Fresh Water

The following discussion presents a synopsis of the relative effects that might be anticipated in the event there were a methanol spill affecting one of the region's rivers or streams, such as could occur along the transportation corridor.

Methanol impacts on both lotic and lentic aquatic systems are correlated with several physical and biological factors. While tolerances vary among organisms (Table 21.2) the potential disruptions of populations or communities depend on amount and duration of spill, water volume and flow rate, temperature, oxygen tension, seasonality or temporality of effected species, and the life stage of organisms with larvae, resistant spores, or motile instars. While few freshwater organisms can tolerate long-term exposure to even 500 ppm methanol, many organisms can survive acute or short-term exposures of 1% volume. Some adult crus tacea may even tolerate 10% for several hours. In general, aquatic insect larvae are subject to narcosis at concentrations as low as 0.5%. In particular, lotic fish prey species of Odonata, Plecoptera, Ephemeroptera, and Diptera are killed at 1% concentrations at ambient temperatures. However, recolonization of experimental spill sites involving these larvae is very rapid. Apparently, the rapid dispersal and dilution of the alcohol in moving water systems allows reoccupation of disrupted habitats through immigration from upstream populations. Insect larvae exposed to, but not killed by alcohol generally recover from the narcotic effects in several hours. However, behavioral disruptions during this recovery period, including disorientation, phototactic and thigmotactic reversals, and color changes make them more vulnerable to predators and physical disruptions.

Observations of some freshwater organisms indicate a wide range of tolerance for methanol. As examples, narcosis occurs in some aquatic insect larvae in concentrations as low as 0.5%, while several crayfish species can live in 10% methanol solutions up to five hours.

Table 21.2

FRESHWATER ORGANISMS -- METHANOL TOXICOLOGY

Organism	LD50 (15°C) (%, 3 hrs.)	(at 500 ppm, 3 hrs.) Disorientation	Narcosis	Color Change
Salmo trutta	0.50	+	+	
Salmo clarkii	0.50	+	+	
Salmo gairdnerii	0.75	+	+	
Gambusia affinis	0.75	+	+	
Pomoxis sp.	0.75	+	+	
Lepomis sp.	0.75	+	+	
Micropterus salmoides	0.75	+	+	
Cyprinus sp.	1.00	+	+	
Pacifasticus 3 spp.	3.0-5.0	+	+	
Procambarus sp.	3.00		+	+
Apus sp.	1.00	+	+	
Asellus sp.	0.75	+	+	
Neuroptera (larva)	0.50	+	+	
Plecoptera (larva)	0.50	+	+	
Ephemeroptera (larva)	0.50	+	+	
Odonata (larva)	0.50	+	+	
Trichoptera (larva)	0.50	+	+	
Diptera (larva)	0.50	+	+	
Coleoptera (larva)	0.50	+	+	
Colepotera (adults)	1.50			
Spongilla 2 spp.*	1.00		+	
Sphaerium 3 spp.	3.00			
Anodonta sp.	3.00			
Physa 3 spp.	1.50			
Pisidium casertanum	2.00			
Oscillatoria sp.	1.00			
Nostoc sp.	1.00			

* Choanocyte activity

Note: Many of these organisms are not present in the Beluga region.

Natural exposure to concentrated alcohols in freshwater habitats is probably negligible, making this latter tolerance remarkable. Several genera of both freshwater and marine bacteria are tolerant of 1% methanol. Under some experimental field and lab conditions, bacteria will metabolize C^{14} labeled methanol as a carbon source. Current assessment of methanol toxicity to small aquatic organisms suggests that the effects of one-time spills or leaks would probably be minimal, except in proximal areas where concentrations reach or exceed 1%.

Control spills in several habitats and laboratory aquaria indicate rapid deterioration of both individuals and community interactions at alcohol concentrations above 5% volume in lentic waters and 5% volume in lotic waters. Although oxygen concentrations appear to influence survivorship, the natural exposure to both alcohols in still, lentic waters seems to be a significant factor in organismic tolerance levels for organisms from this habitat. While recovery observations are still being carried out, preliminary evidence suggests more rapid stabilization in running, lentic waters. This is probably due to the more allogenic, colonizer-based community structure in this habitat, wherein major components move in from upstream waters. These studies will continue to document seasonal variations in community structure and species diversity.

Specific neuronal dysfunctions have been monitored for the crayfish Pacifasticus exposed to 5, 20, 30 and 50% of methanol for 30 and 60 minute periods. Cardiac nuclei desynchony, tachycardia, bradycardia, and other symptoms were noted. Other experiments of 30% and 50% methanol proved irreversibly toxic in 90% of the exposure situations.

Tolerances for several larval Trichoptera species have been established for both methanol-water and ethanol-water solutions. These important freshwater insect larvae occupy several niches and could prove useful as indicator organisms in the case of alcohol spills.

Depending on species, previous exposure, water temperature, oxygen tension, and chemical factors, Trichoptera tolerate 1 to 10% methanol or ethanol by volume. Important genera evaluated have included _Tinodes_ and _Athripsodis_, and other key groups.

Chronic toxicity studies with the eggs of the mayfly _Ephemerella (Ephemerella) infrequens_ have indicated that at concentrations of 1.0 and 1.6% methanol, there was no additional mortality but that development and hatching were somewhat delayed. At 2.5% methanol overall survival was low (only 10.6% at 60 days) and no eggs hatched. At even higher concentrations (3.0% plus) no eggs developed. _Ephemerella_ eggs appear to be less sensitive to methanol than those of several fish species including grayling and Arctic char.

Acute toxicity studies of the nymphs of five species of benthic macroinvertebrates -- the mayflies _Rithrogena doddsi_, _Ephemerella (Ephemerella) infrequens_, and _Siphlonurus columbianus_, the stonefly _Isogenus (Isogenoides) elongatus_, and the caddiesfly _Hydropsyche slossonae_. The resultant data indicate that:

a. If comparisons are restricted to intermediate nymphal stages, _Isogenus_ is least sensitive to methanol, with _Diphlonurus_ and _Ephemerella_ intermediate, and _Rithrogena_ most sensitive;

b. There was no consistent significant difference between the toxicity of analytical and technical grade methanol;

c. For _Siphlonurus_, there appears to be no difference in the sensitivity of mature nymphs and the black wingpad stage, whereas for _Ephemerella_, the latter stage is significantly more sensitive than the mature nymph;

d. In comparison with Arctic char, two species, _Hydropsyche_ and _Rithrogena_ appear to be at least as sensitive, while three species, *Ephemerella*, *Siphlonurus*, and *Isogenus* appear to be less sensitive than the fish.

Effects of methanol on permanent and seasonal freshwater fish are considered later in this section. Selected methanol toxicology is summarized in Table 21.2.

Terrestrial Effects -- Direct Exposure

The following discussion presents a synopsis of the relative effects that might be anticipated if there were a methanol spill on land.

Macrobiota and microbiota components in soil exposure experiments have wide ranges of tolerance in methanol. Soft-bodied organisms such as oligochaete and enchytraeid worms, nematodes, and soil protozoa are quickly eliminated in surface saturation experiments. Arthropod populations dependent on surface canopy vegetation are also drastically reduced, as grasses, mosses, and other plants are killed by surface saturation of methanol. However, arthropods at lower soil depths, or that are very mobile in the soil, are not affected (Table 21.3). Monitored plots of soil surface saturation spills in oak forest habitats indicate rapid recolonization of surface horizons. Animal populations below 20 cm in these plots were affected little by saturation spills.

In addition, fungal and bacterial populations show great tolerance and recolonization of surface horizons exposed to methanol. Preliminary data show about 60% of initial fungal activity recovers in horizons 10 to 30 cm deep one week after surface saturation. Ninety percent recovery is noted in similar plots and depths three weeks after saturation. Bacterial activity at 10 to 30 cm horizons is 85% of initial after three weeks. The rapid recovery or recolonization of these important agents of nutrient cycling is probably due to the very resistant spores and resistant stages produced by many species. Surface nitrates in experimental plots were nearly stable,

Table 21.3

ORGANISMIC RECOLONIZATION OF SURFACE SATURATED SOILS
METHANOL TOXICOLOGY

Organism	Population Loss (5% Intervals)	Post Exposure 1 week (% below initial)	Post Exposure 3 weeks (% below initial)
Lepidoptera (larva) 5 spp.	100	100	100
Diptera (larva) 2 spp.	90	90	90
Collembola 4 spp.	100	50	5
Nematoda 4 spp.	85	30	15
Enchytraeid 2 spp.	85	25	20
Oligochaeta	90	30	10
Coleoptera (adult)	90	20	0
Coleptera (larvae)	90	90	90
mites 4 spp.	95	40	15
millipedes 3 spp.	70	40	10
centipedes 2 spp.	10	100	100
Orthoptera 3 spp.	100	100	100
bacteria	90	40	15
fungi	70	60	10

also indicating the rapid recovery of the microfauna. Laboratory assessment of lateral and vertical movement of methanol in soil shows both rapid initial penetration and degradation of C^{14} labeled spills. In oak forest soils, penetration and movement is limited to the immediate spill area. Methothrophic soil bacteria become labeled in a few hours at the perimeter of such tracer sites.

Emissions

Preliminary evaluation of the toxicity of methanol spills or evaporative emissions shows minimal organismic effects. Flow chamber experiments indicate little disruption of plant and animal physiology at anticipated levels of methanol. Reversible narcosis occurs in many flying insect species at 500 ppm methanol for 1 hour exposures. Important pollinators may be adversely affected by methanol emissions under chronic or massive exposure, but further work is needed to determine the extent of direct and indirect disruptions.

Additional consideraton has been given to other pollinator and flying predator species of insects, including various Hymenoptera, Diptera, and Lepidoptera. More active fliers appear to be less tolerant of alcohol emissions, but low-level exposures elicited reversible narcosis and other effects in most cases. Exposure chamber evaluations demonstrated reversible disorientation and decreased feeding-gathering behavior in honeybee, wild bee, wasp, skipper, butterfly, and moth species tested at expected levels of pollution. Two species of carpenter bee, and three species of hover flies lost flying territory orientation under similar conditions. However, all of species' territories were reestablished in clean-air conditions in 0.5 to 2.5 hours after initial exposure completion. Predatory wasp prey capture abilities were decreased from 31% to 3% success ratio in chamber presentations of prey species. Larvae of the honeybee, Apis, and several species of moth soil larvae were killed by open air exposures (1,000 ppm methanol).

Other studies have involved the neuronal, hormonal, and muscular effects of methanol, ethanol, and indolene on selected arthropods. Various Hymenoptera, Diptera, and Orthoptera have been evaluated. The results indicated a relationship of tolerance to metabolic rate. The more rapid breathing and flying Hymenoptera and Diptera were more susceptible to gaseous fuels than the more terrestrial Orthoptera. In conditions approximating 500 ppm at 18° to 22°C, indolene most quickly caused narcosis and disorientation, followed by ethanol and methanol, respectively. Electronic monitoring of heart function showed arrhythmia, deletions, and secondary beats under all three fuel exposures. Possible permanent flight muscle dysfunction in honeybees at the above conditions was recorded in these experiments and is currently under investigation.

Other projects have involved arachnid exposures to methanol near or above levels expected in field spill situations. The results of these tests indicate a gradient of tolerance among these important predatory, nutrient cycling, and pollinator organisms. Arachnids as a group proved extremely hardy, showing reversible narcosis only after prolonged exposure to 300 ppm methanol. Narcosis and reversible neuronal disruptions occurred at 100 ppm ethanol/methanol in air for several orders of flying insects. Ongoing investigations involve hormone and pheromone disruptions at expected field spill levels of methanol. As most insect pheromones are short carbon chains of low molecular weight, the effects of low levels of alcohol are expected to be minimal.

METHANOL IN THE ENVIRONMENT (SPECIFIC)

Introduction

An overview of the biological consequences of methanol spills and leaks demonstrates a wide range of effects in different situations. The specific consequences of methanol on animal populations in the

Beluga to Drift River areas are associated with both biological and physical factors. In particular, life stage, nutritional state, seasonal reproduction, microhabitat, migration, sediment load, oxygen concentration, temperature, and exposure levels are most important in assessing impacts of spills or leaks from the plant site, pipeline, or tanker terminal. The consequences of methanol spill/ leak incidents may be summarized in organismic groupings.

Fish

Experimental tests for acute and chronic exposure to methanol indicate a wide range of tolerance, which varies within taxanomic groups, adult, age/size, and life stage. In addition, availability of oxygen during exposure, post exposure conditions, and other factors contribute to degree of disruption in fish by supra-ambient concentrations of methanol.

Several trout and salmon species may tolerate 1% methanol for 3 to 5 days. While behavioral alterations occur at this concentration, permanent damage is uncommon. It is probable that the eggs, sperm, embryos, and post-embryonic alevins of salmonid fishes can withstand brief exposures to methanol at 1%. A 1% concentration kills grayling eggs if continued over their incubation period. Trout fry are apparently unharmed by 24-hour exposures to 0.8%. Adult rainbow and brook trout tolerate 3% methanol for 24 hours, when aeration of water is supplied.

Blood analyses for methanol in exposed trout and salmon indicate non-selective removal of the alcohol via urine and gill surface diffusion. Adult brook trout exposed to 1% methanol show complete clearance in blood tests 12 hours after exposure.

A 10% concentration of methanol is lethal to most fish, depending upon oxygen demands and availability in each case. Eggs and embryonic stages of most fish are killed at 10% methanol, even during exposures of less than 1 minute.

Several unknowns exist for salmon and other fish of the Beluga-Drift River area in interactions with methanol accidents. Preliminary results show delayed embryogenesis and hatching at sublethal doses. The effect of ambient methanol on fertilization is unknown. Both sperm and ova could be extremely sensitive to low concentrations of methanol. It is also likely that sublethal doses of methanol could disrupt sensory recognition in spawning, migration, and courtship in some fish. In the sediment-laden waters of the upper inlet, these disruptions could prove significant. The exposure of spawning, migrating, or developing fish to methanol concentrations approaching 1% is potentially very disruptive. In addition, food chain alterations for resident or anadromous feeding fish may be significant in reproductive and adult success.

Human consumption of methanol-killed fish is not advisable. While this alcohol is rapidly removed from live tissues, it can remain in dead organisms in significant amounts.

Crustaceans

Crabs and shrimp in the Beluga-Drift River area are much more vulnerable to methanol exposure at developmental stages than at the adult stage. Studies have demonstrated reversible physiological disruptions in various crustaceans exposed to high ambient methanol concentrations. However, preliminary data suggest delayed metamorphis, color alteration, and reduced size in various crustacean instars associated with 100 to 1,000 ppm methanol. These data suggest potential damage to the tanner crab fisheries following any major incident, as this species has a floating, surface-dwelling larvae found throughout the lower inlet. Other species of commercially important crabs and shrimp have free-swimming larvae capable of avoiding temporary surface concentrations of methanol. However, tanner crab adults are generally found far south of the Drift River Terminal. Significant and commercially important crustacea in lower Cook Inlet include:

King Crab	Paralithodes camschatica
Tanner Crab	Chinoecetes bairdi
Dungeness Crab	Cancer magister
Pink Shrimp	Pandalus borealis
Humpy Shrimp	Pandalus goniuris
Coonstripe Shrimp	Pandalus bypsinotus
Spot Shrimp	Pandalus platyceros
Sidestripe Shrimp	Pandalopsis dispar

Most adult crabs and shrimp in the area of interest are somewhat migratory. King crab populations, for example, occupy deep waters in various localities throughout most of the year, and early in the spring the adults move to shallow waters (15 to 30 fathoms) to breed. Fertilized eggs are carried for a year. The following spring (usually mid-April) free-swimming larvae occupy middle and lower levels of shallower waters. Consequently, this species is not found in extremely shallow areas, or at the surface where vulnerability to methanol would be increased. In addition, like nearly all commercially important crustacea of this inlet, the king crab population are far removed from the Beluga-Drift River area.

In general, the significant crab and shrimp populations of Cook Inlet are in minimal jeopardy from methanol for several reasons: Adult mobility, adult tolerance levels, most have subsurface larvae, and geographic distance from likely spill locations (plant and terminal sites).

<u>Molluscs</u>

Molluscan species in the area of interest are more vulnerable as larvae than as adults. While ciliary narcosis is common in clams and other molluscs exposed to methanol, the effects of concentrations up to 3% are usually reversible. Only adults in very high alcohol concentrations for extended periods would be lost in spill situations. Significant and commercially important mollusca in lower Cook Inlet include:

Razor clam	Siliqua patula
Northern (or Weathervane) scallop	Patinopecten caurinus
Heart clam	1. Cinocardium ciliatum 2. Cinocardium californiense
Soft-Shelled clam	1. Mya sp. 2. Yoldia myalis
Bent-Nosed clam	Macoma balthica

While razor clams and other clams are abundant in the central and lower portions of the inlet, the sport and commercially significant beds occur away from the proposed methanol plant site. However, Harriet Point near Drift River is on the surface current line from the Drift River Terminal. This area could suffer minor adult losses in a major spill situation. Methanol concentrations would have to exceed 3% over a 24-hour tidal period for damage to occur.

However, as the veligers of some clams (including the razor clam) are tapetic or infaunal in pools or soft mud, they may be more vulnerable to low ambient methanol concentrations. Californian strand and estuarine clam veligers are killed by 100 to 1,000 ppm methanol, depending on species, temperature, and available oxygen. It is considered very unlikely that spills from the Beluga-Drift River area could reach recognized clam beds in significant amounts.

Birds and Mammals

Disruptions to bird and mammal populations in Cook Inlet from any methanol spills are considered unlikely. Since methanol is not biologically magnified within food chains, it is not ordinarily passed from prey to predator. Studies have demonstrated high non-primate tolerance for methanol, in both acute and chronic exposure studies. Habitat disruption from methanol spills into marshlands or mudflats would be less permanent than from crude oil or diesel fuel spills. Recovery of habitats following methanol spills is very rapid. Marsh nesting birds and mammals could suffer temporary loss of canopy in a saturation spill. Mobile cetaceans and pinnipeds would suffer minimal disruptions from either acute or chronic spills. Consumption of contaminated fish or crustaceans by birds or mammals following a spill similarly presents little hazard to non-human vertebrates.

Summary

The rapid dispersal, dilution, evaporation, and biological degradation of methanol in both aquatic and terrestrial habitats minimize its impact on living systems. Methanol in low levels is a normal component in many habitats, particularly mudflats, and many organisms are behaviorally, biochemically, and morphologically equipped to tolerate its presence. Soil penetration and aquifer involvement are minimal concerns with methanol production. The extreme currents and tides of the Beluga-Drift River area and the subsequent dilution of any spilled methanol from this facility, suggest that most impacts would not be severe or of long duration. Human impacts to fish and crustacean fisheries would be very localized in any spill situation from methanol plant to tanker terminal. Long-term disruptions to fisheries, or bird and mammal populations are considered unlikely in all but the most localized, worst-case possibilities.

22.0 SAFETY AND RISK ANALYSIS

INTRODUCTION

The purpose of this section is to assess an occupational health and safety program for the proposed methanol plant, because there are potentially hazardous situations inherent to the coal gasification process. Regulatory standards are cited where compliance is mandatory to achieve a given level of protection. In addition, potential hazards are enumerated to facilitate further evaluation of the programs necessary to achieve the desired level of protection. The most serious hazards are created by the possibility of fugitive emissions of carbon monoxide, hydrogen sulfide and methane.

A thorough safety/risk analysis involves complete identification and evaluation of hazardous elements to protect personnel, facilities and the environment against accidents. This level of analysis would consider the entire project from mining to shipping. A more detailed assessment as well as similar evaluations relative to the operation of the mine, transportation system, pipeline, and marine loading facility will be made in Phase II.

ASSESSMENT PROCEDURES

Program Characteristics

An early and complete safety analysis can eliminate potential safety and health problems that may otherwise, unknowingly, be produced during planning and construction phases of the project. This analysis can also provide the foundation upon which a thorough safety program can be developed for the construction and operation phases of the project. This safety program can minimize the impact of physical and chemical hazards on human health. An effective safety program requires management commitment both to the development of the program and to its implementation.

A thorough safety analysis should begin prior to the commencement of construction to provide optimum cost effectiveness. Implementation procedures and guideline characteristics for such a preconstruction safety analysis and review should include:

1. Management's accident control philosophy should be described by a clear, workable policy.

2. Responsibility must be clearly defined to cover all aspects of the program.

3. An organization must be formed to carry out the program.

4. Realistic objectives must be set.

5. Reporting procedures must be implemented so that accident facts can be recorded and causative factors analyzed.

6. An analysis of the relationship of facilities, personnel, equipment and materials to accident causes must be performed.

7. Personnel must be properly trained in their jobs, and management must promote realistic caution at all times.

8. Programs must be evaluated regularly to strengthen weaknesses.

9. Recognition must be provided for outstanding effort and achievement.

10. Top management must exert leadership in order to maintain program effectiveness.

Regulatory Assessment

An important area of regulatory concern is focused on the possible carcinogenic, mutagenic and teratogenic effects of polycyclic aromatic hydrocarbons (PAH) on human health. Polycyclic aromatic hydrocarbons are present in highest concentrations where incomplete combustion occurs. However, the Winkler gasifier is a partial oxidation system whereby the PAH compounds are converted into carbon oxides and hydrogen due to the relatively high temperature of gasification. Therefore, the major concern of the Winkler gasifier is not PAH compounds but, rather, the exposure to carbon monoxide and hydrogen sulfide, substances normally inherent to gasification processes.

The Occupational Safety and Health Administration (OSHA) Regulations, Title 29, Code of Federal Regulations, Part 1910 (cited 29 CFR 1910) at Subpart 2 (cited 29 CFR 1910 Subpart 2) lists a number of toxic and hazardous substance exposure limits. Of these toxic substances listed by OSHA, the following trace compounds in the raw gas are predicted to fall within the following ranges:

NH_3	3 to 10 ppm (vol.)
HCN	10 to 20 ppm (vol.)
C_2H_2	50 to 150 ppm (vol.)
C_6H_6	10 to 30 ppm (vol.)
H_2S	700 ppm (vol.)
COS	100 ppm (vol.)

It should be noted that the above concentrations of H_2S and C_6H_6 are above acceptable ceiling limits pursuant to OSHA standards (i.e. 20 ppm - H_2S; 1 ppm C_6H_6). Further applicable regulations are cited throughout this section where mandatory standards apply.

SAFETY OVERVIEW

Health Effects

The major hindrance to accurate risk assessment in a coal gasification plant arises because occupational exposures are to complex mixtures of chemicals rather than a single chemical. Chemicals similar in constitution and toxicologic mechanisms may simply have an additive toxic effect; or others may have a more serious synergistic effect, which is of particular concern with carcinogens. Some non-carcinogenic chemicals may enhance the potency of carcinogens when present. However, if components act independently, each can be considered as though the others were not present.

Effects of toxicant exposure on human health deviate dramatically. Assessment of these effects, again, are complicated by the complex chemical mixtures present. Exposure effects may vary from temporary irritation (e.g. ammonia exposure) to death within minutes (e.g. hydrogen sulfide exposure). Exposure to polycyclic aromatic hydrocarbons may cause problems that are not apparent for decades. Protection of the work environment from these hazards requires an effective sampling program to determine potential toxicant exposure. Effective engineering and work practice controls can be developed through this sampling program.

Coal gasification is essentially a closed process with few continual opportunities for air or surface contamination. Process operating conditions will determine the source of potential exposure. For example, vessel entry would be the predominant exposure source during down time (maintenance), while fugitive emissions from process equipment could be the primary exposure source when on-stream (operating). It is therefore logical to define possible hazards with respect to operating stages. The gasification process can be broken down into four modes of operation: Process Down Time, Start-up, On-stream Operation and Shutdown.

- Process Down Time

  Process down time exposures would result primarily from maintenance and repair operations which require an employee to enter a vessel. Vessels may contain residual gases and surface contaminants such that entry may pose health hazards to employees. A safe work permit system should be established as a checklist for the employee to proceed safely.

  The following hazards apply both to vessels and confined areas. Similar hazards exist when opening a process line and thus require similar attention. Among the health and safety hazards that must be checked prior to vessel entry are:

Atmosphere: Areas containing less than 19% oxygen concentrations are considered inert for human respiratory functions. Oxygen concentrations far below 19% should be expected in all areas of the gasification process and may further exist in the baghouse areas.

Enclosed area within the process may contain vapors from volatile liquids. These vapors are capable of forming explosive mixtures upon contact with air. Coal dust present in the coal preparation areas is equally capable of explosion at high concentrations.

Gases and Liquids: A number of liquid, gaseous and vaporous constituents in the process are toxic. These toxic constituents should be expected in all gas stream vessels and lines.

To insure these hazards are minimized before opening the vessel, all material must be evacuated and properly disposed of in a safe manner. Flushing the vessel with steam or an adequate solvent will remove toxic gases and residues. Purging with an inert gas following flushing should remove the last traces of toxic gases and vapors. Physical isolation of the vessel is required to separate it from all sources of hazardous material. Isolation of a vessel involves plugging a line or removing a section of process pipe. Only if other methods are not possible should the use of a valve be permitted as an isolation method; then both supervisor and worker should "lock-out" a closed valve.

Before human entry, the existing (inert) vessel atmosphere should be thoroughly exhausted by means of exhaust fans and flexible ducts inserted into vessel crevices. Testing of the vessel should verify:

1. Greater than 19% oxygen concentration;

2. Atmospheres less than 1/10 the Lower Explosive Limit (as given in the Handbook of Industrial Loss Prevention);

3. Absence of toxic gases and vapors, determined by either direct instrument reading or indicator tubes.

If testing indicates insufficient oxygen or toxic vapors are present, respiratory equipment must be provided in accordance with 29 CFR 1910.134. However, respiratory equipment is a last resort method only to be used after it has been demonstrated that engineering work practice offers insufficient protection.

No more employees shall enter a vessel than there are means to retrieve safely in an emergency. A standby employee must be present at all times outside the vessel whenever an employee is inside a vessel. The standby employee should maintain continuous contact with the person inside and should be prepared to initiate rescue procedures should it become necessary.

Opening a process line may expose a worker to the same toxic hazards as entering a vessel. Prior to opening, the process line should be blocked both upstream and downstream. An exhaust hood should be used to remove any toxic gases and vapors to the flare. Once an exhaust hood is in place, the bleed valve can be opened gradually.

- <u>Start-up</u>

Start-up procedures should include leak tests. Cold and hot testing with an inert gas are necessary for adequate detection of any potential process leaks. Detection of these leaks before operation begins will reduce the probability both of health hazards and emergency shutdowns. Adequate training programs prior to start-up are a necessity.

° <u>On-stream Operation</u>

Worker exposure would occur from process equipment leaks. Equipment such as pumps, compressors, valves and flanges are subject to relatively high temperatures and pressures. Corrosive and acidic liquids may be encountered especially in pumping coal runoff water from the retention ponds. Proper selection of equipment, seals and gasket materials to withstand such abuse is needed to minimize the potential for leaks. Triple mechanical seals may be necessary to effectively reduce the possibility of toxic material leaks in some areas of the process scheme.

Leaks occurring at operating pressure should be readily recognized as adverse effects on operating parameters or spontaneous combustion upon gaseous entry into the atmosphere. Neither condition is acceptable for any length of time; therefore little exposure from a continuous source is expected as operating procedures would provide for shutdown and repair.

Numerous techniques can be employed to further reduce the risks from process related leaks, among them various types of exhaust ventilation. Requirements for ventilation are given in 29 CFR 1910.94; furthermore, construction, installation, inspection and maintenance of exhaust systems must conform to standards given in American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2 - 1960, and ANSI Z33.1 - 1961. "Elephant hoses" can and should be utilized in enclosed areas. These long flexible exhaust hoses should be conveniently located so they can be placed over a leak as it occurs. When not in use each hose should be dampered. Areas where more frequent leaking occurs should utilize local exhaust ventilation.

Liquid leak exposures can be minimized by the use of portable shields and drip pans. Lines containing toxic materials should be designed with parallel duplicate lines and valves so that leaks can be bypassed to allow for continued operation. In critical process areas, the installation of parallel pumps and compressors could circumvent an unplanned shutdown due to leaks.

° Shutdowns

Shutdown essentially would present the same hazards as those encountered with the process down time operation. The only difference is that line material would be vented to the flare. To insure safety, the lines should be purged with inert gas until instrumentation indicates no process gas remains. All other safety procedures as given in the Process Down Time section should be adhered to as part of normal safety practice.

PROCESS HAZARDS

While process operating conditions will establish the type and limits of exposure, a thorough safety/risk analysis must also evaluate operational hazards unique to each process section. Extensive preconstruction investigation of each process section is required to develop an adequate safety program. This review will be accomplished in Phase II.

Coal Storage

Potential hazards inherent in coal storage are dusting, fire and leaching.

Dust is an intermittent health hazard caused by the loading, unloading and clean-up of coal in the storage area. Only storage facility personnel should be affected, as the area is located a significant distance from the process itself. Good housekeeping techniques can substantially reduce hazards and should be rigidly enforced.

Lignite and sub-bituminous coals can ignite when dry and exposed to ambient air conditions. These surface fires produce hazardous gases and particulates similar to coke oven emissions. These emissions are a source of polycyclic aromatic hydrocarbons and should be handled accordingly. As with dusting, good housekeeping procedures can reduce hazards.

Coal Preparation

Exposure to dust and excessive noise are the primary safety concerns in the coal preparation area.

Dusting is possible from any equipment, especially equipment that requires frequent disassembly for maintenance. Dust produced from crushing coal presents a number of inhalation hazards, most notably precipitating pneumoccniosis. Dust explosion also increases the possibility of a fire hazard.

Additioanl fire and inhalation hazards exist in the coal drying area should the temperature in the drying zone exceed safe limits. The possibility of fire from spontaneous combustion also exists during conveying of this dried coal.

All grinding operations are inherently noisy. Although operation is located away from the process plant, operating personnel may still be affected psychologically. Mandatory occupational noise exposure limits are set in 29 CFR 1910.95.

Coal Feeding

Valves in the coal feeding process are subject to extraordinary abuse, particularly lockhopper valves. Faulty valves may cause reactor off-gas to escape to the atmosphere, as these valves are located at the low pressure portion of the system. A double block valve arrangement will be utilized minimizing potential leaks. Preliminary designs of the valves will occur in Phase II as well as the interlock control system.

Gasification

Potential health and safety hazards in the gasification areas will be due primarily to: leaks, plugged lines and insulation problems.

Leaks may involve the temporary release of extremely toxic substances into the gasification areas, most notably carbon monoxide and, to a lesser extent, hydrogen sulfide. Even though leaks would be detected quickly in this area, potential loss of life is a grave reality should only minimal exposure occur.

Plugged lines may be a frequent problem in gasification and all previous safety precautions given in the process down safety assessment apply. Due to the formation of extremely toxic gases and vapors, additional emphasis should be placed on all safety precautions before vessel entry. Solids present in the gasifier should be essentially inert as they will be highly coked or ashed.

Ash Removal and Disposal

Valves in the ash removal and disposal lockhoppers are subject to the same abuses as those in the coal feeding process. High failure incidence may occur in these valves. Valve leaks can allow process gas to escape to the atmosphere causing potential inhalation hazards. Ash and chars are essentially inert but may absorb dissolved trace elements from recycle water. These elements may later leach out upon rain exposure and produce a potentially toxic leachate.

Venturi Scrubber

The Venturi Scrubber recycle pump is subject to excessive wear due to the pumping of solids. This excessive wear necessitates frequent visual inspections to prevent possible leaking of toxic substances.

Appropriate sampling techniques are necessary to reduce the possibility of burns from hot sample water. Sludge must also be handled carefully to prevent both worker exposure and accidental spills.

Shift Conversion

In normal operation, few hazards are foreseen with the shift conversion process. Normal maintenance operations should also present few hazards if the high concentrations of carbon monoxide in the reaction vessels are adequately purged.

Acid Gas Removal

If leaking gas and vapors occur from the acid gas removal system, there may be the possibility of toxic exposure. Fugitive emissions may release toxic substances (e.g. H_2S) from any section of the process up to and including the sulfur recovery system.

Methanol Synthesis

Adherence to proper operating procedures should produce few hazards. Leaks may occur due to: plugged bed or lines, leaking valves or leaking pumps. Leaks will release carbon monoxide, methane and hydrogen in the work place. It is expected that carbon monoxide will be emitted in greater amounts than methane or hydrogen. However, frequency and severity of such leaks should be far less than in the upstream portion of the plant. Leaks may also occur in the reformer section of the process, possibly releasing carbon monoxide, hydrocarbon gases or hydrogen.

Methanol Distillation

If leaking occurs in the distillation columns, there is a possibility of worker exposure to the high concentration of methanol. Due to the extremely toxic nature of methanol, exposure to it should be avoided under all circumstances.

Utilities

The coal-to-methanol process would require numerous support utilities for operation. Utilities are generally located within a single building and are inherently noisy.

MONITORING THE PROCESS ENVIRONMENT

Industrial Hygiene

An effective industrial hygiene program is composed of the following occupational health programs functioning together.

Monitoring

A monitoring program is implemented as a warning signal. The signal utilizes an indicator substance present in the process scheme such that any leak of the indicator would allow determination of a toxic constituent. The toxic constituent can be assumed to leak in the same ratio as the indicator substance. Although this assumption may not always be valid, the signal is not proposed as an absolute test of compliance, but rather an indicator of possible noncompliance.

This type of monitoring program avoids insensitivity to trace constituents at a reasonable cost.

Carbon monoxide would appear to be the best indicator for the gasification process. Carbon monoxide is present in high concentrations, and is also easily monitored in real time or by remote samplers. Alarm systems are available that can detect carbon monoxide levels as low a 0.2 mg/M^3.

Medical

Employees should be provided with preplacement and periodic medical examinations. The preplacement examination should include full physical and laboratory tests to ascertain general fitness, identify high-risk individuals, and set a basis for further routine examinations.

Medical records should be compiled for each employee and these records must contain employee exposure data. Medical records should be maintained for 40 years in accordance with OSHA regulations (29 CFR 1910.20).

Education and Training

Periodic meetings of all employees should be conducted to describe all potential health hazards in detail. Details of the medical program should also be made available to each employee. Personal hygiene should be emphasized to further promote worker protection.

Toxic effects can also be reduced by minimizing skin contact with soiled clothing. Plant shower facilities should be provided, as should laundering facilities for protective clothing. Requirements for these installations and other plant sanitation equipment are given at 29 CFR 1910.141.

Compliance

Control methods should be implemented and evaluated regularly. Control methods include engineering, work practice and administrative controls. Protective devices should also be evaluated to determine compliance with safety and health standards (i.e., Occupational Noise Exposure [29 CFR 1910.95]; Personal Protective Equipment [29 CFR 1910, Subpart I]; etc).

Regulated Areas

Process areas may be regulated that exceed carbon monoxide concentrations of 35 ppm on a regular basis. Job functions may also be regulated to reduce the number of exposures to a particular hazard.

Posting of warning signs to reinforce adherence to specific safety requirements in each area enhances the effectiveness of the overall health and safety program. Specifications for such safety signs are given at 29 CFR 1910 145. Safety color coding should also be used to mark physical hazards as given at 29 CFR 1910.144.

Emergency Procedures

Emergency procedures should be developed where hazardous substances are handled. These procedures should be compiled in writing. Sufficient protection training should also be given to the applicable personnel. Means of egress and emergency procedures should be provided as given at 29 CFR 1910, Subpart E and 29 CFR 1910, Subpart Z.

FIRE SAFETY

A potential fire hazard exists whenever a vessel, duct, flange, pump, compressor or valve is opened. Coal particles adsorb a number of gases readily so that the possibility of a fire occurring remains even after gas purging of the system.

Gaseous effluents from the gasifier are the primary sources of fire hazards. Hot gas can escape from ruptured pipes, leaks or improper sampling procedures. Fugitive gas can ignite spontaneously upon entry to the atmosphere or drift several hundred feet before exploding. The number of potential leak hazards can be eliminated by installation of double valve sampling ports.

All automatic process control systems should have redundant instrumentation to prevent vessels from overheating.

Requirements for fire protection and equipment are given by OSHA at 29 CFR 1910, Subpart L.

Conclusion

This report was developed as the foundation for a thorough safety analysis. The report presents an attempt to realize potential safety hazards and assess their detrimental effects on human welfare. Although further safety evaluation is necessary, every conscientious effort shall be made to minimize physical and chemical hazards afflicting human health.

The ultimate objective of this evaluation shall be final application of an acceptable safety program at the CIRI/Placer Amex Production Facility; this ultimate objective will be accomplished in Phase II.

SITE EVALUATION SUMMARY

23.0 SITE SELECTION

INTRODUCTION

Construction of a methanol plant is being considered in a major coal resource area on west Cook Inlet referred to as the Beluga area. For purposes of this study this is an area of approximately 450 square miles bounded on the north by the Beluga River, on the south by Nikolai Creek, on the west by the Capps Glacier and on the east by the shore of Cook Inlet. In order to narrow the alternatives for siting the methanol plant within this broad area a screening analysis was used. Due to unavailability, Tyonek Native Corporation lands (former Moquawkie Indian Reservation) and the Bass Hunt Wilson coal lease areas were eliminated from consideration, thereby reducing the 450 square miles area to 370 square miles. By eliminating the areas of natural water courses and the wetlands consisting of small lakes and other significant standing water, the candidate area is further reduced to about 150 square miles. To proceed further with plant site selection the following three-step process was used to narrow the alternatives to the best available site:

Level I - Screening Analysis
Level II - Preliminary Site Selection
Level III - Final Site Selection

The Level I and Level II reviews were done as part of this feasibility study. Level III, "Final Site Selection", will be conducted during Phase II of development of this project if it is determined feasible to proceed. The following discussion summarizes the review process that determined a proposed plant site to use as a base case for this feasibility study.

Level I - Screening Analysis

The apparent alternatives for siting a methanol plant are to place it near the feedstock source (the mine); place it near the transportation infrastructure (a dock on Cook Inlet); or place it in a location remote from the feedstock source (most likely a market area). With this in mind, four specific areas were reviewed:

a. Granite Point and vicinity on Cook Inlet
b. The Capps coal mine area
c. The Chuitna coal mine area
d. Remote location

° Granite Point on Cook Inlet

The area reviewed is approximately 10 square miles in size on the west Cook Inlet shoreline generally between Granite Point and the mouth of Nikolai Creek. A distinct advantage of this location would be realized in the transportation of the finished product due to close proximity to the existing 20-inch diameter Cook Inlet pipeline, which currently transports crude oil to a tanker terminal operation at Drift River, approximately 40 miles to the south. The oil fields served by this line are nearly depleted, and the pipeline would be available by the time the plant were in operation. Also, a plant near the shore would ease the movement of large prefabricated plant modules, allowing more flexibility in planning and construction. Other positive factors include a more favorable climate and shorter period of snow cover than at the higher elevations of the mine areas. A disadvantage is that the plant would be 15 to 25 miles from the coal feedstock necessitating a mine-to-plant transportation system.

° Capps Coal Field Area

The Capps Field is one of two proposed mining areas that would provide coal to the methanol plant. The Capps mine area is approximately 25 miles from Cook Inlet, at about 2,000 feet elevation near the Capps Glacier. An advantage of this location is that it would not only be near the feedstock source but also near the first coal that would be produced from either mine area. It would also be sufficiently removed from the shores of Cook Inlet to be visually unnoticeable. A principal disadvantage would be the need for a pipeline system from the mine to Cook Inlet to transport the methanol. Another disadvantage to the upland location would be difficulty in obtaining sufficient water for plant operation. It is unlikely that significant quantities of groundwater could be obtained in the vicinity, and the surface sources are inappropriate due to their seasonal nature as sources, and due to water quality and/or use as a fish habitat.

A further disadvantage to the Capps location is that the coal produced from the Chuitna Field would have to be hauled upgrade from approximately 1,400 feet elevation to 2,000 feet, the elevation to the plant at the Capps mine. To operate a plant in this location would require investment in both coal and methanol transportation systems.

° Chuitna Coal Field Area

The Chuitna mine area is approximately 15 miles from the shore of Cook Inlet at an elevation of about 1,400 feet. This field is generally on a direct line route from Cook Inlet to the Capps Field. Advantages of the Chuitna mine area would include the relatively unnoticeable location and its nearness to the feedstock. The pipeline transportation system to carry methanol to Cook Inlet would be approximately 10 miles shorter than from a Capps site and the coal supplied from the Capps mine could be transported downgrade, instead of uphill from Chuitna to a Capps plant site.

- Remote Location

To complete the site selection alternatives, the possibility of an area away from Beluga or even outside of Alaska was also recognized. A remote site was dismissed as unfeasible particularly due to the need for double handling of coal, and additional marine transportation costs associated with getting coal to the processing location. In light of present market conditions and current and anticipated energy policies during the life of this project it appears essential to economic feasibility to have the plant close enough to the coal source so that the coal may be provided with minimal handling utilizing no more than one major mode of transportation. The relatively clean and undeveloped Alaska location also offer advantages in environmental permitting, since there are not already significant contributions of air pollution or wastewaters in the area consuming allowable "increments" of emissions to the environment, as would be the case in most west coast locations.

- Comparison of Alternatives

At this point the Capps Mine and the remote location were eliminated from further consideration for reasons generally described above. The two more likely alternatives, Granite Point and the Chuitna Field, were then further compared using evaluation criteria relevant to both locations. Each site was assigned a numerical value (3 = good, 2 = average, 1 = poor) reflecting its compatability with the requirements or restrictions associated with each of the evaluation criteria. Table 23.1 shows the results of this comparison and numerical ranking.

Although all qualitative rating criteria were considered equally in the above table, greater weight should be given to transportation, environment, and capital costs. The ratings on each of these three criteria, as well as the overall outcome favored the

Table 23.1

QUALITATIVE COMPARISON OF SITES

Evaluation Criteria	Site Alternatives: Chuitna Mine	Site Alternatives: Shore of Cook Inlet
Coal Transportation	3	1
General Environmental	2	2
Capital Costs	1	3
Permit Concerns	2	2
Wetlands	3	2
Product Transportation	1	3
Geotechnical	1	2
Climate	1	2
Water Availability	1	3
Power (external)	1	2
Dock Access	1	3
Land Availability	2	2
Site Preparation	2	2
Support Services	1	2
Wastewater Discharge	1	3
Labor Factors	1	2
Visibility	2	1
Site Drainage	2	2
TOTAL	28	39

Cook Inlet site, so a second comparison using weighting factors for certain criteria was not necessary. The conclusion of the screening analysis is that a site near the shore of Cook Inlet would best serve the objectives of this project.

A disadvantage of the tidewater site noted in the analysis was the need for a transportation system to move the coal to the process facility. This concern becomes less significant in light of the reasonable assumption that regardless of plant location, there eventually will be a mine-to-shore transportation system for movement and marketing of bulk coal totally unrelated to this project. This reaffirms the selection of the Cook Inlet site.

Level II - Preliminary Site Selection

The next level of site selection involved choosing a specific area with a minimum of 1,000 contiguous acres near the shore of Cook Inlet between Granite Point and the mouth of Nikolai Creek that appears suitable for location of the methanol plant. The site designated in this review would form the base case for this feasibility study.

The area under review is approximately 10 square miles, constrained by extensive wetlands and standing water to the north, the Trading Bay State Game Refuge to the south, the shore of Cook Inlet to the west, and, on the east, the desire to remain reasonably close to Cook Inlet. Within these parameters there are two general site alternatives for the plant: Tidewater in the low-lying area below the bluffs, or in the upland area between the bluff line and Congahbuna Lake.

- Near Tidewater

  There is a somewhat confined area very near high tideline in elevation between Granite Point and the mouth of Nikolai Creek that could be considered a candidate plant site. The land is sufficiently restricted in area, however, that it may not allow for sufficient flexibility in the final plant lay-out if site-specific geotechnical analysis or other considerations imposed further constraints. The physical characteristics of the site might require splitting the facility into upland and tidewater-elevation locations in any case. The foremost advantage of this tidewater location would be that it would enable the plant to be constructed utilizing very large prefabricated plant units which could be barged into place through dredged channels and then fixed into position; the channels could be reclaimed by backfilling. This method of building the plant could have a positive affect on capital costs which could not be realized utilizing an inland site. A tidewater location also would facilitate the discharge of treated wastewater effluent into Cook Inlet, the most likely receiving body of water for an industrial discharge. However, this tidewater location is a wetlands area and would require a Corps of Engineers permit. Obtaining a permit could be very controversial due to proximity to the Trading Bay State Game Refuge. The permit application would have a reasonable potential to be denied in favor of more environmentally acceptable upland locations. A plant located at tidewater also would be susceptible to damage from storm-generated high tides.

- Upland Location

An upland location 4 square miles in area was identified for this site alternative (Sections 17, 18, 19 and 20, T11N, R13W, Seward Meridian). Three-quarters of this land is controlled by the project participant, CIRI. Selection of this location would avoid the natural hazards associated with being near the shoreline at sea level, but also would remove the option of being able to barge large prefabricated plant units into place. However, it still would be possible to receive and install large prefabricated interplant modules using a coordinated barge and surface transportation network. Portions of this candidate site area are considered wetlands by definition; however, it is believed that these wetland areas fall under the jurisdiction of the Corps of Engineers nationwide permit authority, a classification which avoids complications that may be associated with obtaining permits for a tidewater location. Environmental and geotechnical constraints all appear reasonable for this location, and indications are that necessary permits could be granted.

The conclusion of the preliminary site selection review is that the methanol plant should be located on the upland somewhere between Congahbuna Lake and the Cook Inlet bluff line. A specific plant site within the general 4 square mile area was designated for use as the base case in this feasibility study.

Level III - Final Site Selection

The last stage of site selection involves adjusting the preliminary site location to make it most compatible with the actual conditions and constraints identified by this feasibility study. This final site selection step would be accomplished under Phase II of project development, if it is determined feasible to proceed with the project. At this point it appears that the primary factor that will influence some adjustment of the site location will be specific soils conditions. Broad areas within the preliminary site area have been found to have greater depths of organic overburden than originally anticipated. Indications are that some relocation of the upland plant site in a northwesterly direction would avoid some deep overburden and reduce capital costs through reduced site preparation. Further engineering soils exploration would precede the final site selection decision.

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