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Development of Design Guidelines for Shore-side Holding Tanks

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DEVELOPMENT OF DESIGN GUIDELINES FOR SHORE-SIDE HOLDING TANKS

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ENVIRONMENT CANADA

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ABSTRACT

This report studies the requirements for shore-side holding tanks receiving sewage collected on board vessels.

Preliminary designs for a basic system and two variations are developed and capital cost estimates are presented. Operating procedures are outlined and estimated annual operating costs for the shore-side holding tank installations are provided.

Several conclusions are drawn from the study. The main conclusion is that properly designed holding tank facilities will be very expensive to construct and operate and that, if possible, direct transfer of the sewage from the vessel to a shore-side sewer or treatment facility should be undertaken. If holding tanks are required, the system denoted as Alternative No. 3 is probably the most acceptable.

RÉSUMÉ

Le présent rapport analyse les exigences relatives à l'installation, sur la terre ferme, de réservoirs destinés à recevoir les eaux usées recueillies à bord des bateaux.

L'avant-projet d'un dispositif et de deux variantes y est présenté, de même que l'estimation des dépenses en immobilisation. Y sont définis les techniques d'exploitation et les coûts estimatifs annuels d'exploitation des installations en question.

Parmi les nombreuses conclusions tirées de l'étude, la principale veut que la construction et l'exploitation de réservoirs bien conçus soient coûteuses et qu'il faille peut-être, si possible, envisager l'évacuation directe des eaux usées des bateaux dans une installation de traitement ou dans des égouts situés sur le bord de l'eau. Toutefois, s'il est indispensable d'utiliser des réservoirs, le système présenté sous le nom Possibilité n^{o} 3 est probablement le plus acceptable.

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1 INTRODUCTION

1.1 Purpose

The purpose of this report is to present the findings of the Consulting Engineer as required under the contract titled "Development of Design Guidelines For Shore-Side Holding Tanks, Task 7 Canada/U.S. Agreement".

1.2 Terms of Reference

The terms of reference for this report are as follows:

(1) Investigate various materials of construction and configurations for shore-side holding tanks for three basic capacities: 5,000 Imperial gallons (22.73 m^3); 10,000 Imperial gallons (45.46 m^3); and, 30,000 Imperial gallons (136.38 m^3) of sewage, sludge and/or dilute sewage sludge generated and held on board shipping vessels in the Great Lakes. Consider multiple tank versus single tank configurations. Choose the most feasible material and configuration for the tank for each capacity considered and present as a preliminary design.

(2) For each of the tanks indicated most feasible in (1), above, carry out a preliminary design for the following:

- (a) tank foundation;
- (b) influent and effluent piping;
- (c) pumping system;
- (d) standby pumping requirement;
- (e) cold weather protection;
- (f) corrosion protection;
- (g) site protection and dyking;
- (h) safety, venting and explosion prevention;

(i) odour Control;
(j) maintenance, access, clean-out;
(k) health protection;
(l) electrical and power supply;
(m) instrumentation and controls; and,
(n) alarm system.

(3) Prepare schematic and typical arrangement drawings for the entire system.

(4) Suggest alternatives to proposed system where location permits derating design.

(5) Prepare description of operational procedure for entire system.

(6) Prepare preliminary cost estimates.

(7) Consider that the location for shore-side holding tanks may be at a number of locations on the Great Lakes area having an eastern boundary at the St. Lambert Locks at Montreal.

1.3 Background Information

To gather information for this project, a number of meetings were held with organizations such as the St. Lawrence Seaway Authority, German and Milne-Naval Architects, the Environmental Protection Service of the Department of Environment, and the Ministry of Transport etc. Visits were made to port facilities at Windsor, Sarnia, Toronto, Prescott, Burlington (Canada Centre for Inland Waters) and Ogdensburg, New York, to become familiar with typical locations for shore-side facilities.

To understand the quantity and quality of the material to be handled, three reports were reviewed and are cited at the end of this report.

2 BASIC DESIGN CRITERIA AND PHILOSOPHY

2.1 Design Philosophy

To produce general guidelines for future use in the design of shore-side holding tanks at specific locations, certain assumptions must be made concerning the "where, what, why, when, how, etc." of the material to be handled and its eventual discharge after a short sojourn in a shore-side holding tank.

In addition, the degree of sophistication of the shore-side holding tanks will vary considerably and a certain basic design which can be modified or upgraded to easily suit specific situations should be established.

No attempt is made in this report to provide detailed plans or equipment arrangements. The drawings presented only illustrate typical arrangements. Each specific location chosen for shore-side holding tanks will require a detailed engineering design for construction, using the elements recommended in this report as they apply to the proposed site and specific situation.

The three sizes of tanks studied in this report are 5,000, 10,000 and 30,000 imperial gallons (22.73, 45.46 and 136.38 m^3).

The main purpose of a shore-side holding tank is to hold sewage discharged from a vessel during times when the municipal collection and treatment facilities can not accommodate a direct discharge from this source. Examples of typical circumstances are:

- Municipal sewers, pumping, and/or treatment facilities may approach overload conditions at peak daytime hours. Transfer of sewage from a holding tank to the municipal facilities would be programmed for off-peak hours.

- Municipal treatment facilities may be incapable of handling concentrated sewage. Transfer of sewage from the holding tank to the municipal facilities would then be regulated to those hours when sufficient dilution is available.
- Smaller municipal systems, due to limitations in organic and/or hydraulic capacity, may be capable of receiving discharge from vessels only at a very low but steady rate.

Other considerations of environmental protection and facility operation are:

- The entire holding tank system should have zero discharge of liquid effluents to the environment.
- There should be a minimum of gaseous emissions (odours) to the environment.
- Holding tanks and ancillary equipment should be suitable for continuous duty during the entire shipping season, March to December, or throughout the year where needed.
- Holding tanks and ancillary equipment should be designed for easy maintenance and for clean-out when needed without discharge of contaminated liquid to the environment.
- The entire system should be under the control of a person or persons trained in sewage handling facilities.
- 100 percent standby capability for all essential mechanical equipment should be provided.
- All holding tank facilities must meet Provincial requirements.

For added flexibility and more absolute environmental protection, a diesel-powered emergency generator for essential electricity supply may be desirable. However, for most locactions, it is not likely that this could be justified in view of the storage time provided in the shore-side holding tanks and the generally short duration of power outages.

Some general considerations regarding siting are:

- The site should be located as close as possible to the water's edge and excessive elevation differences between the water level and the holding tank should be avoided.
- The site should be set safely above the high water levels so that ice damage or flooding will not be a problem.
- The site should be accessible by road under year-round weather conditions.
- The site should be protected as much as possible against tampering and damage by vandals.

2.2 Sewage Characteristics

To determine the basic characteristics of typical influent sewage, a meeting was held with representatives of the Environmental Protection Service, Ministry of Transport, German and Milne, and M.M. Dillon Limited. From this meeting and from referral to the Maritime Research Information Service (1) and a German and Milne report (2) some general characteristics of typical influent sewage and the manner of the delivery etc. were determined.

The data supplied in the Maritime Research Information Service Report suggest the following approximate characteristics.

- volume of body waste per capita per day is .36 Imperial gallons (1.63 liters);

- suspended solids per capita per day is 90 grams; and,
- BOD_5 per capita per day is 68 grams.

From information found in the German and Milne report, the diluent usage is given below. From this and from the above information, sewage strengths were calculated.

Type of Toilets*	Diluent Use* I gal/cap/day	Total Sanitary Flow I gal/cap/day	Strength in mg/1 SS	BOD
Conventional	30 (136.2 1)	30.36 (137.83 1)	653	493
Low Usage (vacuum)	2.4 (10.9 1)	2.76 (12.53 1)	7,183	5,427
Recirculating	0.13 (0.6 1)	0.5 (2.27 1)	39,648	29,956

*Assumed that grey water will not be collected in ship's holding tank.

Based on the recommendations of the German and Milne report, only wastes from the conventional type of system should be considered. This system, from a volume point of view, obviously presents the most critical situation as well.

It is concluded also in the German and Milne report that a certain degree of "treatment" or "stabilization" will occur in the shipboard holding tanks. However, for the purposes of this study it is assumed that no stabilization will take place and that the sewage received from vessels will be in the most critical condition i.e. septic. In addition, a pH range of from 3 to 9 is anticipated.

No large solids should be present in the sewage as it is recommended that the shipboard holding facilities will be equipped with a macerator or comminutor unit. In the event that this is not the case, it would be a simple task to add a macerator unit to the shore-side holding tank facilities. The macerator unit (vertical rotating type) could easily be added to the influent line.

2.3 Vessel Discharging

It is assumed that all vessels of significant size will be equipped with an on-board pump for the discharge of sewage to shore-side facilities. The head available at the shore connection should be 30 feet (9.15 m) according to the German and Milne report recommendations. In addition, universally acceptable quick disconnect couplings will be used except in the case of some foreign vessels which require "International" fittings. The recommended maximum sewage off-loading time is 30 minutes. Based on unit volumes generated for a conventional system onboard the vessel, the maximum volume to be handled in this time (30 minutes) will be 12,600 gallons (57.28 m^3), representing a maximum vessel effluent flow rate of 420 Igpm (1909 l/min) for an individual vessel. It is feasible that wastewaters could be discharged from the vessel into a collection system having multiple connections, or transhipped via a barge or portable tanks to the shore-side holding tank, however, the holding tank influent flow rate should not exceed 420 Igpm (1909 l/min).

Problems with topography, crowded port facilities, etc. may be encountered such that the 30 foot (9.15 m) head available at the shore connection would not be sufficient to carry the sewage to the shore-side holding tank. In this case, it will be necessary to provide a simple transfer pumping station of sufficient total dynamic head (TDH) to repump the sewage to the shore-side holding tank. There are other methods of accomplishing this, such as using a vacuum system to augment the on-board pumps and a booster pumping system; however, considering capital and operating costs, simplicity of operation and maintenance requirements, the transfer pumping station is the most feasible and can be easily "tacked on" to the basic shore-side holding tank facility.

2.4 Alternative Facilities

As noted in Section 2.1, a basic facility is proposed which can be readily upgraded to suit specific situations. In addition, two alternative facilities of increasing sophistication are presented as being typical for specific situations. The three alternative facilities are:

Alternative Number 1 is the "basic facility" and comprises the bare essentials of a shore-side holding tank. All operation is manual. This alternative should only be considered for the lightest use locations.

Alternative Number 2 is as Number 1 above plus the necessary system components required to provide automatic control and improved environmental protection except for gaseous emissions.

Alternative Number 3 is the facility which will most likely be required for busy ports adjacent to heavily populated areas. This alternative provides the highest standard of environmental protection and includes all the system components discussed in Section 3 of this report.

3 DISCUSSION OF SYSTEM COMPONENTS

3.1 Holding Tanks

As noted in Section 2.2, sewage with a pH ranging from 3 to 9 is anticipated, therefore corrosion protection must be provided. Thus, the following materials of construction for tanks were investigated:

- reinforced concrete;
- coal tar epoxy lined steel;
- fiberglass reinforced plastic (FRP); and,
- steel cable reinforced (exterior to tank) plastic.

For the three tank capacities studied, single tanks are preferred to multiple tanks because of economies in tank fabrication, cold weather protection and ancillary systems, valves and piping. Multiple tanks do present the advantage of an increased level of facility reliability, i.e. if a single tank failure occurs the facility can still function. However, this must be considered in light of the low probability of a failure of the type of tanks being considered. The advantage of multiple tanks over a single tank is, therefore, of little overall importance.

The most economical material and configuration for each tank size were investigated. The costs for various materials and possible configurations were studied and are summarized as follows:

Tank Volume (I. gal.)	Reinforced* Concrete	Coal Tar Expoxy Lined Steel	FRP	Steel Reinforced FRP
5,000 (22.73 m^3)	VC,R	HC,VC,R,S	HC,VC,R	HC,VC
10,000 (45.46 m^3)	VC,R	HC,VC,R,S	HC,VC,R	HC,VC
30,000 (136.38 m^3)	VC,R	VC,S	VC	VC

*Two cases studied - in-ground and above-ground.

HC=Horizontal Cylindrical VC=Vertical Cylindrical

R=Rectangular S=Spherical

Desirable freeboard, dimensions and wall thicknesses were selected for each material and shape and the approximate cost of each alternative was determined. For steel and plastic tanks, inquiries were sent to several fabricators to determine an average cost for comparison purposes. To ensure realistic prices, tanks were priced on the basis of compliance with accepted codes in the respective industry, i.e. steel tanks in accordance with API and DBIU Codes; concrete tanks in accordance with NBC Code (1970); and, FRP tanks in accordance with CGSB Code. The summary of prices noted in Table 1 include a foundation (where required), corrosion protection, insulation (for above-ground tanks), and provide a totally covered tank.

In all cases the vertical cylindrical configuration was the most economical and is the type costed in Table 1.

As can be seen from Table 1, estimated costs for steel and both above-ground concrete and in-ground concrete tanks are very close. Thus, each system would have to be priced for each location contemplated. For example, high groundwater in a certain location may preclude the consideration of an in-ground tank. In another area, the cost of supplying ready-mix concrete could be excessively high and the only feasible alternative might be a prefabricated steel tank.

The basic conclusions that can be derived from the cost comparisons are that:

- The vertical cyclindrical tanks are the preferred configuration.
- FRP and Steel Cable Reinforced FRP tanks are not competitive with the epoxy lined carbon steel or concrete tanks for this application.
- Detailed cost comparisons for each individual site will have to be carried out before a choice is made between the three competitive alternatives.

TABLE 1. SUMMARY OF ESTIMATED TANK COSTS BASED ON A VERTICAL CYLINDRICAL CONFIGURATION

Tank Material And Volume	Tank	Foundation	Excavation	Corrosion Protection	Painting & Insulation	Total
Steel						
5,000 (22.73 m^3)	$ 2,000	$ 400	$ 100	$ 650	$2,150	$ 5,300
10,000 (45.46 m^3)	3,000	600	150	1,000	3,300	8,050
30,000 (136.38 m^3)	10,000	1,600	400	2,200	7,200	21,400
Concrete (Above Ground)						
5,000 (22.73 m^3)	$ 2,600	$ 100	$ 100	-	$1,500	$ 4,300
10,000 (45.46 m^3)	4,200	150	150	-	2,300	6,800
30,000 (136.38 m^3)	8,400	400	400	-	5,000	14,200
Concrete (In-Ground)						
5,000 (22.73 m^3)	$ 2,600	$ 100	$ 550	-	-	$ 3,250
10,000 (45.46 m^3)	5,200	150	1,000	-	-	6,350
30,000 (136.38 m^3)	15,500	400	2,000	-	-	18,100
FRP						
5,000 (22.73 m^3)	$ 6,900	$ 400	$ 100	-	$1,500	$ 8,900
10,000 (45.46 m^3)	8,600	600	150	-	2,300	11,650
30,000 136.38 m^3)	29,000	1,600	400	-	5,000	36,000
Steele Cable Reinforced FRP						
5,000 (22.73 m^3)	$ 3,600	$ 400	$ 100	-	$1,500	$ 5,600
10,000 (45.46 m^3)	5,500	600	150	-	2,300	8,550
30,000 (136.38 m^3)	22,500	1,600	400	-	5,000	29,500

For estimating purposes:
5,000 I gal (22.73 m^3) $ 5,500
10,000 I gal (45.46 m^3) $ 8,500
30,000 I gal (136.38 m^3) $22,000

In the following discussions on system components consideration will be given as to applicability to both in-ground and above-ground tanks. A typical above-ground tank is shown in Figure 1.

3.2 Tank Foundations

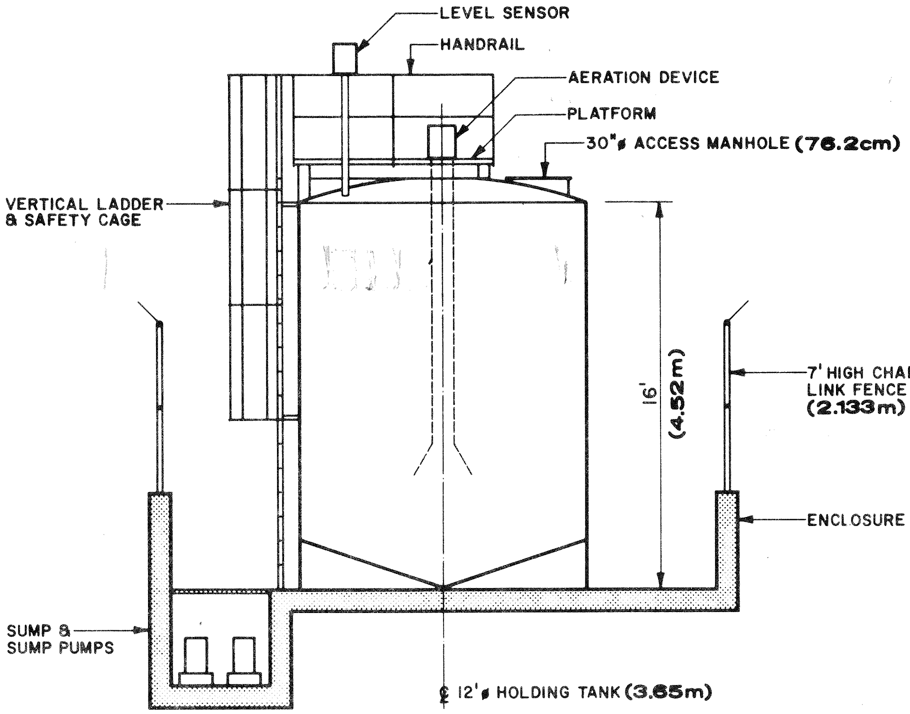
The foundation for any given installation will be dictated by the soil conditions, groundwater level, and topography of the particular site. For comparison purposes in Table 1 a nine-inch thick slab on grade was assumed with an 18-inch (45.5 cm) granular base in excavated soil. Depending on actual site conditions, certain locations could require expensive piled foundations.

3.3 Aeration System

The aeration system recommended is intended to prevent significant odour problems from occurring, solids from depositing on the bottom of the tank, and the formation of explosive and hazardous gases. In accomplishing the above objectives the aeration system will also provide a certain degree of treatment for the wastes received from the vessels.

Two basic types of aeration devices are available; they are generally categorized as mechanical aerators or diffused airsystems. For this application, a diffused air system is recommended because:

- better mixing and oxygen transfer occurs (for the tank sizes considered);
- no structural supports need be added to the tanks as for mechanical aerators;
- the level of liquid in the tank is variable (the mechanical aerator would have to be of the floating type which would be unsuitable for use in a closed tank); and,
- the heating and connection effect of the compressed air should be sufficient to obviate



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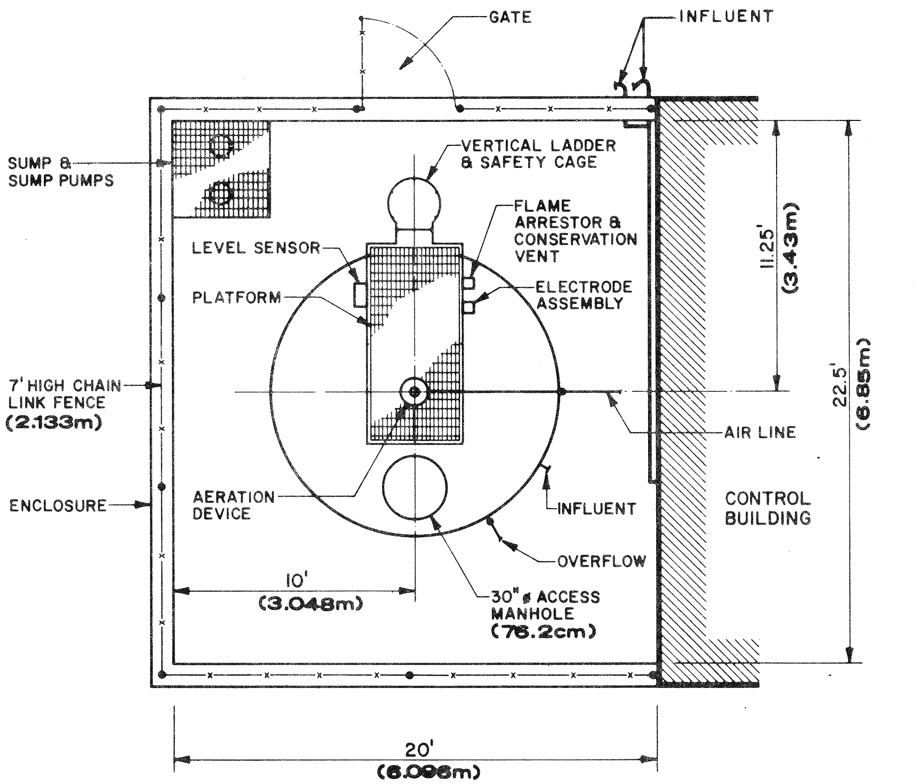


PLAN

SCALE: 1/8" = 1'-0"
(0.3175cm = 30.48cm)

TYPICAL
HOLDING TANK
ALTERNATIVE No. 3

fig 1

the need to heat the tank (if above ground,
tank would require insulation only).

There are many methods of introducing air into the tank and many manufacturers with "off-the-shelf" designs and equipment. There is no need to be specific about the diffuser system. However, the system adopted should be simple and easily removable from a full tank.

The excess air emanating from the liquid surface of the aeration device should be discharged to the atmosphere through a proper venting system. However, it can be retained in the closed tank space above the liquid and drawn off for recirculation.

If air recirculation is being practised, a moisture trap of the impingement type is required in the blower recirculating suction line to prevent liquid from damaging the blower*. Since the recirculative system cannot be totally closed, small volumes of make-up air will have to be supplied. A separate blower is proposed for make-up air.

The blowers should be installed in a building for noise attenuation and should be of the rotary positive displacement type due to the varying liquid levels which will be encountered. Air requirements to provide complete mixing of a full tank have been calculated and are as follows:

RECIRCULATING AIR

Tank Size I gal (m^3)	Air Requirement $ft^3/min(m^3/min)$	Blower hp(kw)
5,000 (22.73)	55 (1.55)	5 (3.73)
10,000 (45.46)	110 (3.11)	7-1/2 (5.6)
30,000 (136.38)	330 (9.33)	20 (14.9)

* "compressor" may be used interchangeably with "blower" in the shipping industry.

The blower supplying make-up air should have an output of from 1.5 ft^3/min (0.042 m^3/min) for the smaller tank to 10 ft^3/min (0.28 m^3/min) for the larger tank. The HP required will be in the 1 to 2 range. The discharge pressure will naturally have to be compatible with the main blower.

Air piping fittings and aeration devices in the tank should be corrosion resistant. Connections should be welded and flanged.

3.4 Odour Control

For the purpose of designing for the extreme case, the sewage discharged from vessel holding tanks is assumed to be septic and at a temperature of 70°F to 80°F (21°C to 27°C) (during summer shipping season) as per Section 2.2. This presents the worst condition for specifying odour control requirements.

Under septic conditions the strength and oxygen demand could be at least three times that of normal fresh domestic sewage and the dissolved oxygen content could be zero.

Shore-side holding tanks will likely collect and retain sewage throughout the day for discharge to a municipal sewer system at night. Thus, it is not unreasonable to assume that the tanks would be required to retain sewage from between 16 hours (normal daily operation) to three days (during weekends, holidays, etc.).

Under these conditions, sewage, even if received in a "fresh" state and not aerated, will turn septic (anaerobic) in the shore-side holding tanks, and hazardous and explosive gas mixtures (e.g. methane) which are extremely odourous would be generated. These odours would not be tolerated in populated areas.

Absolute elimination of odours from any tank is extremely difficult. Whenever a tank is filled, vapour above the liquid will be displaced to the atmosphere. To totally remove odours from such vapour would require a complex system such as scrubbing, charcoal absorption, condensation or oxidation using such chemicals as hypochlorite, permanganate, chlorine or ozone, all of which could lead to further pollution problems (e.g. spent scrubber water) and which are extremely costly to build and operate.

Minimizing the possible odour problem without using a costly absolute elimination system can be achieved with varying degrees of success by using:

odour control chemicals;
aeration systems;
covered tanks;
recirculative diffused air systems.

Odour control chemicals operate either as odour masking compounds (e.g. the odour of the control chemical blocks out the sewage odour at the olfactory nerves) or as biological inhibitors which prevent bacterial action from producing odourous compounds. Often, with some commercial odour control chemicals, both reactions occur simultaneously.

A report entitled "An Assessment of Odour Control Chemicals for Use in Marine Holding Tanks and Toilets" was recently prepared for the Department of the Environment (3). In this study, nineteen commercially available odour control chemicals were investigated and the conclusions were as follows:

1. Only five of the products tested produced acceptable odour control.
2. The most effective odour control chemical tested was a product which costs 8.25 cents per gallon (4.546 l) of sewage treated at the dosage required.
3. For the other acceptable odour control chemicals, the cost ranged to a maximum of 21.25 cents per gallon (4.546 l) of sewage treated at the dosage required.

4. All of the effective odour control chemicals have a deleterious effect on biological treatment processes if discharged in sufficient quantities. Shock loading of these chemicals to a municipal treatment plant could adversely affect the biological activity and sludge settling characteristics. The plant effluent may also be distinctly discoloured.
5. All of the chemical studied contained highly toxic compounds requiring special handling precautions.

From the conclusions above, it is apparent that odours emanating from shore-side holding tanks could not feasibly be controlled by the use of odour control chemicals. The only value of these chemicals is as a masking agent intended for occasional use only. Potential odours from shore-side holding tanks should therefore be controlled by other means.

For Alternatives No. 1 and 2 odour control requirements should be limited to covering the holding tank and providing aeration of the tank contents, thus inhibiting dispersal and preventing odour formation by keeping the sewage in a relatively aerobic condition. For more critical locations (Alternative 3) the use of a recirculative diffused air aeration system will probably be necessary. It may even be necessary, in very unusual cases, to "treat" the minimal volumes of air which do escape utilizing, at relatively high cost, one of the methods noted in this Section.

3.5 Venting and Explosion Prevention

Normally, the contents of the shore-side holding tank will be maintained in a well aerated state. However, the possibility does exist that a sudden shock or upset could cause anaerobic conditions to persist in the tank, with the associated production of explosive gas mixtures containing methane.

Since the closed tank recommended must be vented to allow for "breathing" during filling and emptying, caution must be taken to prevent the possibility of flame propagation through the vent.

A combination flame arrestor and conservation vent such as the type used on petroleum storage tanks or sewage plant digestors is recommended. This device automatically admits air when the liquid level falls in the tank (during pump out) and expels air during filling or displacement due to makeup air. The pressure setting should be $\pm$ 8 oz per square inch (35 gm/cm^2).

The device should be sized so as to pass a volume of air equivalent to the volumetric pumping rate for filling or emptying, whichever is greater. This device would have to be insulated and possibly heated, depending on local climatic conditions, to prevent freezing in cold weather.

The device is relatively simple, small and inexpensive and is recommended for installation on all Alternatives.

3.6 Tank Overflow

With the use of the conservation vent and flame arrestor, the tank must be provided with a trapped overflow pipe to accommodate accidental overfilling of the tank with sewage. The overflow should be sized to handle the maximum influent rate. The trap using a liquid seal (water) must provide for an internal pressure of about 12 inches (30.5 cm). Considering freeboard etc., the water height should be 15-18 inches (38 - 46 cm).

3.7 Site Protection and Dyking

The entire site may be fenced using a security type chain-link fence and a lockable double gate; or the control building only may be made vandal proof and secure giving a site which will be much more aesthetically pleasing. The immediate area around the tank will have to be fenced (7 foot [2.13 m] chain link) to prevent public access.

Since shore-side holding tanks will normallly be located adjacent to the water's edge, dyking must be provided around the tank for the purpose of:

- retaining tank overflows; and,
- retaining the entire contents of the tank should a failure or leak develop in the tank shell or piping connections (only in the case of above ground tanks).

Dykes should be constructed of reinforced concrete. The height of the dyke will be determined by the amount of liquid to be held plus a nominal allowance of 6 inches (15 cm) for freeboard. In the case of in-ground tanks, a dyked enclosure around the top of the tanks should provide for retaining an overflow volume equivalent to the maximum influent rate for a nominal 15 minutes.

A sump and sump pump could be provided within the dyked enclosure, however, this is not felt to be necessary for any but the most critical location (Alternative 3). If provided, the sump pump should be a small submersible or wet pit type and rated nominally at 50 Igpm (227.3 l/min). In some locations it may be possible to connect the sump directly to a nearby sanitary drain.

3.8 Maintenance, Access and Cleanout

All equipment within the tank must be installed so that it can be removed for maintenance. The only time the tank should be entered, except for emergency situations, would be during the annual inspection and clean out. This would normally be done in winter during the off-season.

The tank could be emptied normally. A manway on the side (for the larger above-ground tanks) or in the top (for the small above-ground tanks and all in-ground tanks) should be provided for access. Water from either a municipal system (if convenient) or pumped from a nearby water body could be used with jet type nozzles for washing.

The wash water collected should be pumped to the municipal sewage system in the normal manner or it could be pumped to a tank truck.

Before entering, the tank must be well ventilated and workmen must don protective clothing. Grit and debris, which can not be flushed out, will have to be manually removed and hauled away for disposal on a landfill site.

Access to the top of the larger above-ground tanks (for servicing the vent and flame arrestor, etc.) should be provided via a platform with handrails and a vertical ladder with approved safety cage.

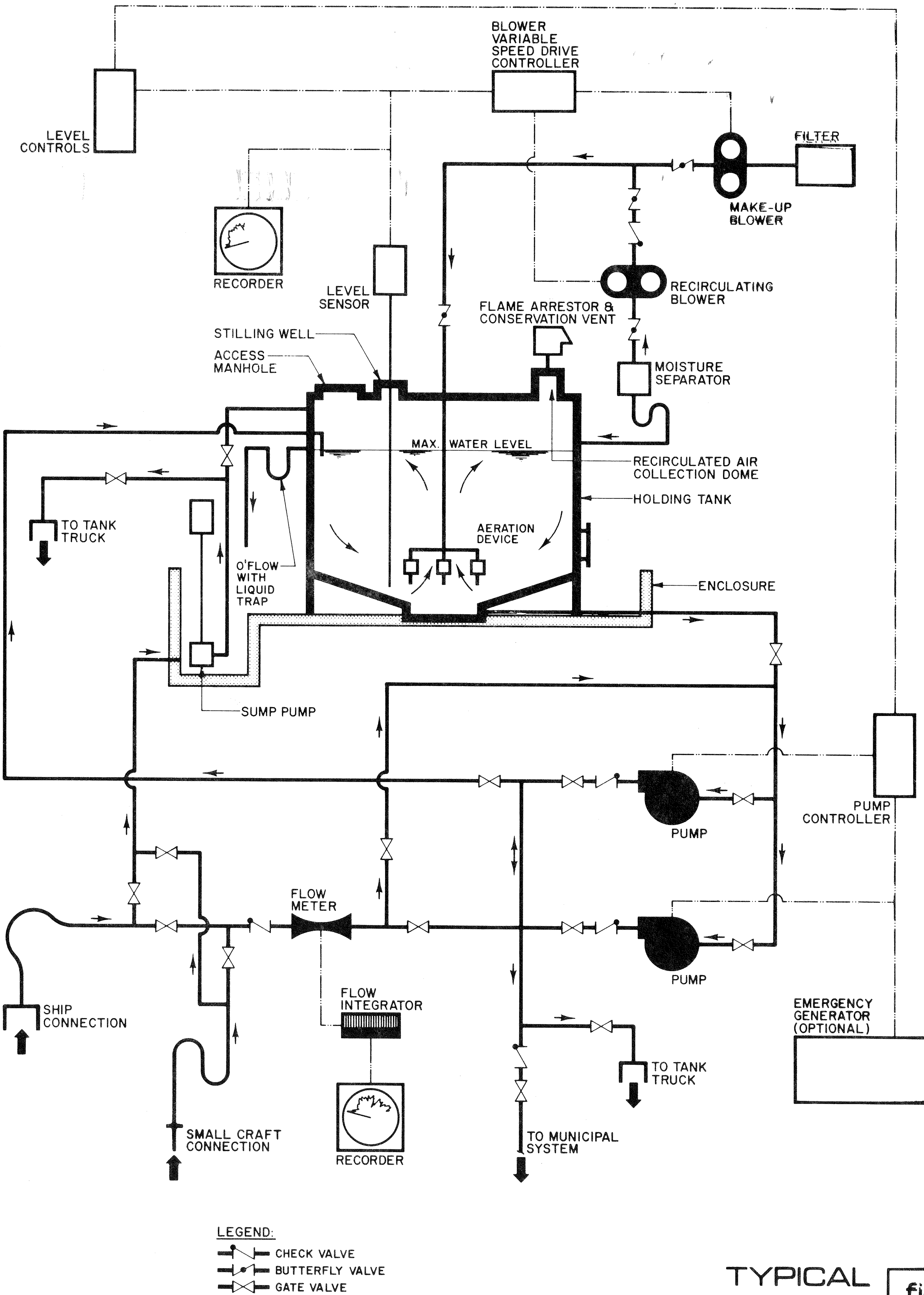
3.9 Influent and Effluent Piping

The influent and effluent piping for all sizes of shore-side holding tanks should be Schedule 40 galvanized iron with threaded or flanged connections, depending on the pipe size.

The minimum influent or suction diameter should be 4 inches (10 cm) to prevent plugging due to grease build up, large solids, hair etc. For ease of installation and economy, the underground portion of the forcemain from the shore-side holding tank to the municipal sewer system (manhole) should be welded polyethylene pipe rated for the pressure conditions particular to each individual system. Other types of pipe such as asbestos cement, ductile iron etc. are also acceptable. Depth of bury of forcemain should be as required for protection against freezing in the locale, but should be a minimum of 5 feet (1.52 m).

Valves and fittings should be in accordance with American Water Works Association (AWWA) Specifications. A typical piping arrangement is shown in schematic in Figure 2. It shows alternative pumping as follows:

- pumping direct from ship to tank
- pumping direct from ship to tank truck
- pumping out tank to municipal system
- pumping out tank to tank truck



TYPICAL FLOW SCHEMATIC ALTERNATIVE No. 3

fig. 2

3.10 Sewage Transfer Device

It is proposed that sewage be transferred from the ships to the shore-side holding tanks with the use of a 4" (10 cm) diameter marine loading arm. The loading arm would be positioned no closer than ten feet (3 m) from the edge of the pier and would be connectedat its base to the permanent shore-side piping. The loading arm, equipped with three swivel joints and counter-balanced, will accommodate the different sizes and heights of ships as well as movement of the ships. The outboard end of the loading arm will be equipped with a quick disconnect coupler and a ball valve requiring only 1/4 turn for full open or full closed. The standard international ship-to-shore flanged connection should also be available for use by foreign ships. This connection should be designed so it can be easily attached to the quick disconnect coupler.

For small craft, an additional 2" (5 cm) diameter marine loading arm equipped as above should be provided. The terminal end of the loading arm will have to be reduced to 1 1/2" (3.8 cm) diameter to accommodate the small craft fittings.

The horizontal reach provided by the 4" (10 cm) loading arm should be fifty feet (15.25 m). The 2" (5 cm) loading arm should have a horizontal reach of thirty feet (9.15 m).

After each use the loading arm will be extended to full length and drained to the holding tank sump. A valve on the shore-side piping will be provided for this purpose. This valve will be located immediately upstream of the main shore pipe shut-off valve.

3.11 Pumping Systems

From information supplied by German and Milne regarding shipboard holding tanks, the shipboard pump should be sized so that the pump-off time to the shore-side facilities is a minimum. It is assumed that this will be no more than 30 minutes.

If shore-side influent pumps are necessary, they must either be sized equal to the influent rate or installed in a wet well which provides very short term storage and thus allows the use of smaller pumps. Because of the critical nature of the shore-side pump, a duplex pumping installation (one normal duty pump and one 100% standby pump) is recommended so that in case of pump or motor failure the off-loading procedure will not be unduly delayed.

The shore-side pumps should be iron construction, self-priming, sewage-type, non-clog vertical centrifugal pumps. Based on the 30 minute pumping duration and the maximum sized vessel holding tank (12,600 gallons, 57.28 m^3) (2), the maximum pump capacity required is 420 Igpm (1909 l/min). This, of course, is only feasible for use on the 30,000 gallon (136.37 m^3) installations and the smaller capacity tanks will naturally require smaller capacity shore-side pumps. The total dynamic head on the pumps will have to be determined for each particular site.

If shore-side pumps are necessary it is suggested that, if at all possible, the shore-side holding tank be placed in such a location that discharge from the tank to a municipal sewer may be by gravity. If this is not possible, then a separate pumping system for discharge to the municipal sewer will be necessary. It is not envisaged that the two pumping systems should be integrated. For the purposes of the estimates in Section 5 it is assumed that all alternatives will require a discharge pumping station. The shore-side pumps will be shown as a separate item, as they will not be necessary for the typical installation. The actual capacity of the municipal sewer would have to be checked at each location and the discharge pumps selected to suit, if necessary. Again, a duplex pumping installation is necessary and pump construction would be the same as for the shore-side pumps, except that it may be feasible to utilize a horizontal pump as well.

3.12 Instrumentation and Controls

a) Air Blower Control

The blower will be constant speed, and will operate continuously as long as the tank level is above the low level cut-off point. If levels fall below this point the blowers will be shut off automatically. A hand-off-automatic switch (HOA) is required, mounted on the motor control centre. A local push button station may be located at the unit itself to facilitate operation.

b) Pump Control

As noted previously, the shore-side holding tanks will likely be emptied during the night when conditions in the municipal collection and treatment system are more favourable for receiving the sewage. Pump start-up at a designated time will be by an automatic level control system activated by a timer. The pump must be equiped with an HOA switch.

Shore-side or influent pumps can be operated automatically by a level control system; however, to ensure supervised off-loading of a vessel, manual controls are suggested. This also ensures that the shore-side holding tanks are not accidentally overfilled. If automatic control is required later it can be added very simply provided that the pumps are equipped initially with an HOA switch with the "A" function not connected.

c) Level Control System

The level controls in the tank should be the bubbler type with a self-contained compressor. This device would produce a continuous proportional signal to a recorder with 7-day circular chart which produces a permanent record of tank levels, and thus fill and drain operations. There would also be a pressure actuated switching point for activating a high level alarm.

This point would be set slightly below the maximum water level.

If a record of tank transfers is not required, displacement type level switches (float switches) may be used in place of the bubbler system for the pump control and alarm functions.

d) <u>Alarm Systems</u>

An alarm system would be connected to a convenient location such as a police station, fire hall, harbour masters office, telephone answering service etc. The system would also have a visual and audible signal at the shore-side holding tank. The alarm would monitor high tank level and power failure only.

e) <u>Flow Measurement</u>

For shore-side holding tanks, flow information is not required for operation or process reasons. It may, however, be required for billing purposes and/or for statistical data.

Several methods are available for collecting flow information. For a basic facility (Alternative No. 1) volumes could be determined with acceptable accuracy from the recorder on the level control system. The most sophisticated method of obtaining the data is by passing the flows to be measured through some type of measuring device. For this purpose magnetic flow meters are most suitable. A meter would be necessary on the influent line but may only be desirable on the discharge to the municipal system. Another method of determining flows is by using timers on pumps through which the flow passes. The accuracy of this method depends almost entirely on the pump curve, with a "flat" curve producing the least accurate flow data. Accuracy closer than ± 15% cannot generally be expected.

In the selection of flow measuring systems, simplicity is the prime consideration. But regardless of the system selected, consistent and accurate records should be maintained.

3.13 Cold Weather Protection

If the facilities are to be operated in freezing weather and since the typical operation is intermittent and not continuous (thus aggravating freezing problems) all exterior sewage piping as well as the flame arrestor, conservation vent and tank overflow should be electrically heat traced. The heating cable should be thermostatically controlled. No heat is required for the tank since the aeration system will supply sufficient heat and turbulence to prevent freezing.

Fiberglass low temperature semi-rigid insulation should be used for all outdoor piping and thin shelled, aboveground holding tanks. A vapour barrier and waterproof outer cover (aluminum or sheet metal) should be provided for all insulation. Additionally, all piping should be laid so that it is self-draining.

3.14 Corrosion Protection

(a) Tanks

If concrete tanks are used, no corrosion protection is necessary. If steel tanks are used, a corrosion-resistant coating must be installed on all interior surfaces. A three-coat high-build coal tar epoxy coating system should be field installed on the steel. Surface preparation should be in accordance with Structural Steel Painting Council Specification No. SSPC SP-10 Near-White Standard. Finished dry film thickness should be 18 to 21 mils (0.45 to 0.53 mm). The vapour barriers and insulation proposed for the tank exterior should be sufficient to arrest corrosion, however, it may be advisable as an added precaution to paint the exterior of the tank. A three-coat (3 mils [0.07 mm] each) cold cured, high gloss epoxy polyamine coating system be field installed. Surface preparation should be in accordance with SSPC-SP6 commercial sand blast.

(b) Equipment

Equipment inside holding tanks should be constructed of American Iron and Steel (AISI) Type 316 Stainless steel. Pumps and blowers should be all-iron construction. Flame arrestor and conservation vents should be equipped with stainless steel internals.

(c) Piping

Air piping should be steel or aluminum. Isolating gaskets and washers may have to be used to prevent electrolytic corrosion. Sewage piping should be galvanized iron up to the connection of the underground forcemain which should be welded polyethylene construction.

3.15 Electrical and Power Supply Systems

Each shore-side holding tank installation will require a three-phase power supply. The blower and pump motors will require 600 volt, 3 phase, 60 hertz power, while 110 volt, single phase, 60 hertz power will be required for heating cables, instrumentation, alarms and lighting, etc. Depending upon the distance from the power supply to the site, a small substation may have to be installed on the site.

Based on a preliminary motor sizing, and allowing for spare capacity, the power supply for the three sizes of facilities studied in this report would be as follows:

Size of Holding Tank (I gal)	Electrical Power Supply (KVA)
5,000 (22,73 m^3)	50
10,000 (45.46 m^3)	75
30,000 (136.37 m^3)	150

Electrical switch gear, metering, magnetic starters and single-phase power panels should be located in a motor control centre housed in a control building.

The only motors that require local push buttons are the shore-side pumps. All other motors could have stop-start functions initiated from the magnetic starts in the motor control centre.

Some locations may be critical enough (e.g. at high volume ports) to warrant the installation of an emergency diesel powered generator unit to power pumps, etc. in case of a power failure. For the three tank sizes considered, the following would be the approximate requirements for an emergency generator system:

Tank Size (I gal) (m^3)	Standby Capacity (k.w.)	Engine (h.p.)	Fuel Consumption (g.p.h.) (1/hr)	Fuel Storage (I gal)
5,000	30	52	19	250
(22.73)		(38.7 kw)	(86.4)	(1137 1)
10,000	45	70	32	500
(45.46)		(52.2 kw)	(145.5)	(2274 1)
30,000	60	96	43	500
(136.37)		(71.5 kw)	(195.5)	(2274 1)

3.16 Control Building

A control building should be provided at each site. The control building (which can be of economical construction such as concrete block or prefabricated metal constructed on a slab-on-grade) is required for housing the following facilities:

- motor control centre and the instrumentation devices such as flow recorders, etc.;
- air blowers;
- the emergency generator (optional Alternative No. 3 only); and,
- administration and convenience facilities.

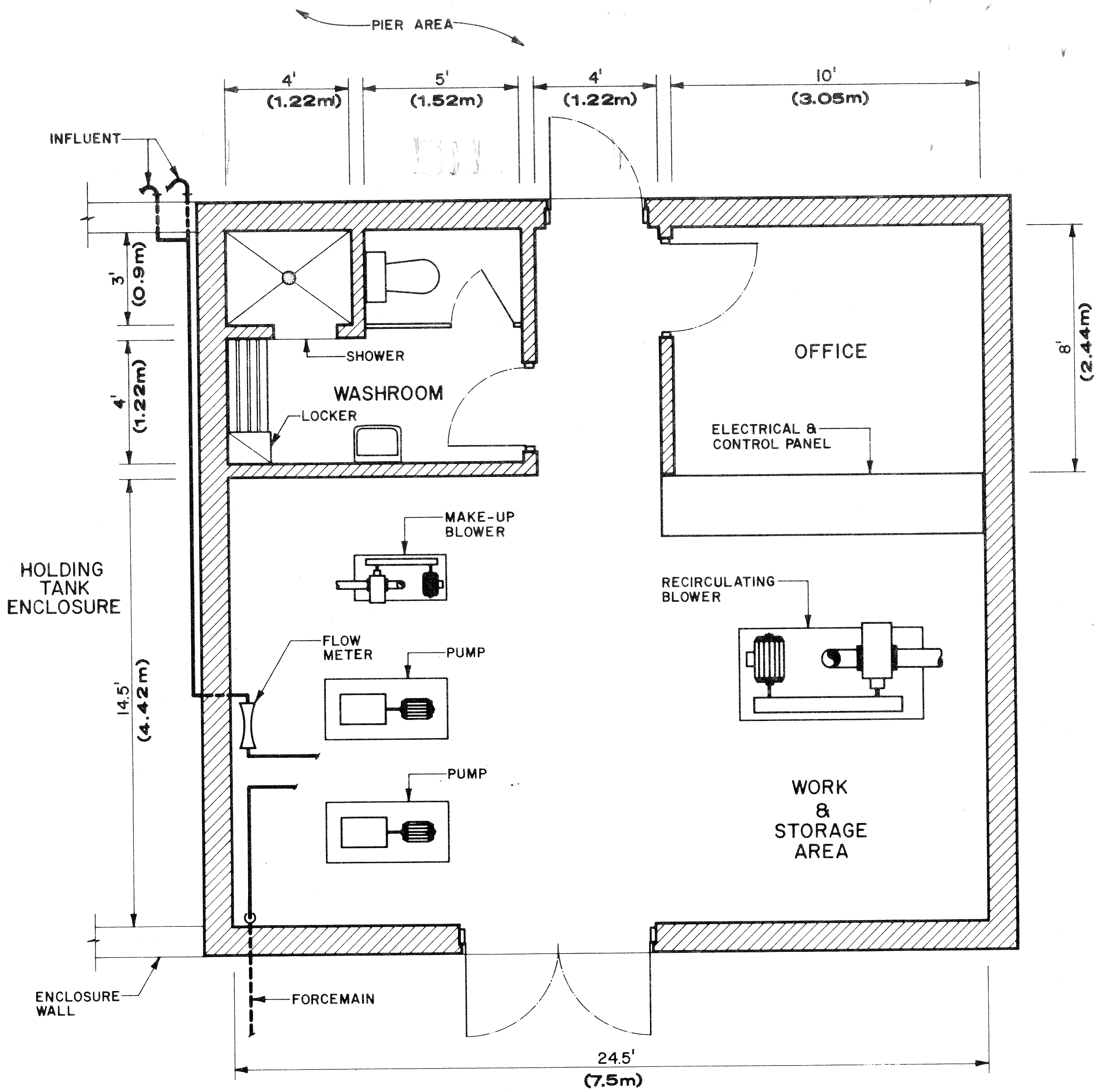
The administration and convenience facilities should include a toilet, a sink, a shower and a clothes locker. A desk and chair should be provided so that the operator can fill out the required forms for maintaining proper records. A telephone should be provided and possibly a ship-to-shore communication system for use in the larger, busier locations.

A small work and storage area is also recommended for the control building.

A typical layout for the control building is shown in Figure 3. Exterior architecture can be added to please local tastes.

3.17 Site Services

The site should be provided with at least a good quality gravel road capable of handling Roads Transportation Association of Canada (RTAC) Class WB40 semi-trailer tank trucks. This is totally sufficient for the basic facility; however, for Alternative No. 3 a parking area of similar quality capable of accommodating three cars should be provided. If the access road is of a length that would make reversing a semi-trailer from the main road impractical, a separate turning space should be provided as well.



SCALE: 3/16" = 1'-0"
(0.476cm = 30.48cm)

TYPICAL
CONTROL BUILDING PLAN
ALTERNATIVE No. 3

fig. 3

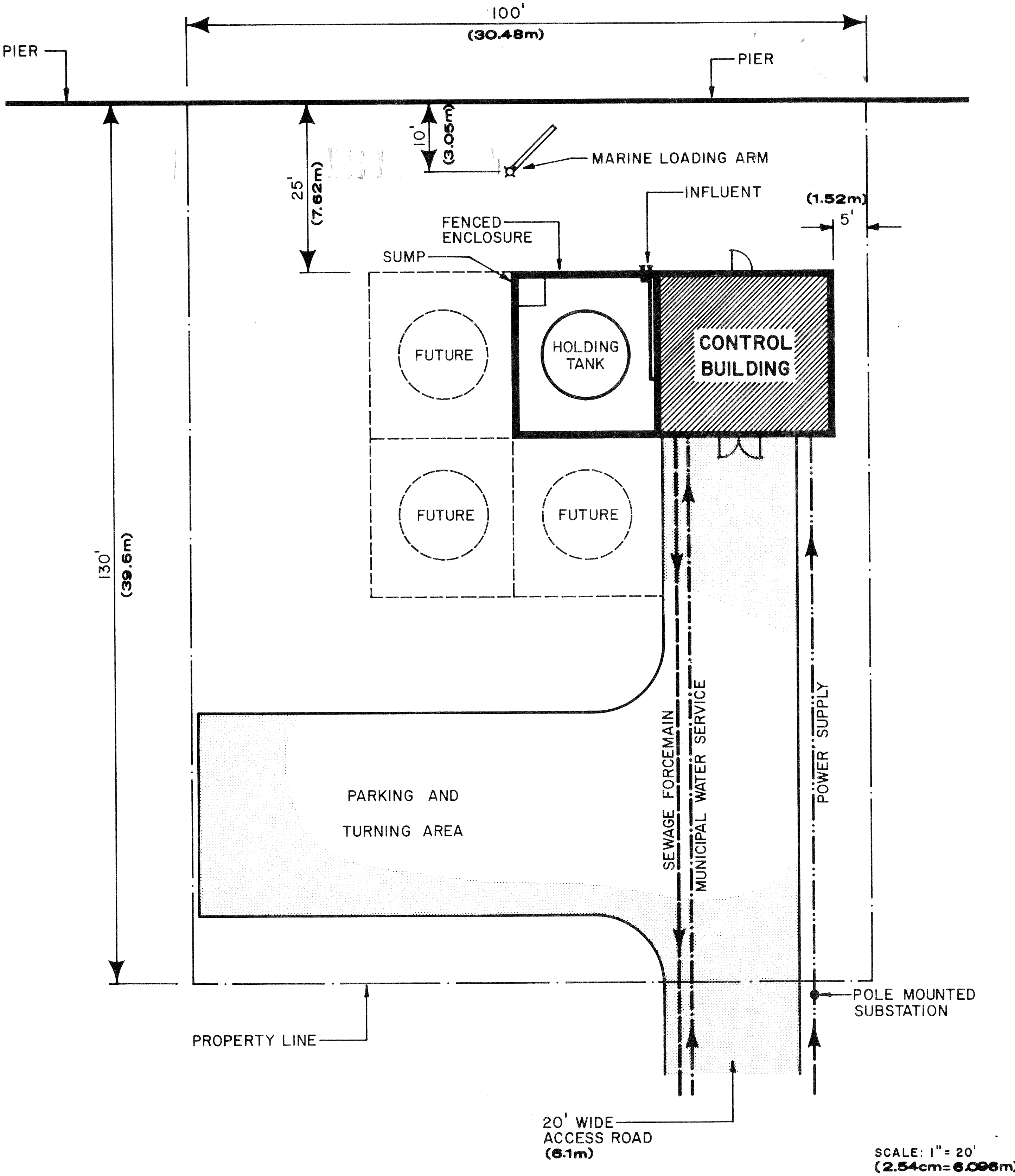
Potable water can be supplied from a municipality if convenient or hauled in by a tank truck. An individual supply using the adjacent water body as a source is not recommended.

Site drainage should present no problems because of the likely close proximity of a suitable gravity outlet. For economy, overland storm drainage should be used instead of sewers, catch basins, etc.

Sanitary waste from the control building should be pumped or run by gravity (for in-ground tanks) to the holding tank.

Suitably sized and placed bollards will be necessary, as part of the pier facilities.

A typical site plan is shown in Figure 4.



TYPICAL SITE PLAN
ALTERNATIVE No. 3

fig. 4

4 OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operating Staff

During the shipping season, the shore-side holding tank facilities will require operator attention in proportion to the number of ships using the facilities. Alternative No. 1, with much of the operating being manual, should be used only in the lightly used ports. Eight hour per day operation, 7 days per week is proposed. The Alternative No. 1 facility would not be operated during the winter months. Alternative No. 2, being more sophisticated and providing a higher degree of environmental protection, should be used in the busier ports and should require 24 hour supervision, 7 days per week, at least during the busy season. The Alternative No. 3 facility should be used in the busiest ports and should be provided with 24 hour supervision, 7 days per week on a year-round basis.

The operator should be experienced in the operation of mechanical and electrical equipment such as pumps, valves, starters and motors, etc. and would preferably have prior experience in the operation of equipment similar to that proposed herein. The use of municipal or other government employees with capabilities in related areas (e.g. sewage systems etc.) could also be considered.

As well as looking after the day-to-day pumping of sewage from ships, the operator would be called upon to do the routine maintenance such as lubrication of equipment, and also much of the major equipment repairs and overhauls. Outside mechanical, electrical or machine shop contractors may also be hired on an as required basis.

4.2 Normal Operation of Proposed System

The following description applies to Alternative No. 3 as described in Section 2.4 because it is the most complex. A typical shore-side holding system as shown in Figures 1 and 2 is assumed.

4.2.1 Pump-off vessel

The operator receives communication that vessel "X" wishes to discharge sewage from its holding tank. The operator checks the status of the shore-side facilities and informs vessel "X" in the affirmative (it is assumed). Flow measurement procedures are commenced if necessary and the appropriate valving arrangement is set.

The operator maneuvers the marine loading arm to the ship's pump out station discharge connection and the crew makes the connection. A ball valve on the end of the loading arm is opened by the crew and pumping to the holding tank or shore-side pumping station is assumed. If a shore-side pumping station is in use, the operator manually starts one of the pumps to relay the sewage received from the vessel to the shore-side holding tank.

When the ship's tank is empty and has been properly purged, the crew will shut off the ball valve. The operator will remove the loading arm and place it in an elongated position. The main shut-off valve will be closed, the drain valve will be opened and any liquid remaining in the loading arm drained to the adjacent sump and thence pumped automatically to the holding tank. Flow measurement procedures are then completed and the ship billed for the amount of sewage pumped off.

In some locations it may be possible to drain the loading arm into the shore-side pumping station wet well. Also it could even be possible in some situations to have the shore pumps provide "suck-back" duty for the loading arm, thus negating the drainage requirement. Pumping from the ship to a tank truck or directly to the municipal system will be accomplished as above but with a different valving arrangement.

4.2.2 Aeration system

The air blower or blowers will run continuously assuming the level in the tank is above a certain minimum. If the tank level is below the low level cut-off point a relay will be activated to open the control circuit for the blowers and shut them off. If the level rises above this low level cut-off point the control circuit will be closed and the blowers will start automatically.

4.2.3 Pump-out tank to municipality

As noted in Section 3.11 (b), pumping to a municipal sewage system will be controlled automatically, with initiation of the pumping sequence being provided by a pump control timer. The timer will have been pre-set to the time period for discharging to the municipal system. Readings for flow measuring purposes will also be taken before pumping commences.

The selected pump is started automatically and discharge to the municipal system commences. When the low level in the holding tank is sensed by the level controller in the tank the pump and air blowers are shut down.

The necessary flow measurements are taken and recorded, the discharge pump switched to off on the HOA switch, and the appropriate valves closed, thus ensuring no uncontrolled discharge to the municipal system.

4.3 Normal Maintenance and Cleanout

4.3.1 Regular maintenance

The regular maintenance required for shore-side holding tanks is as follows:

- Lubrication of equipment (greasing, oiling) in accordance with manufacturers' instructions.
- Instrumentation and controls checking and calibration. This should be done on a regular basis in accordance with the manufacturers' instructions. For example, the level control points should be checked once per month against actual tank levels.

- Housekeeping of site and in building.
- Routine painting.

Since the equipment suggested for use for the shore-side facilities would be rated for continuous duty, the regular maintenance suggested above should circumvent equipment failure. If repairs are required during the time that the facilities are in use, the operator, with the assistance of an outside contractor as required, should be capable of returning the equipment to operation with a minimum of delay.

4.3.2 Off-season maintenance

During the off-season equipment overhaul that is required should be carried out. A definite plan of equipment inspection repair and lubrication should be developed prior to the off-season and adhered to. Replacement of small, key parts such as bearings, wearing rings, seals, packing etc. should be done in spite of their condition and particularly if the part is in a position that is not readily accessible.

The holding tank should be entered and flushed and cleaned out as necessary. Caution should be taken to properly protect the personnel undertaking this work by adhering to the proper regulations regarding tank entry and work in a confined space. A fresh air supply may be necessary as may safety harnesses. If the tank is made of steel, care must be taken to avoid damage to the epoxy coating. The cleaning of the tank is definitely a two man job.

5 COST ESTIMATES

5.1 General

Capital and operating costs are presented for the three alternative facilities described in Section 2.4 of this report. The alternative facilities range from the most basic (Alternative No. 1) to the most sophisticated (Alternative No. 3). These estimates do not include such indeterminate items as the cost of an access road, the cost of power transmission to the site, the cost of the forcemain from the site to the closest receiving point in the municipal system, the cost of a municipal water supply to the control building or the cost of land. For preliminary estimating purposes it is suggested that these items be estimated on the basis of the following for any given site:

- Access road: single lane, 18 inches (45.7 cm) of granular material (12 inches, 30.5 cm) sand, 6 inches (15.2 cm) gravel) shaped and graded, estimated at $7 per linear foot (0.3048 m).
- Power transmission: 4160 volts, 3 phase 150 KVA capacity, 4 wire line installed using creosoted jack pine poles spaced at 200 feet (61 m) including insulators, estimated at $4 per linear foot (0.3048 m).
- Transmission forcemain: 4-inch (10 cm) welded polyethylene series 60 installed five feet (1.52 m) below grade in trench, native backfill, estimated at $9 per linear foot (0.3048 m).
- Municipal water service: 1-inch (2.54 cm) copper pipe installed as above estimated at $5 per linear (0.3048 m).
- The land requirement for all tank sizes and alternatives is estimated at about 15,000 square feet (1393 m^3) or 1/3 acre (0.135 hectare). The cost would vary widely from site to site but could

average $4,000. It is quite possible that the land may be owned by the federal, provincial or municipal government.

The cost estimates also do not provide for a pier or pier facilities such as bollards.

5.2 Alternative No. 1 - Estimated Costs

(a) Capital Costs

Item	Holding Tank Size (I gal) 5,000 (22.73 m^3)	10,000 (45.46 m^3)	30,000 (136.37 m^3)
1) Tank - as per Table 1	$5,500	$ 8,500	$22,000
-appurtances	1,000	2,000	2,500
2) Aeration System - standard	8,000	10,000	15,000
3) Site Protection and Dyking	5,000	8,000	19,000
4) Influent and Effluent Piping	3,000	4,000	6,000
5) Pumping Systems	4,500	4,500	6,500
6) Instrumentation and Controls	-	-	-
7) Cold Weather Protection	-	-	-
8) Electrical and Power Supply	5,000	5,000	6,000
9) Control Building	12,500	12,500	12,500
10) Site Services	3,000	3,000	3,000
11) Sewage Transfer Devices	11,500	11,500	11,500
Total Estimated Construction Costs	$59,000	$69,000	$104,000
Engineering and Contingencies (15%)	8,850	10,350	15,600
Estimated Cost of Alternative No. 1	$67,850	$79,350	$119,600
Estimated Cost of Shore-side Pumping Station (if required)	$10,000	$10,000	$12,000

(b) Operating Costs

Item	Holding Tank Size (I gal) 5,000 ($22.73\ m^3$)	10,000 ($45.46\ m^3$)	30,000 ($136.37\ m^3$)
1) Power	600	700	1,600
2) Manpower - assumes 56 hours per week for 8 months	9,700	9,700	9,700
3) Supplies and Maintenance	2,500	3,000	4,000
4) Sundry Items	1,500	1,500	1,500
Estimated Annual Operating Cost for Alternative No. 1	$14,300	$14,900	$16,800

5.3 Alternative No. 2 - Estimated Costs

(a) Capital Costs

Item		Holding Tank Size (I gal)		
		5,000 (22.73 m^3)	10,000 (45.46 m^3)	30,000 (136.37 m^3)
1)	Tank - as per Table 1	$5,500	$ 8,500	$22,000
	-appurtenances	1,000	2,000	2,500
2)	Aeration System - standard	8,000	10,000	15,000
3)	Site Protection and Dyking	5,000	8,000	19,000
4)	Influent and Effluent Piping	3,000	4,000	6,000
5)	Pumping Systems	4,500	4,500	6,500
6)	Instrumentation and Controls	4,000	4,000	4,000
7)	Cold Weather Protection	1,500	1,500	1,700
8)	Electrical and Power Supply Systems	5,000	5,000	6,000
9)	Control Building	12,500	12,500	12,500
10)	Site Services	3,000	3,000	3,000
11)	Sewage Transfer Devices	11,500	11,500	11,500
Total Estimated Construction Costs		$64,500	$74,500	$109,700
Engineering and Contingencies (15%)		9,675	11,175	16,455
Estimated Cost of Alternative No. 2		$74,175	$85,675	$126,155
Estimated Cost of Shore-side		$10,000	$10,000	$12,000

(b) Operating Costs

Item	Holding Tank Size (I gal)		
	5,000 (22.73 m^3)	10,000 (45.46 m^3)	30,000 (136.37 m^3)
1) Power	800	1,000	2,000
2) Manpower - assumes 168 hours per week for 8 months and 56 hours per week for 4 months	34,000	34,000	34,000
3) Supplies and Maintenance	3,000	3,500	4,500
4) Sundry Items	2,000	2,000	2,000
Estimated Annual Operating Cost for Alternative No. 2	$39,800	$40,500	$42,500

5.4 Alternative No. 3 - Estimated Costs

(a) Capital Costs

Item	Holding Tank Size (I gal) 5,000 (22.73 m^3)	10,000 (45.46 m^3)	30,000 (136.37 m^3)
1) Tank - as per Table 1	$5,500	$ 8,500	$22,000
- appurtenances	1,000	2,000	2,500
2) Aeration System - recirculative	11,000	13,000	18,000
3) Site Protection and Dyking	5,000	8,000	19,000
4) Influent and Effluent Piping	3,000	4,000	6,000
5) Pumping Systems	4,500	4,500	6,500
6) Instrumentation and Controls -includes a magnetic meter	10,000	10,000	11,500
7) Cold Weather Protection	1,500	1,500	1,700
8) Electrical and Power Supply -includes standby generator plus provisions for additional equipment noted above	14,000	15,000	17,000
9) Control Building	15,000	15,000	15,000
10) Site Services	5,000	5,000	5,000
11) Sewage Transfer Devices	11,500	11,500	11,500
Total Estimated Construction Costs	$87,000	$98,000	$135,700
Engineering and Contingencies (15%)	13,050	14,700	20,355
Estimated Cost of Alternative No. 3	$100,050	$112,700	$156,055
Estimated Cost of Shore-side Pumping Station (if required)	$10,000	$10,000	$12,000

(b) Operating Costs

Item	Holding Tank Size (I gal) 5,000 ($22.73\ m^3$)	10,000 ($45.46\ m^3$)	30,000 ($136.37\ m^3$)
1) Power	1,000	1,200	2,200
2) Manpower - assumes one man full time but for only 10 months a year	43,700	43,700	43,700
3) Supplies and Maintenance	5,000	5,500	6,500
4) Sundry Items	2,000	2,000	2,000
Estimated Annual Operating Cost for Alternative No. 3	$51,700	$52,400	$54,400

6 CONCLUSIONS

The following conclusions are drawn:

1) Holding tanks should meet the requirements of the provincial regulatory authorities. These requirements are reasonably stringent with respect to prevention of spills, odour control and use of sound sanitary engineering design practise.

2) Each specific location chosen for shore-side holding tanks will require development based on detailed engineering using the guidelines provided in this report.

3) These guidelines depend heavily upon the shipping industry complying with the German and Milne report on "Design Guidelines for Shipboard Holding Tanks" (2). If, through experience, it is found that industry does not comply, then the shore-side holding tank guidelines can be easily adapted to suit the new situations. For instance, maceration of the sewage can easily be undertaken just prior to discharge to the shore-side holding tanks rather than on board as recommended.

4) The shore-side holding tanks should be located as close to the wharf edge as possible and excessive differences in elevation between the water and the shore-side holding tank should be avoided.

5) In selecting the degree of sophistication for a specific shore-side holding tank, simplicity, ease of operation and safety should receive high priority.

6) Operation of a shore-side holding tank should be undertaken by someone versed and experienced in sewage handling equipment.

7) Finally, in view of the relatively high capital and operating costs for shore-side holding tanks, it is recommended that where practicable vessels discharge directly to municipal sewage systems.

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- Mr. R. Vandersee of the Ogdensburg N.Y. Port Authority.
- Mr. W. Milne, Naval Architect of the firm of German and Milne.
- Mr. K. Symons of the Ontario Ministry of the Environment.

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1. "Treatment and Disposal of Vessel Sanitary Wastes" prepared by the panel on treatment and disposal of sanitary wastes of the Maritime Information Committee -Maritime Research Information Service (MRIS), National Research Council, Washington, D.C.

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