflict with the

MIACC guidelines and be prohibited until such time as either the chlorine storage at the plant is further reduced; technology changes; or, the plant closes. The uses permitted under the alternate operational scenario and those which would be prohibited by covenant until they would satisfy the MIACC guidelines are identified by zone within Bylaw 6762.

- b) **Development Regulations:** The recommended size, shape and siting regulations for each CD zone are generally based on the existing commercial and light industrial zone regulations. A matrix (Attachment F) compares the development regulations for each of the three CD Zones. The Bylaw also establishes landscaping and parking regulations.

REQUIRED AGREEMENTS:

In order for the rezoning and ultimately the development of the realigned highway to proceed, COPL will execute restrictive covenants and covenants under Section 215 of the Land Title Act. These will be registered against title to COPL's development lands and remaining plant lands and are designed to enforce the limits on land use, and the chlorine storage/shipping conditions at the Plant, as identified in the QRA. The overall implementation process for these agreements are set out in an umbrella "Implementation Agreement" which will be signed by the District and COPL. Specifics on the implementation agreement and the series of covenants are outlined in Attachment G.

Timing/Approval Process :

If the rezoning proposal is acceptable to Council, it is recommended that Bylaw 6762 be held at third reading until the conditions of the alternate scenario are achieved and verified and the required agreements are executed and registered. Following compliance with the conditions of the alternate scenario, execution of the agreements and adoption of the zoning bylaw, COPL will advance it's share of the construction costs for a realigned Dollarton Highway.

Public Input:

In May 1994, staff and COPL held three public meetings to outline the proposed realignment of Dollarton Highway, the development of COPL lands and the future municipal business park. The majority of the public concerns expressed at those meetings involved the implications of the road changes and the possibility of "big box" retail uses. Since that time, there have been discussions with the local business and residential communities regarding the road realignment and the other necessary traffic changes in the area. However, the issue of the proposed land uses has not been a point of contention for the area residents and business owners.

SUBJECT: REZONING APPLICATION - CANADIAN OCCIDENTIAL PETROLEUM LTD.

May 24, 1996

Page 5

Advisory Planning Commission:

This proposal was initially reviewed and supported by the APC on April 19, 1995, however, this was without the benefit of the QRA Study. The APC reconsidered the proposal at its meeting on April 17, 1996 and recommended support in principle subject to any risk issues being addressed in the restrictive covenants (excerpt is included as Attachment H).

PUBLIC HEARING:

The earliest date for a public hearing is June 11, 1996.

Doug Allan
Registered Planner
Senior Development Planner

DA/ld/dw

<u>REVIEWED WITH:</u>	<u>REVIEWED WITH:</u>	<u>REVIEWED WITH:</u>	<u>REVIEWED WITH:</u>
☐ Communications	☐ Finance	External Agencies:	Advisory Committees:
☐ Env. Protection	☐ Fire Services	☐ Recreation Commission	☐ _____
☐ Human Resources	☐ Legislative Services	☐ Library Board	☐ _____
☐ Eng. Public Works	☐ Land	☐ Health Dept.	☐ _____
☐ Eng. Admin.	☐ Permits & Licenses	☐ RCMP	
☐ Eng. Parks	☐ Planning	☐ Other: _____	
	☐ Social Planning		



Industrial
Chemicals
Limited
Partnership

100 Amherst Avenue, North Vancouver, B.C. V7H 1S4
(604) 929-3441
Fax (604) 929-7610 / 929-7600

May 5, 1995

To: Recipient

Re: CXY Chemicals (CanadianOxy) North Vancouver Plant Quantitative Assessment of Safety
Risks Report (the "Quantitative Risk Assessment Report")

The Quantitative Risk Assessment Report has been prepared for CXY Chemicals at its initiative in furtherance of CXY Chemicals corporate social responsibilities and its responsibilities as a Responsible Care® member of the Canadian Chemical Producers Association. The Quantitative Risk Assessment Report was prepared as the basis for developing a multistakeholder risk communications forum and dialog and to provide for long term risk management. We believe that a reasoned approach to the issues is required in order to properly respect all stakeholders concerns, especially those of our employees, the community, and the numerous other business which directly and indirectly rely on the continued operation of our North Vancouver facility.

The Quantitative Risk Assessment Report on its own is a very complicated technical and statistical analysis that must be understood in its proper context. As such, we would be pleased to have you attend a presentation that will provide additional information crucial to a full understanding of the report.

Should you have any questions or comments with respect to the Quantitative Risk Assessment Report, we would be pleased to discuss them with you. We strongly urge and invite all interested parties to make inquiries regarding their concerns. All inquiries should be directed to Brian Thornton, Plant Manager, at 604-929-3441.

Yours truly,
CXY CHEMICALS CANADA LIMITED PARTNERSHIP

A handwritten signature in black ink, appearing to read "Brian Thornton".

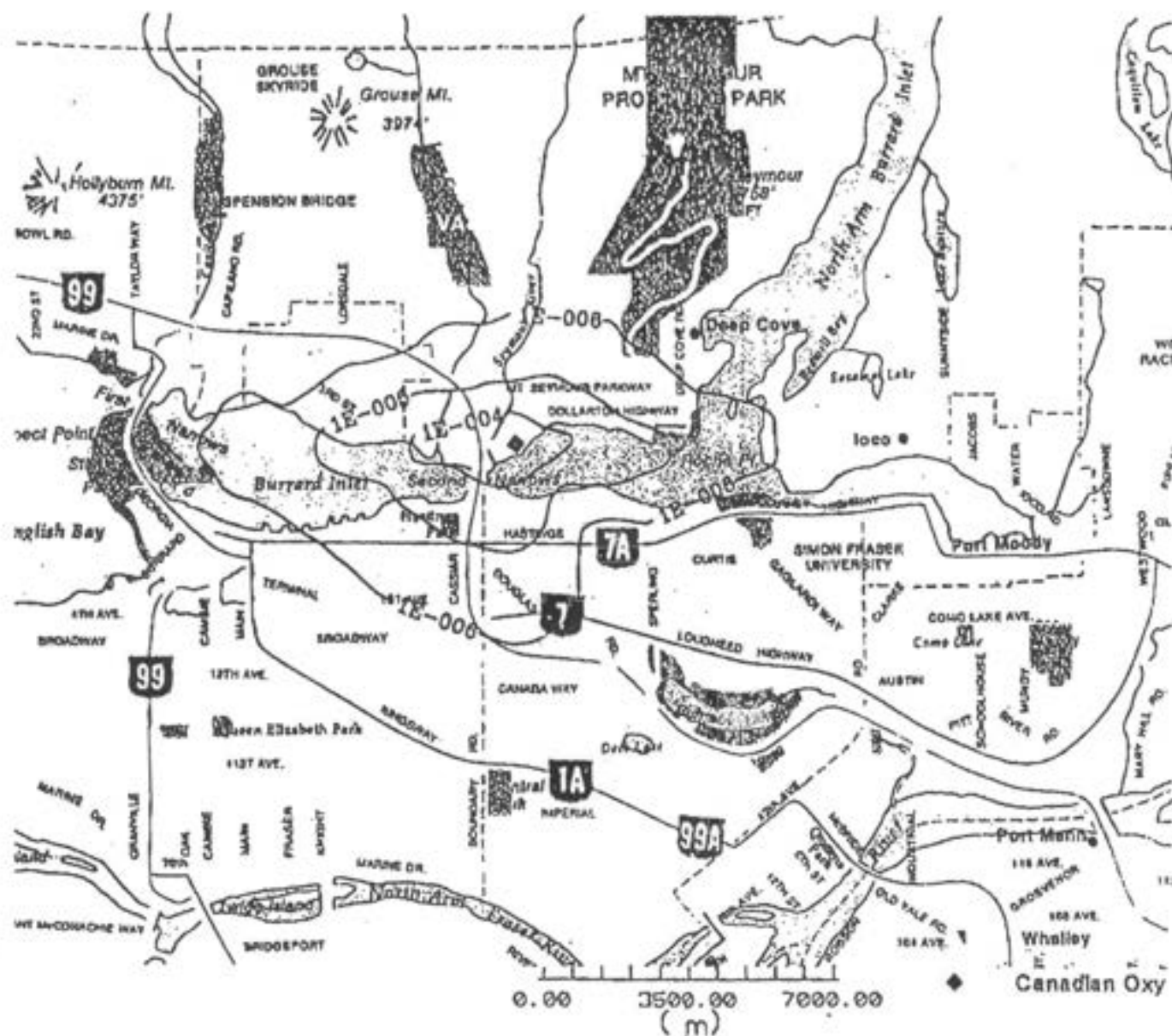
Brian W. Thornton
Plant Manager

ADDENDUM

May 8, 1995

The attached graphs depict the situation with a 500 tonne maximum inventory.

FIGURE 3-4 Individual Risk Distribution Around the Plant - Scenario 4 (500 t maximum inventory)



CANADIAN OXY NORTH VANCOUVER PLANT
QUANTITATIVE ASSESSMENT OF SAFETY RISKS

BCE.J3609.1

Prepared for

Canadian Oxy Chemicals
100 Amherst Avenue
North Vancouver, BC
V6H 1S4

Prepared by

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BOVAR-CONCORD Environmental
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August 1994

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1 INTRODUCTION

The District of North Vancouver and the Vancouver Port Corporation have proposals to develop some of the land north of Canadian Oxy Chemicals' North Vancouver Plant (the general area of the plant and the proposed developments are shown in Figures 1-1a and 1-1b). This plant manufactures chlorine and large quantities of this material are commonly present at the plant. Chlorine is a toxic gas and can pose a significant hazard at relatively large distances if released from its containment into the atmosphere. As part of its Responsible Care commitment and in order to assist in land use planning in the vicinity of the plant, Canadian Oxy Chemicals have commissioned the present study to assess the public safety risks associated with the operation of this plant.

The objective of the present report is to examine, in quantified form, the public safety risks of the North Vancouver Plant. The emphasis is on public safety, that is, on accidents with a low expected frequency but high potential consequences in terms of public fatalities or injuries, *rather than* public health (which would generally imply an assessment of long term impacts of relatively routine releases into the environment) or occupational health and safety (in which case the emphasis would be on the day-to-day health and safety of plant personnel).

The level of detail in quantitative risk assessments, and hence the accuracy of the estimated risk, can vary significantly, depending on the scope selected at the beginning of the assessment. The current scope provided for the following:

- familiarization with plant systems and operation based on review of plant drawings, findings of existing studies, and a brief site visit,
- identification of the more significant events which could lead to releases with potential public consequences, based on the review and plant visit,

FIGURE 1-1a General Area of Canadian Oxy Chemicals North Vancouver Plant

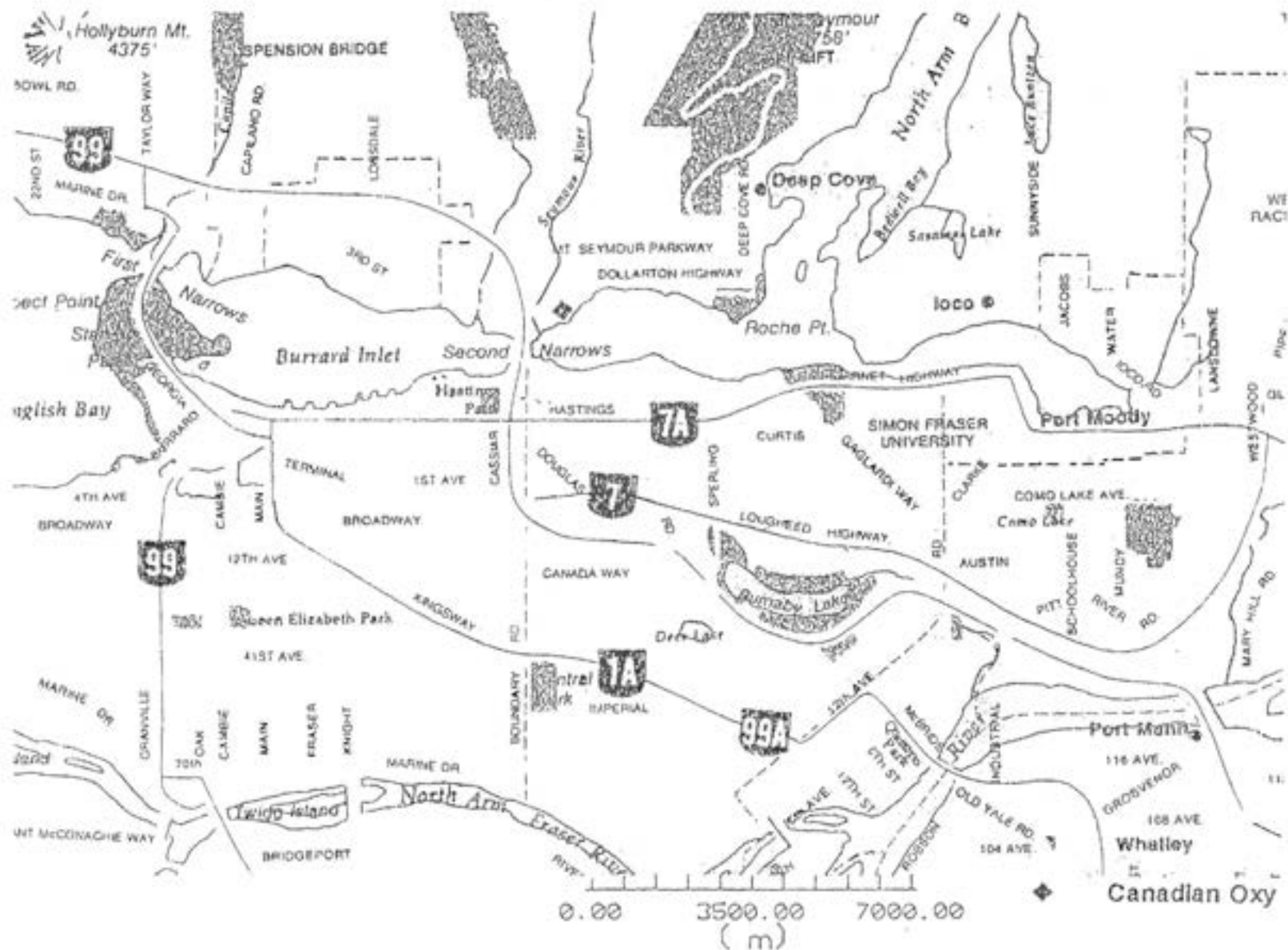


FIGURE 1-1b

Areas Proposed for Development North of Canadian Oxy Chemicals North Vancouver Plant



- estimation of frequencies of these events based on a combination of historical accident data and top level fault trees where historical data were not sufficient,
- estimation of hazard zones and potential consequences for the release events, using state-of-the-art dispersion and vulnerability models, taking into account the commonly encountered weather conditions at the plant site,
- estimation and presentation of risk in quantitative terms, by combining the frequency and consequence information, and
- evaluation of this risk by comparing it to commonly used acceptability criteria.

Two operational scenarios have been examined in this study. The first scenario consists of the current operations; the second case consists of operating with a much reduced chlorine inventory than the present operations allow, using a single storage tank further strengthened against earthquakes, and without the use of the barge.

The phenomena leading to releases, and once the release event occurs, the behaviour of the released material in the atmosphere, are very complex. Many simplifying assumptions are therefore required in carrying out the quantitative analysis of risks associated with these events. For proper interpretation of the results, it is essential that the readers of this report understand the basic concepts underlying the calculation of risk levels as well as the simplifying assumptions involved in the analysis.

The report accomplishes this objective by first presenting a discussion of basic risk concepts and definitions in Section 2, along with commonly used risk acceptability guidelines. The plant systems are then described briefly in Section 3. In

Section 4 the selection of potential release scenarios and estimation of event frequencies are discussed. Meteorology of the area, in terms of the parameters relevant to chlorine spills, is described in Section 4. Estimation of potential "individual" consequences of releases, and the hazard zones under selected weather conditions, are presented in Section 6. Individual risk contours (i.e., variation of individual risk as a function of distance from the risk source) are given in Section 7 along with a discussion comparing the estimated risks to risk acceptability guidelines. Options for future direction are then discussed in Section 8.

2 BASIC RISK CONCEPTS AND DEFINITIONS

2.1 DEFINING AND CALCULATING RISK

Risk is defined as a measure of frequency and severity of harm due to a hazard. The hazard is the presence of chemicals having various characteristics: toxicity, explosivity, inflammability, etc.

Risk is characterized by the nature of the harm, i.e., to humans, to property or to the environment. In this report, the harm is characterized by the "probability of a given effect on a selected type of receptor". The emphasis however is on harm to humans in terms of fatalities, we are therefore calculating the risk of fatality.

Safety is relative, it is a judgement of the acceptability of risk: an activity is considered safe if its risks are considered acceptable. This definition of safety emphasizes the decision making process. It recognizes that there is no such thing as "zero risk" because no matter what precautionary steps are taken, there is always some chance of an accidental release of a dangerous substance and a chance that someone may be adversely affected.

The common and convenient measure of risk due to a specific hazardous event is calculated by:

$$\text{Event Risk} = \text{Event Frequency} \times \text{Event Consequence}$$

There are many possible hazardous events for any facility, which depend on the quantity and nature of storage or process vessels, piping, valving, loading and unloading operations, etc. Each possible hazardous event contributes its share to the overall "facility risk", which is calculated by summing the risks of all possible events that could occur in the facility. In order to simplify the risk analysis, events

with similar consequences are considered in groups, such as "large releases" or "small releases".

Public risk can be thought of from an individual and a societal perspective.

Individual risk of fatality is the chance (in any year) that a person living near a hazardous facility might die due to potential accidents in that facility. Since the severity of impact of accidents usually decreases with distance from the facility, the individual risk (of fatality) will decrease with distance. The variation of individual risk around a facility is usually presented on a map in terms of constant risk lines or contours. Other factors, depending on the nature of the accident, such as wind direction, topography, climatic conditions, all affect the risk zones and hence the risk contours. Similar risk contours can be drawn for risk of injury.

Societal (event) risk is the expected number of fatalities for that event (the product of event frequency and event consequences in terms of the number of potential fatalities if that event occurs). Societal facility risk is the total expected number of fatalities in a year due to a hazardous facility and is estimated from all possible events.

Societal risk can also be thought of as the number of people exposed to given levels of individual risk (i.e., the number of people within the individual risk contours), which can be visualized easily when the risk contours are presented on a map showing land use. The risk acceptability guidelines proposed by MIACC (Major Industrial Accidents Council of Canada) are based on this interpretation of societal risk (see below). The emphasis in the present report for presenting risk information will therefore be in terms of risk contours superimposed on a map. Societal risk information is sometimes presented graphically showing the relation between event frequencies and the number of people that could be affected by each event. These graphs are called "FN Curves" or Frequency/Number curves. In some foreign jurisdictions, risk acceptability guidelines are cast in the form of

FN curves. Presentation of results in this form has not been attempted in the present report.

2.2 RISK ACCEPTABILITY

Acceptability of risks depends on the nature of the risk and who may bear it. Every person faces risk in every aspect of their life, some are faced voluntarily, some are imposed. Generally individuals will adjust behaviour or activities to reduce voluntary risks to an acceptable level, but for imposed risks they may have no degree of control or influence.

Broadly there are levels of risk that people will accept, and other levels that they will not. Adjusting risk levels often implies costs (of risk reduction activities) that may be borne by persons other than those who bear the risk, and benefits (of reduced risk) that are often attributed to persons other than those who bear the costs. The levels of costs and benefits as well as who bears or receives them will affect the acceptability of risk.

The judgement of risks means that "tolerable" or "acceptable" risk levels will vary with the benefits and costs no matter how they are calculated and by whom. In between the "not acceptable" risk level and the "acceptable" risk level is the area where risks may or may not be acceptable depending on the situation. Risks in this area are generally acceptable only if all reasonably practical measures have been taken to reduce risks.

Risk acceptability criteria are often set based on the premise that the risk being evaluated should not make a substantial addition to existing risk of everyday life. An increase of 1% (over existing levels) in the individual risk of death due to a specific hazardous activity is the basis of many criteria of non acceptable or intolerable risk. Acceptable or tolerable risk criteria are generally taken as a factor of 10 to 100 less than for intolerable risk. Between intolerable and tolerable risk

levels, risk reduction is desirable. The reduction in risk levels is achieved by taking risk control measures (see below).

Individual risk is often expressed in terms of an annual probability of death for an exposed person. An annual probability (or chance) of death of one in a million is often taken as an acceptable level - this level is written mathematically as 10^{-6} per year. An unacceptable annual probability of death is commonly taken as one in 10,000 which is written mathematically as 10^{-4} per year.

In Canada, MIACC developed the risk acceptability criteria presented in Figure 2-1. These criteria are specified in terms of allowable land-uses for specified levels of individual risk. This approach implicitly provides a guideline for allowable societal risk in one simple statement.

2.3 THE RISK MANAGEMENT PROCESS

The process of estimating the risks of a facility, judging its safety, and development of risk control measures if required, comprise the risk management process. The steps in the risk management process are shown in flow chart form in Figure 2-2.

System description consists of understanding the components of the facility and how it operates, establishing an inventory of dangerous substances used, manufactured during the process, or produced, and the surrounding area that might be affected by the events in the facility, in terms of population, land-use, and climate, etc.

Hazard identification answers the question: *What can go wrong?* Potentially hazardous events are identified and defined in this step. For example, in a flammable liquid storage facility, the realization that a release might lead to a pool fire and/or an explosion, and that there could be small, large or catastrophic releases, constitutes the hazard identification step.

FIGURE 2-1 MIACC's Risk Acceptability Criteria (based on Annual Individual Risk)

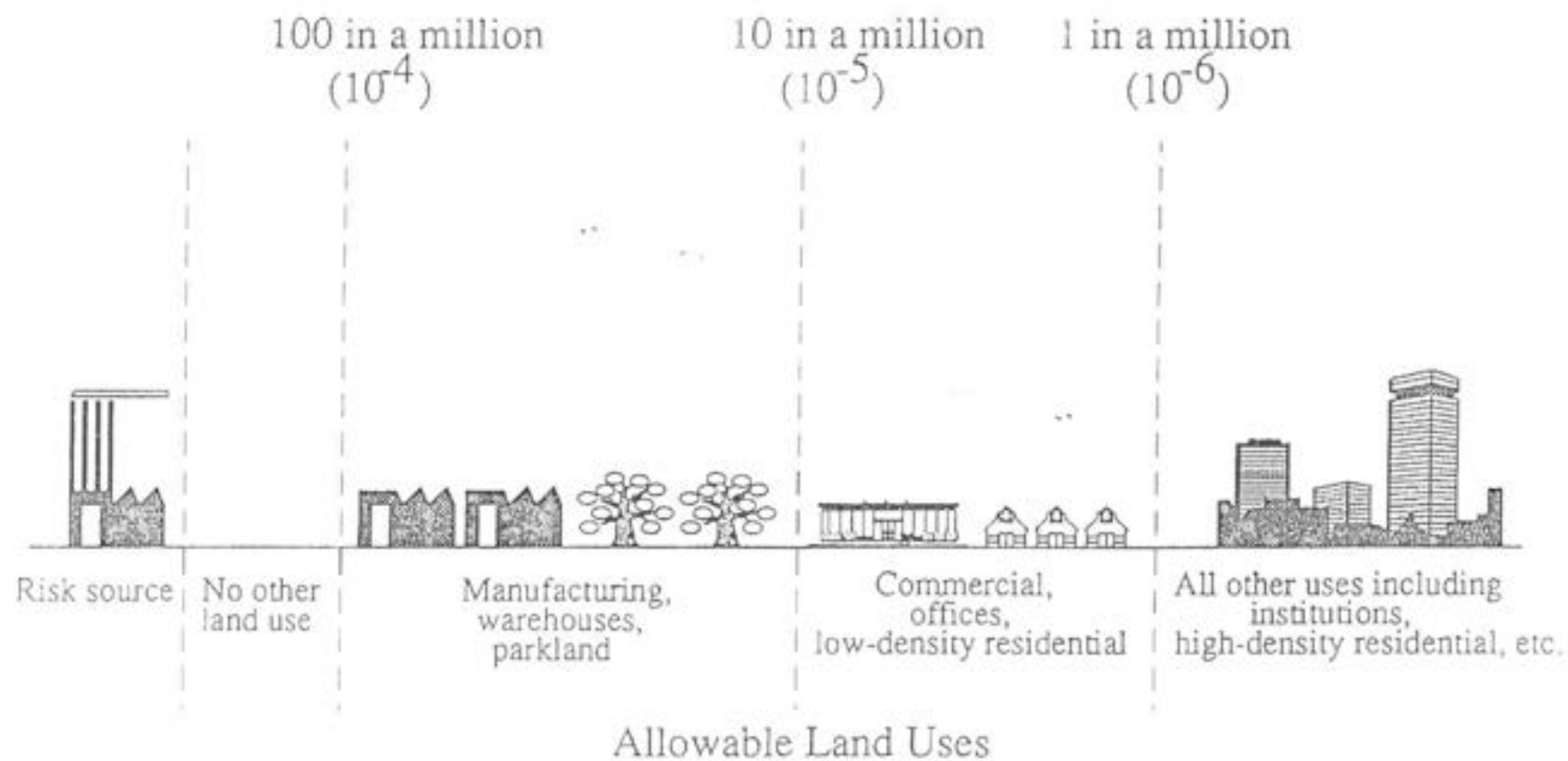
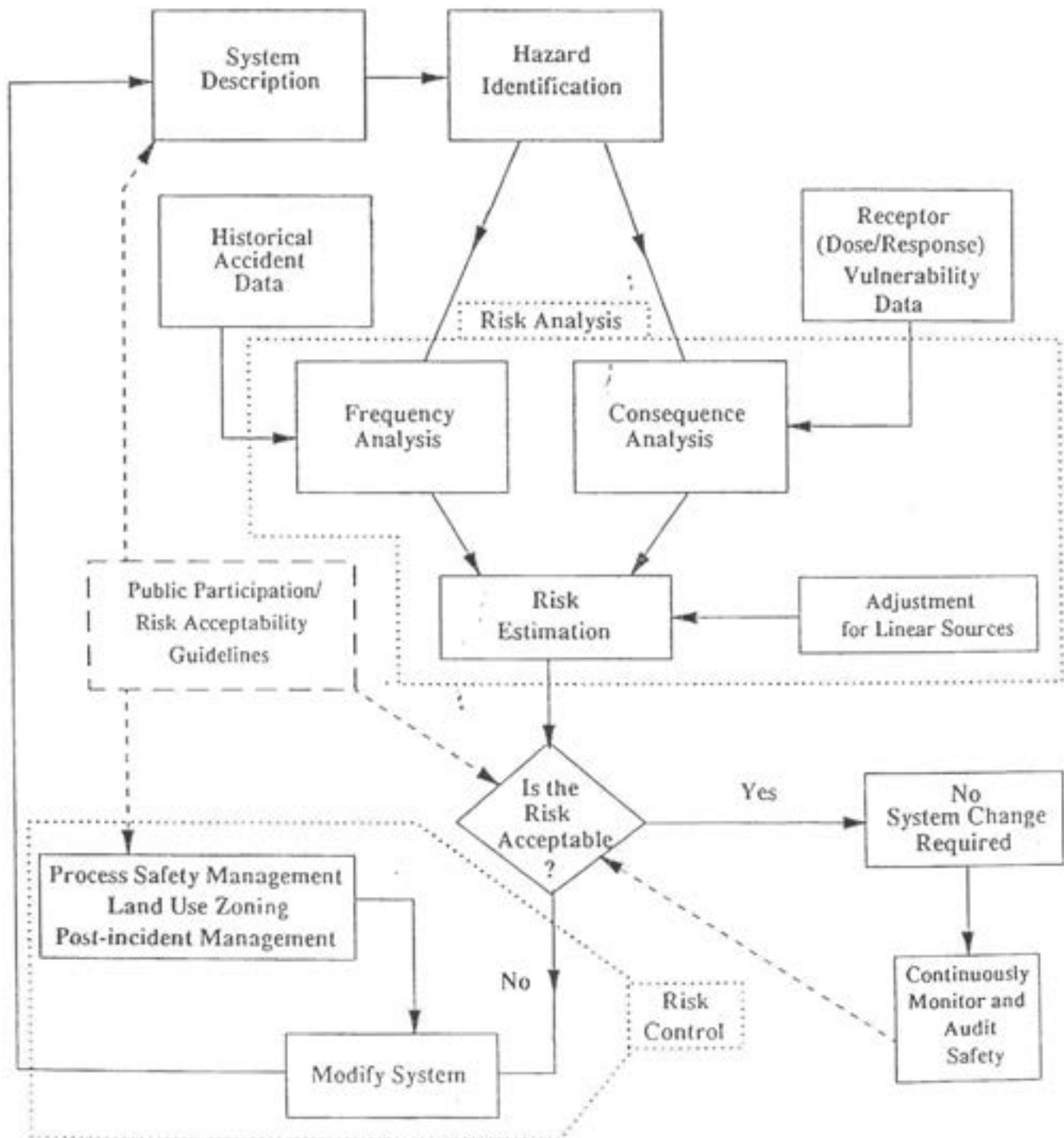


FIGURE 2-2 The Risk Management Process



Before risk can be managed, it must be understood. *Risk analysis* defines the risk of a hazardous facility and the reductions in risk achievable given certain risk control measures. It answers the following questions for the identified events: *How often is the event expected to occur?* and, if it occurs, *What are the consequences of the event?* Frequency analysis makes use of historical accident data in similar facilities. For very rare events, fault and event trees are also used. Consequence analysis consists of modelling the behaviour of releases of hazardous substances, and their impact on critical receptors making use of dose/response (vulnerability) data and models. Risk analysis is the process by which the frequencies and consequences of events are estimated and then combined to quantify risk. The results of risk analysis are used extensively in risk management decisions throughout the world. The uncertainties in estimating the chance of rare events, and in projecting the effects on human populations, are considerable. However, high uncertainty does not mean high risk. Estimation of uncertainties in risk estimates is currently an area of active research.

Risk evaluation answers the questions: *Is the risk judged to be acceptable?*, and, *Do we need to do anything about it?* Whether we judge a risk to be small or large, acceptable or unacceptable depends on many factors. Voluntary risks are those we assume due to some perceived benefit, e.g., smoking, sky-diving. Involuntary risks are imposed on people by decisions made by others or by natural occurrence, e.g., second-hand smoke, violent storms. A hazardous facility is often seen as posing an involuntary risk on someone living nearby (especially if the facility is new), but it might be seen as a voluntary risk if someone chooses to live near an existing facility provided that the person is aware of the risks before moving there. The MIACC risk acceptability criteria are designed for cases of involuntary risk such as due to hazardous facilities. They are intended to be used as public safety guidelines, along with economic and socio-political considerations in making a decision.

Communication of the risks to the public exposed to these risks, and public participation regarding the acceptability of these risks and the risk control

measures that would be implemented, are essential components of the risk management process.

The combined process of risk analysis and risk evaluation is usually called *risk assessment*.

If the risks are judged to be acceptable, then further risk control measures, or system changes, will not be required. However, in this case, it is essential to develop programs to monitor the situation so that it does not deteriorate over a period of time. Safety audits are among the tools used for this purpose.

If it is judged that further safety improvements are required, risk control options introducing system modifications, would be examined.

Uncertainty analysis answers the question: *What are the limits of accuracy?*

Risk estimates are based on simplifying assumptions and failure rate data that have associated error bands with it. As a result, evaluation of these uncertainties is an important part of a comprehensive risk assessment/risk management program. Furthermore, there is always concern with the underestimation of risk, and thus the upper bound estimates are of greater interest than the lower bound. In the present study, upper bound estimates were used where warranted by lack of definitive data.

Risk control answers the question: *What can be done to reduce the risks?* Risk can be reduced by decreasing the chance and/or consequences of hazardous events. Risk control measures can be broadly classified into

- process safety management, which includes technological measures, such as design changes, inventory reduction, etc., and management measures, such as inspection, maintenance, training and work practices,

- land-use restrictions, and
- post-incident management, such as emergency response plans and exercises.

Risk control measures will have certain costs associated with them. By estimating the risk reduction possible for each option, it is possible to assess the costs and benefits for each option, and informed decisions on which option should be selected can be made on this basis.

3 SYSTEM DESCRIPTION

The North Vancouver Plant produces chlorine, caustic soda (sodium hydroxide) and muriatic acid (hydrochloric acid) using the "Chlor-Alkali Process". The process uses three raw materials: salt (sodium chloride), water and electrical energy. A purified salt solution is fed into an electrolytic cell. In the cell, an electrical current passes through the salt solution, between electrodes, decomposing it into its basic elements.

The chemical reaction for this process can be represented by



Approximately 2900 kilowatt hours of electricity are required to produce one tonne of chlorine, 1.13 tonnes of sodium hydroxide and 29 kilograms of hydrogen.

The annual plant production ranges from 110,000 to 145,000 tonnes of chlorine.

The plant layout is shown in Figure 3-1 and a simplified flow sheet of the chlorine system is given in Figure 3-2.

Brine: (NaCl solution)

The raw material is solar evaporated sodium chloride colloquially termed common sea salt and comes to the plant by ship from Mexico. It is unloaded by conveyors to salt holding tanks and a paved pad. Fresh and recycled process water is added to the salt to form a saturated salt solution (raw brine). This raw brine also contains impurities primarily calcium and magnesium that come with the salt. The raw brine is purified by adding sodium carbonate and caustic soda; then filtered and sent to the cell house. Here it is warmed by exchanging heat with the warm hydrogen gas from the cells. Before the heated brine is pumped to the diaphragm cells, it is resaturated with salt that has been recovered in the evaporation of the caustic cell liquor.

FIGURE 3-1 Plant Layout

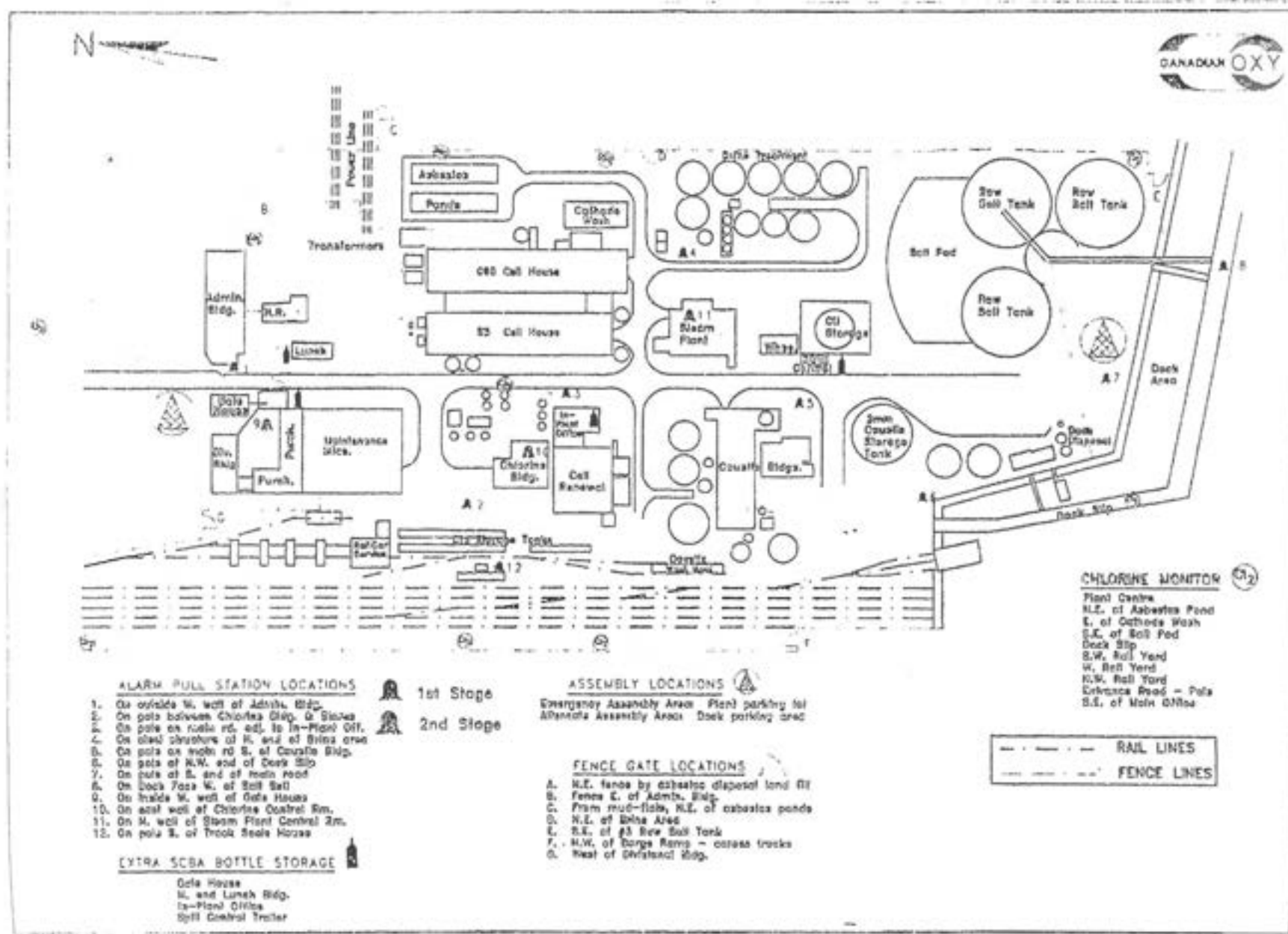
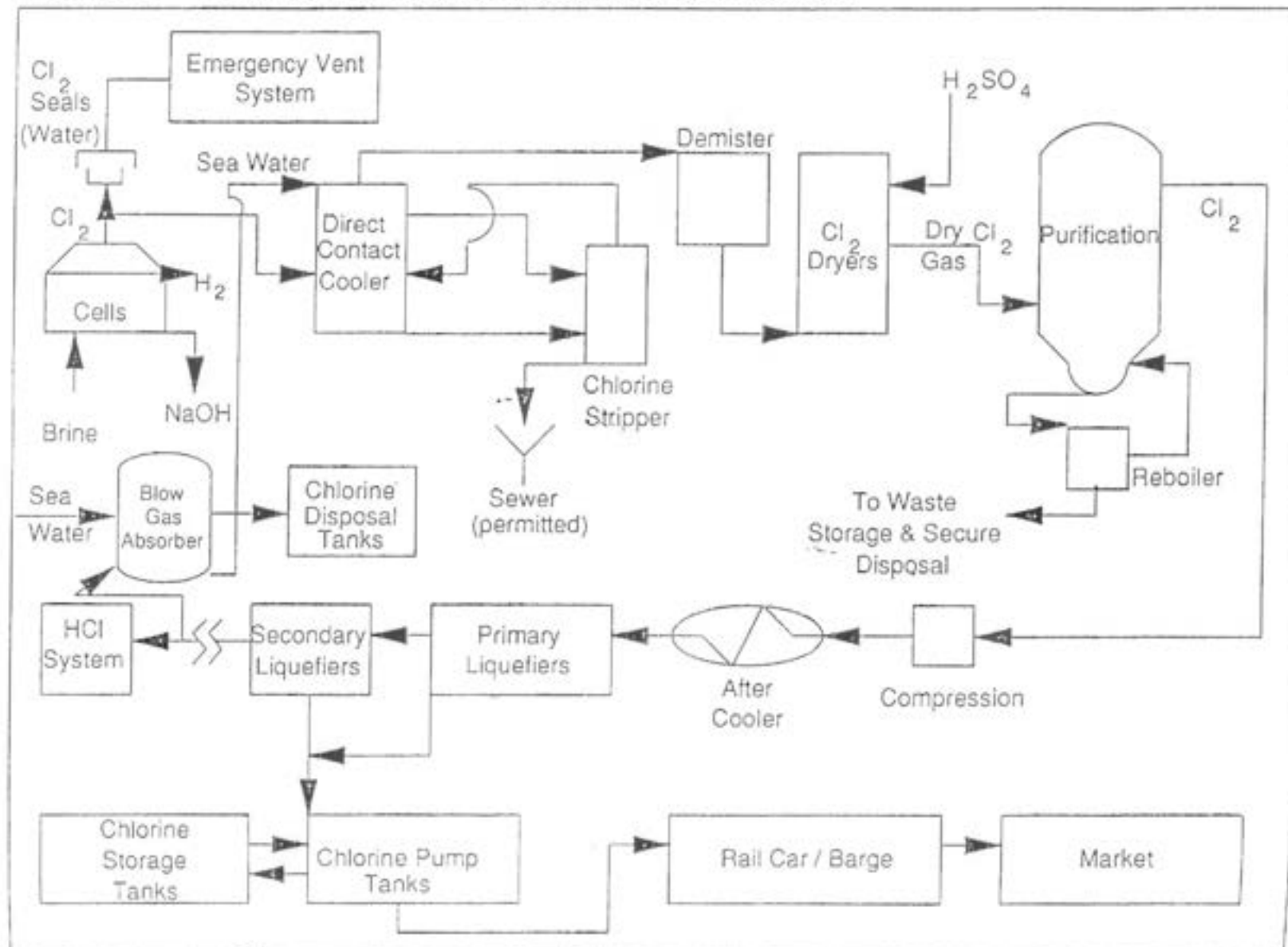


FIGURE 3-2 Simplified Flow Sheet for the Chlorine Processing System



Electrolytic Cells

The electrolysis, i.e., the decomposition of sodium chloride solution or purified brine, occurs in 322 cells divided into three circuits. The cells in each circuit are connected in series and arranged in rows in the cell house. A cell consists of:

- The metal anode, or positive electrode.
- The steel cathode, or negative electrode located in the catholyte chamber.
- The diaphragm. It is a characteristic feature of the electrolytic cell that the anode compartment and the cathode compartment are separated by a semi-permeable partition wall, a diaphragm.

The electrolytic process begins by feeding purified, saturated, warm brine into the cell and allowing the direct electrical current to cross the electrodes. The negative chloride ions are attracted to the positive anode and react to form chlorine gas.

The chlorine gas is collected within the fibreglas top and then flows into the main pipeline under a negative pressure developed by the chlorine compressor. The negative pressure or suction (like that developed by a vacuum cleaner) acts as a safety feature, preventing the leakage of chlorine cell gas in the surrounding area.

The positive sodium ions are attracted to the negative cathode and react with water to form sodium hydroxide (caustic soda) and release hydrogen gas.

About 50% of the brine fed to a cell is converted to caustic soda. The solution leaving the cell, called "cell liquor", contains about 12% caustic soda and 15% salt and is sent to storage tanks before being fed to 50% and 73% caustic evaporators for concentration and salt removal.

The hydrogen gas collects in the top portion of the cathode chamber and flows into a common collection pipe outside the cell to a hydrogen tower where it is cooled by contact with cool brine. The hydrogen is then compressed and used as a fuel in the boiler, and also burned with chlorine to produce muriatic acid.

The Diaphragm

The key to a safe and economical cell operation is the diaphragm. The diaphragm serves two important functions: First, it separates the hydrogen gas from the chlorine gas, which could form explosive mixtures if mixed in the cell. As an additional safeguard, the hydrogen concentration in the chlorine gas is constantly monitored. Second, the diaphragm prevents bulk mixing of the cell liquor and chlorine gas, which is essential to the production of separate chlorine and caustic products.

Periodically, an electrolytic cell must be pulled off the line and reconstructed. Installation or removal of a diaphragm cell from a cell circuit is accomplished quickly and safely by using an electrical jumper switch which bypasses electrical power around that particular cell.

Power Supply

The electrolysis process requires electric power in the form of direct current. Two BC Hydro 60,000 volt power lines supply the power for the plant. This power is transformed by rectifiers to direct current before being used in the cells.

Chlorine (Cl_2)

The chlorine gas from the cells is at first cooled by contact with water and dried when contacted with sulphuric acid in three stages. The dry gas is further cooled by direct contact with liquid chlorine and purified in a purification column. The purified chlorine gas is compressed to 40 pounds per square inch, cooled and

liquefied in two stages by freon liquefiers. (The liquefiers work very much like the refrigerator in a home.)

During this procedure, liquid chlorine is produced in a constant stream ready for storage and for shipping to the customer. Ninety-nine percent of the chlorine **condenses** with the remainder being absorbed by caustic solution in neutralization tanks.

Under current operational procedures, chlorine is stored on site (in liquefied form, at about -20°C) in two 600-tonne and one 300-tonne tank. It is shipped to markets by the tank barge Metlakatla, which has three (uninsulated) 300-tonne tanks, or in rail cars (insulated; 90-tonne capacity). Rail cars are sent to markets either by rail or by the rail barge Hyak King.

Under a second operational scenario examined in this report, only the 300-tonne tank would be used and shipping would be by rail cars. The 600-tonne tanks, which are used to support the barge operations, would not be used along with the barge.

Hydrogen (H₂)

The hot hydrogen gas from the cells is cooled by contact with brine, compressed and used as auxiliary fuel in the boiler, sold as gas, and burned with chlorine to produce muriatic acid.

Steam Plant

The steam plant consists of two Riley-type steam generators, commonly called boilers. Each unit has a maximum capacity of 100,000 lbs. of steam per hour, at a pressure of 150 pounds per square inch. The boilers are fired by natural gas, hydrogen and fuel oil. Natural gas supplied by B.C. Hydro is on an interruptible

basis, that is, it is diverted to the community when household fuel demand is highest, during cold weather. At this time hydrogen and fuel oil is used.

Caustic Soda (Sodium Hydroxide, NaOH)

The cell liquor from the electrolytic cells is evaporated in three stages with steam produced by the boilers. During the evaporation, the salt precipitates as crystals, is separated, washed and recovered. The recovered salt is used, as mentioned previously, in resaturating the cell brine. The 50% caustic soda product is cooled, filtered and pumped to storage from where it is shipped. A side stream of 50% caustic is further concentrated to 73% before going to storage for shipping.

Muriatic Acid (Hydrochloric Acid, HCl)

A small stream of compressed hydrogen is burned in the presence of chlorine to produce hydrogen chloride gas. This gas is then absorbed in water to form a solution which is 35% muriatic acid and 65% water. This solution is stored in fibreglass tanks for shipment.

SAFETY AND ENVIRONMENTAL PROTECTION

Emergency Vent Scrubber (EVS)

The (EVS) chlorine scrubbing system was installed to handle process upsets in the diaphragm cells and/or the chlorine liquefying system. The system is designed to handle the entire plant capacity to prevent chlorine being vented to the atmosphere, however, actual usage is measured in seconds or minutes.

Disposal Tanks - Chlorine Neutralization

There are five disposal tanks situated around the plant that are used to absorb chlorine vented from empty rail cars, storage tanks, barge tanks and the uncondensed gas from the chlorine liquefying system.

The two above systems use 15% caustic soda as the absorbing medium. The spent caustic soda (now bleach) is broken down to salt and returned to the salt area.

4 HAZARD IDENTIFICATION AND FREQUENCY ANALYSIS

The methodology used for identifying potential hazards associated with the North Vancouver Plant and the techniques used in analyzing the frequency of occurrence of these hazards are described in this section. The hazardous events selected for further analysis and their estimated frequencies are also presented. The hazardous events of interest to the present study are the occurrence of chlorine releases into the atmosphere. The major hazard of concern is toxicity of a chlorine cloud that has the potential to impact areas outside the plant boundaries.

4.1 TASKS UNDERTAKEN FOR HAZARD IDENTIFICATION

The tasks undertaken as part of the hazard identification phase consisted of the following:

- review of an existing hazard and operability study (HAZOP) previously undertaken by Canadian Oxy personnel on critical systems,
- review of the drawings sent to Concord,
- site inspection at the plant during October 25 to 29, 1993, and
- systematic examination of each plant system from the point of view of potential chlorine releases.

4.2 FREQUENCY ANALYSIS TECHNIQUES USED IN THE STUDY

Several approaches were adopted in the study to estimate the frequency of hazardous events.

The first approach involved using the existing historical accident records for chlorine releases. Numerous sources were contacted to obtain the historical records. These were examined to see if they could be applied in the risk assessment. The various sources contacted during the project are identified in the following discussion on the historical records and the results obtained are presented.

The second approach involved Fault Tree Analysis which is a common approach when the events of interest have a very low probability of occurrence, i.e., they have occurred only very infrequently or not at all in the past. Top level fault trees are presented for selected systems which could not be modelled adequately based on historical data alone. A brief discussion of these techniques is provided prior to the frequency analysis results for each system.

The balance of this section will be organized according to the system analysed. A discussion will be provided on the approach used in the estimation of event frequencies for each system. Each event is designated by an identification code. This discussion will include the assumptions made. The final result estimated for each scenario will be provided.

4.2.1 Historical Incident Records

The use of historical records in risk assessment assumes that the historical record is complete and the population of events is large enough so that the event likelihood determined is statistically significant. The record of reported occurrences should include failure modes such as human factors, common-cause failures, management systems and industrial sabotage (CCPS, 1989).

The application of incident records in risk assessment must satisfy several criteria which include:

- the number of recorded incidents must be related to some exposure term (called a divisor) so that a frequency estimate can be made, e.g., plant years, pipeline mile-years, truck.km, etc.;
- data are from an appropriate source, i.e., applicable to the case at hand;
- sufficient records exist so that the data are statistically meaningful.

Several sources were identified and approached during the study in order to develop incident likelihood estimates for the plant. The following contacts were made:

- Environment Canada, Environmental Emergencies Branch
- Ministry of Environment and Energy, Ontario Action Center;
- BC Environment, Environment Emergency Office;
- U.S. Environmental Protection Agency, Chemical Emergency Preparedness and Prevention Office.
- The Chlorine Institute.

The data obtained from the Chlorine Institute were chosen on the basis that it represented the largest population of operating producers of chlorine. Release data from the Chlorine Institute covers the period 1989-1992. Data on provincial incidents provided useful information on the incidents for producers and users in each province but the number of producers covered is small when compared to the Chlorine Institute data base. The federal government database (NATES) is not as comprehensive and is not complete for the later years, e.g., not all the provincial incidents are included in the NATES database. It provided useful incident information suitable for use in the hazard identification step, but not suitable for use in frequency analysis. The information from the US EPA suffers from similar limitations.

4.2.2 External Events Analysis

External events can impact the plant and lead to major hazardous events. The major categories are:

Natural Events - earthquakes, floods, tornadoes, extreme temperature, lightning, etc.

Man-Induced Events - aircraft crash, missile, nearby industrial activity, sabotage, etc.

Some of these events were considered in the frequency analysis. Earthquakes were found to be the most significant external events for present purposes. The earthquake analyses conducted for the present study are presented in Appendix A1 ((a) and (b)).

The typical steps when determining the event frequencies associated with external events are:

- estimate the plant system/structural response to a specified external hazard intensity, e.g., the response of interest is a failure leading to a release of chlorine as compared to a failure which might lead to nonelastic deformation of the equipment. The response to external events is usually expressed in probabilistic terms in nuclear plant risk assessments, however in the chemical processing industries, simple point discrete estimates are generally adequate (CCPS, 1989);
- estimate the frequency of exceedance of this intensity, e.g., annual probability of exceedance for the discrete event;
- estimate the frequency of failure;
- incorporate this frequency into plant system and sequence analysis (fault and event trees).

Some of the uncertainties associated with external event analysis is the component fragility/vulnerability analysis. Also, when external event results are combined with historical failure data, the possibility of double counting exists. Uncertainties with external events analysis are potentially higher than other parts of the frequency analysis (CCPS, 1989).

4.2.3 Fault Tree Analysis

Fault trees are logic diagrams that show how a system can fail. Fault tree analysis usually starts with a top event identified in the hazard identification step. Top events are major events such as toxic or flammable material releases, or vessel failures. 10-20 top events are usually sufficient to characterize the risk from a single process. Beginning with the top event, the necessary and sufficient causes for the top event are identified together with their logical relationship. This is accomplished using a "backward logic", asking questions like "How can this happen?" or "What are the causes of this event?" To follow the events within a plant, it is useful to use a guide word approach, and for each line ask questions like:

What would cause [no, more, less] [flow, pressure] in this line ?

and go backwards until an basic event with a known frequency, such as pump failure or human error, is identified.

Fault tree construction is an art rather than a science. Manually constructed fault trees are inherently subjective and may be incomplete. However, the technique allows the fullest possible expression of the analyst's understanding of the system and can provide great insights into the potential failure modes. Manual construction of fault trees is the most common approach.

In the present study, fault trees have been used in developing some of the event frequencies, as described in Appendix 2.

4.3 SELECTED REPRESENTATIVE RELEASE EVENTS AND ASSOCIATED FREQUENCIES

The hazards identified as a result of the hazard identification step are described in detail in Appendix 2, separately for each system at the plant, starting at the shipping end, and working backwards through the process units.

Also presented in Appendix 2 are:

- i) the details of application of the above frequency analysis methods to these hazard events, and
- ii) the selection of events for further examination, taking into account their frequencies, and their potential impact potential where possible.

The events selected for further examination on this basis are summarized in Tables 4-1 and 4-2, for the operational scenarios examined in the study. The next step in the risk assessment is heavy gas dispersion modelling as part of the consequence analysis, followed by vulnerability analysis.

TABLE 4-1 Summary of Events Selected for Further Analysis
- Current Operational Setting

EVENT	DESCRIPTION	FREQUENCY (event/year)
1.1a	Large Breach of 600-tonne Storage Tank	2.1×10^{-4}
1.1b	Large Breach of 300-tonne Storage Tank	2.1×10^{-4}
1.2	Small Breach of 600-tonne Storage Tank	10^{-3}
1.4	PSV Release from Storage Tanks	0.094
2.1	Large Breach of Pump Tank	2.1×10^{-4}
3.1	Breach of Liquid Line to Barge (Long Segment)	0.14
3.2	Breach of Liquid Line to Barge (Small Segment)	0.14
4.1	In-Plant Gas/Liquid Line Breach (High Pressure Side)	0.031
5.1	Large Breach of Rail Car	1.25×10^{-6}
6.1	Large Breach of Barge Tank (Marine Accident)	10^{-5}
6.2	Small Breach of Barge Tank	10^{-4}
6.4	Barge Tank Loading Arm Failure	1.8×10^{-5}
7.1	Scrubber Release	0.41
A	Large Breach of All Storage Tanks	2.1×10^{-4}

TABLE 4-2 Summary of Events Selected for Further Analysis
 - Alternative Operations with Reduced Inventory

EVENT	DESCRIPTION	FREQUENCY (event/year)
1.1b(i)	Large Breach of 300-tonne Storage Tank - Large Release	3.3×10^{-6}
1.1b(j)	Large Breach of 300-tonne Storage Tank - Medium Release	1.3×10^{-4}
1.1b(k)	Large Breach of 300-tonne Storage Tank - Small Release	2.0×10^{-4}
1.2b(j)	Small Breach of 300-tonne Storage Tank - Large Release	0
1.2b(k)	Small Breach of 300-tonne Storage Tank - Small Release	0
1.4(i)	Large Release from PSVs	10^{-4}
1.4(j)	Small Release from PSVs	0.094
2.1	Large Breach of Pump Tank	3.3×10^{-4}
4.1	Large Release from In-Plant Gas/Liquid Line Breach (High Pressure side)	0.031
4.2	Small Release from In-Plant Gas/Liquid Line Breach (High Pressure side)	0.279
5.1	Large Breach of Rail Car	1.25×10^{-6}
7.1	Scrubber Release	0.41

5 METEOROLOGY OF THE AREA

The frequency of occurrence of different wind conditions (speed and direction) and turbulence regimes (atmospheric stability) are required so that potential impacts of spills occurring under these different weather conditions can be properly incorporated into the risk analysis.

The terrain surrounding the Plant is very complex (Figure 1-1). The winds and dispersive conditions are influenced by high hills and mountains, the presence of the water body, as well as the channelling effect of the Burrard Inlet. The nearest Environment Canada station in the area where data suitable for estimating atmospheric stability using standard schemes is at Vancouver International Airport. This location is too far from the Plant, with a very different topography. The data from this station are therefore not useful for the purposes of the present study.

There are several GVRD stations in the area. The station closest to the Plant is the Second Narrows Bridge Station (Station T6) which is located east of the Bridge and west of the Plant. The data from this station include (vectorized) hourly wind speed and direction data but not any measurements which can be used for determining atmospheric stability. There are three other GVRD stations in the area where, in addition to wind speed and direction, temperature is also measured. These are Anmore (T7), Rocky Point Park (T9) and Burnaby Mountain (T14) Stations. These stations are at different heights from the sea level (about 150 m, 0 m, and 400 m, for stations T7, T9 and T14, respectively). Although the meteorological parameters measured at these stations are not sufficient to estimate atmospheric stability at any one of these locations, it is possible to derive an approximate effective stability class using the temperature measurements from the three locations with a temperature-gradient-based scheme assuming that the temperatures from the three locations would be representative of the temperatures at different heights at the same location. Clearly, this assumption would likely introduce large uncertainties; however it also represents the best that can be done with these data.

Two years' of data (1990-91) from the three stations (T7, T9, T14) were processed for the present study. The hourly stabilities which were estimated for each temperature difference pair (T7-T9, T7-T14, T9-T14) were averaged to generate an approximate effective stability to represent the dispersive regime for any release at the Plant site. The hourly effective stability data generated in this way were then merged with the hourly wind data from the Second Narrows Bridge Station to generate a data set which would represent approximately the dispersion conditions in the vicinity of the Plant.

Another data set available for us is the set from Canadian Oxy's own meteorological tower at the Plant. All the meteorological parameters that would be required for dispersion studies are measured at this tower. However, the period of available data is very limited (4368 hourly records in 1993, with large gaps), and the quality of the archived data might be questionable since the primary purpose of this system is to provide on-line weather information in case of an emergency.

Keeping in mind the limitations of the available data sets, the two data sets were analyzed for purposes of the present study. The wind roses for the two sets are presented in Figures 5-1 and 5-2. The patterns are quite similar, indicating that the wind direction frequency information based on these data sets can be used with some confidence. The stability information however poses some uncertainties. The joint frequency distribution of stability, wind speed and wind direction from the two data sets are shown in Tables 5-1 and 5-2. The data have been grouped together into two stability classes made up of Pasquill stability classes A-D (unstable to neutral) and E-F (stable), in anticipation of the ensuing consequence assessment. Use of two classes provides sufficient resolution to understand the range of possible hazard zones, while at the same time reducing the amount of effort required in modelling the spill scenarios.

FIGURE 5-1 Windrose for Second Narrows Bridge Station (GVRD Station T6, Years 1990-91)

