CHAPTER 4

CAPE DORSET TRUCKFILL STATION

SCHEMATICS AND FUNCTIONAL DATA

WATER SUPPLY IMPROVEMENTS
CAPE DORSET, NORTHWEST TERRITORIES
COMPONENTS AND SYSTEMS

1.0 INTRODUCTION

The Terms of Reference for the Department of Public Works Project 90-4306 for Water Supply Improvements in Cape Dorset includes a new water storage, truckfill station and any necessary interconnection for the existing system. A previous report has considered the layout of various features on the site. This report presents the various components and systems which are required in the new water storage and truckfill facility in Cape Dorset. The Terms of Reference for this project excludes the existing Tee Lake pump house and water supply main.

The general site layout which has been established is depicted in the attached Figure 3.

The functions which must be carried out at this facility include storage of water, delivery truck filling, water storage replenishment and prevention of freezing of the stored water. The systems required to provide these functions include:

- interconnecting piping joining the fill line, storage tank and truckfill station building;
- water storage tank;
- freeze prevention;
- the truck loading system;
- chemical storage mixing and feed system;
- instrumentation and control systems;
- support services including electrical power, fuel storage and communications.

The following sections of this report provides the methodology incorporation into the final design.

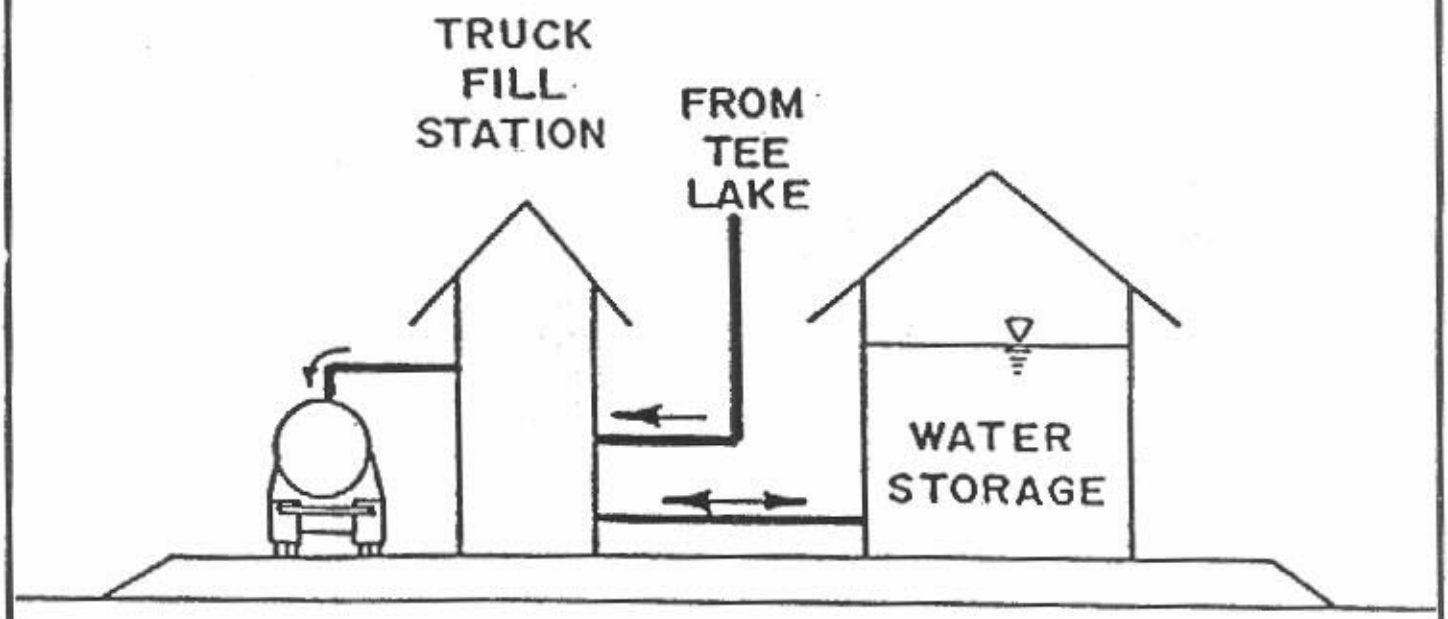
2.0 SITE PIPING

The storage refill main does not form part of this project. This main must, however make connection to this main. Thus, the piping arrangement which interconnects the water storage tank, truckfill station and water fill line from Tee Lake must be established. The arrangement of this interconnecting piping are depicted schematically in Figure 4. In Alternative 2, the fill line is connected to the truckfill station building. In this instance the interconnecting pipe between the tank and the building serves both the truckfill and water storage replenishment purposes.

Freeze prevention of the supply line from Tee Lake requires draining of this piping following each tank refill cycle. Within Alternative 2, a drain-down arrangement for the fill line from Tee Lake is required within the truckfill station building. The use of a drain sump and transfer pump, which permits the piping to remain near grade, requires that the necessary mechanical equipment be installed within the truckfill station building.

During replenishment of the reservoir, monitoring of incoming flows, temperature and heat trace operation. This places the equipment in an accessible and maintainable location and does not require transmission of signals from remote sensors. Routing the fill line through the building provides the opportunity to sample influent water from Tee Lake.

Current design standards require means for automatic chlorination of water supplies. This may be achieved through chemical application at various opportunities including during reservoir replenishment and during the water truck loading. Chlorination is discussed in detail in subsequent sections. Application during storage refill provides the appropriate contact time and ensures disinfection of all stored water. Because of the large quantity of water held in storage, it is easy to adjust the chlorine application rate to obtain the



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SCALE: N.T.S.	TITLE: CAPE DORSET TRUCKFILL STATION SITE PIPING	FIG. 4

desired concentration of the stored water. This becomes especially helpful if fluoridation is introduced in the future due to the low concentrations used and the narrow tolerance and dosage range used for this chemical.

3.0 WATER STORAGE TANK

Evaluation of the water storage tank requires consideration of the envelope to contain the stored water; an enclosure and thermal protection for this water storage and any required appurtenances.

A required stored volume of 534.3 cubic metres has been identified in the terms of reference. There are a family of tank dimensions which can accommodate the storage volume. Selection of a set of tank dimensions which minimizes the surface area of steel will lead to a lower purchase cost, lower shipping cost, a reduced quantity of field welding and tends to minimize the quantity of internal coating required. A tank which is 8.9 metres in diameter by 8.8 metres high possesses the minimum steel area required to enclose the required volume. These dimensions include a free board allowance of 0.2 metres.

It is desirable to minimize the external surface requiring insulation and cladding. This leads to reduced capital costs for these elements of the tank. Minimizing exposed surface area minimizes heat loss from the tank which has a strong effect upon the ongoing operating costs for the water storage tank. The above dimensions provide a tank which is within 3 percent of the minimum surface area requiring insulation and cladding.

A summary of analysis indicates that a tank which is 8.9 metres in diameter and 8.8 metres high contains the minimum quantity of steel and is near minimum in terms of area requiring insulation and cladding. For these reasons these tank dimensions have been selected as appropriate for the storage of 534 cubic metres of water.

From both the perspective of capital cost and operation cost, it has been determined that there is no advantage to providing additional storage volume at this date.

The operation cost were analyzed and were found to be insensitive to insulation thickness if the insulation is greater than 50 mm thick. On this basis, an insulation thickness of 62 mm has been selected. This selected insulation thickness compares well to that used in previous installations including Griese Fjord.

The tank insulation must be protected from moisture entry and mechanical damage. Moisture protection may be achieved using a spray on polyurethane coating. Mechanical protection in the form of metal cladding is required for the tank walls.

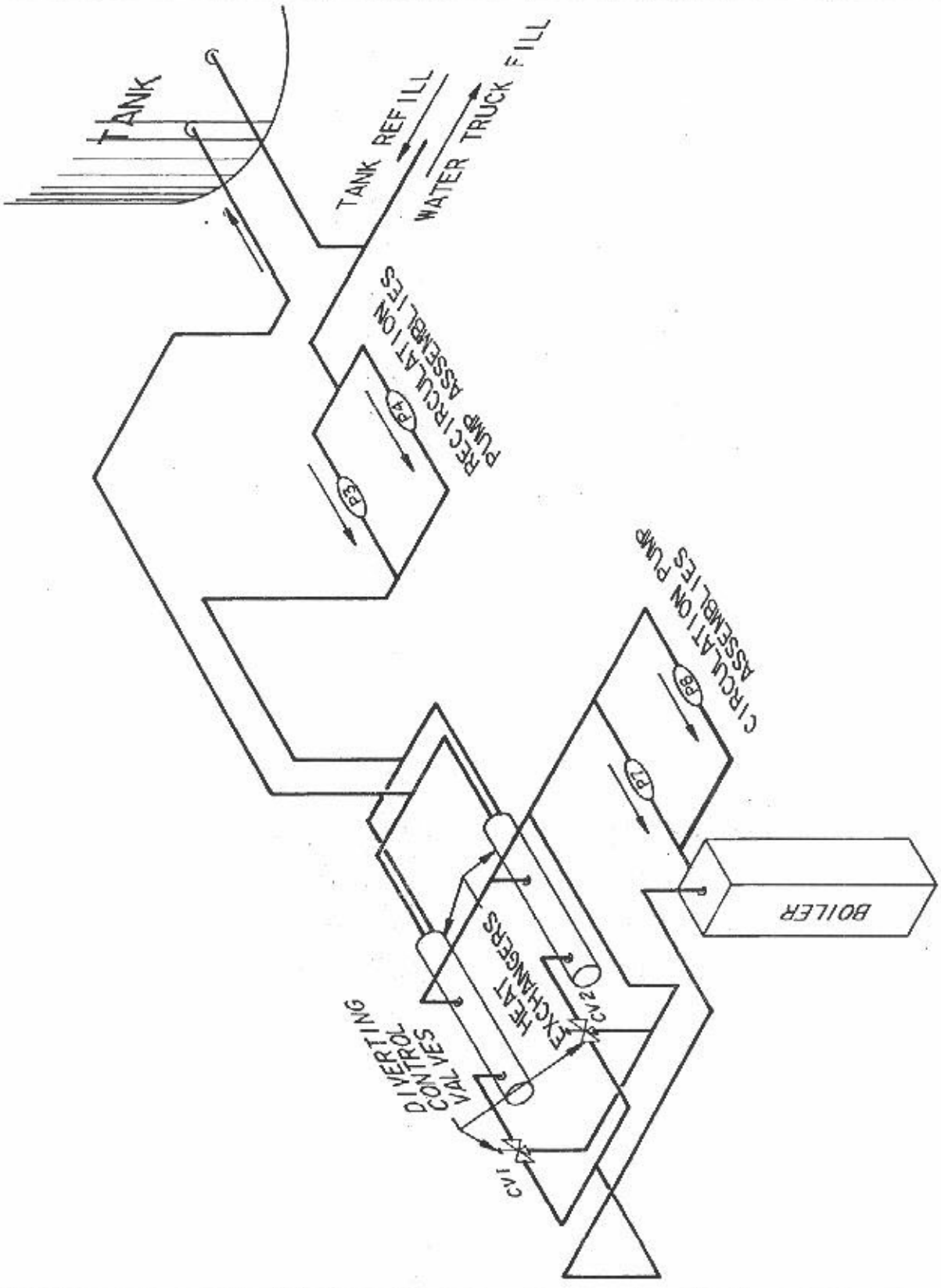
4.0 FREEZE PREVENTION

Freeze prevention measures must be provided for three key elements; these being the water storage tank, the tank refill line and the water truck loading arm.

Alternative methods of achieving freeze prevention have been evaluated and are presented in the following sections.

4.1 Freeze Prevention For The Water Storage Tank

Freeze prevention for the water storage tank is depicted schematically in Figure 5. With this arrangement, water is recirculated from the tank through a heat exchanger in the truckfill station building and is returned to the tank. This alternative requires that a tempered water return line be installed between the truckfill station and the tank. This arrangement permits the placement of all heating and control equipment within the building. This places the equipment away from hostile climates and causes it to be accessible for maintenance and repair. Positive circulation of the tank contents can be achieved within this arrangement through the use of a diffuser on the tempered water return line. This



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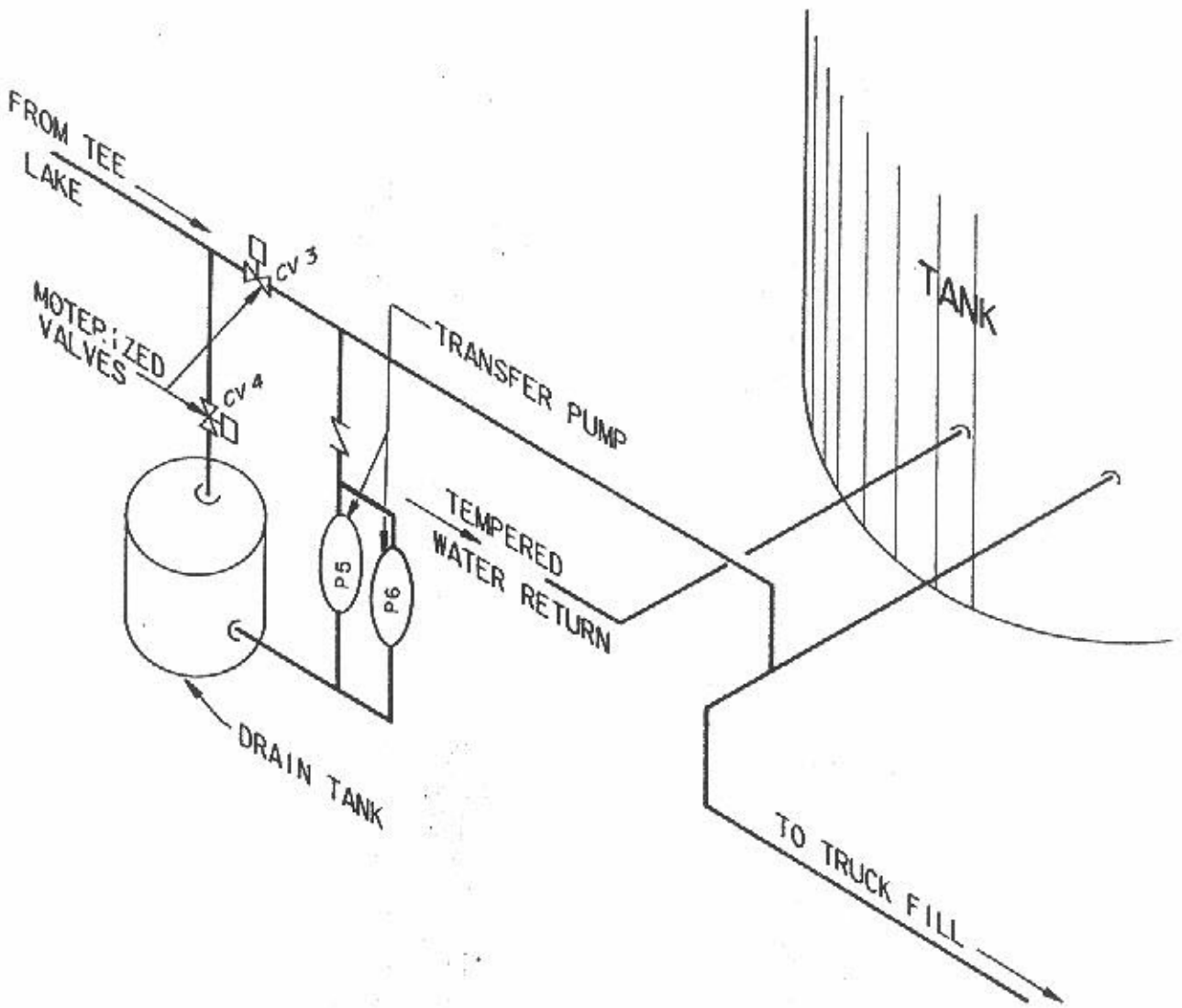
SCALE: N.T.S.	TITLE: CAPE DORSET TRUCKFILL STATION STORAGE TANK FREEZE PREVENTION - ALTERNATIVE I	FIG. 5



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SCALE: N.T.S.	TITLE: CAPE DORSET TRUCKFILL STATION REFILL LINE FREEZE PREVENTION—ALTERNATIVE I	FIG. 6

method of freeze prevention assures continuous flow through all piping connecting the tank to the truckfill station. Continuous circulation will prevent thermal stratification.

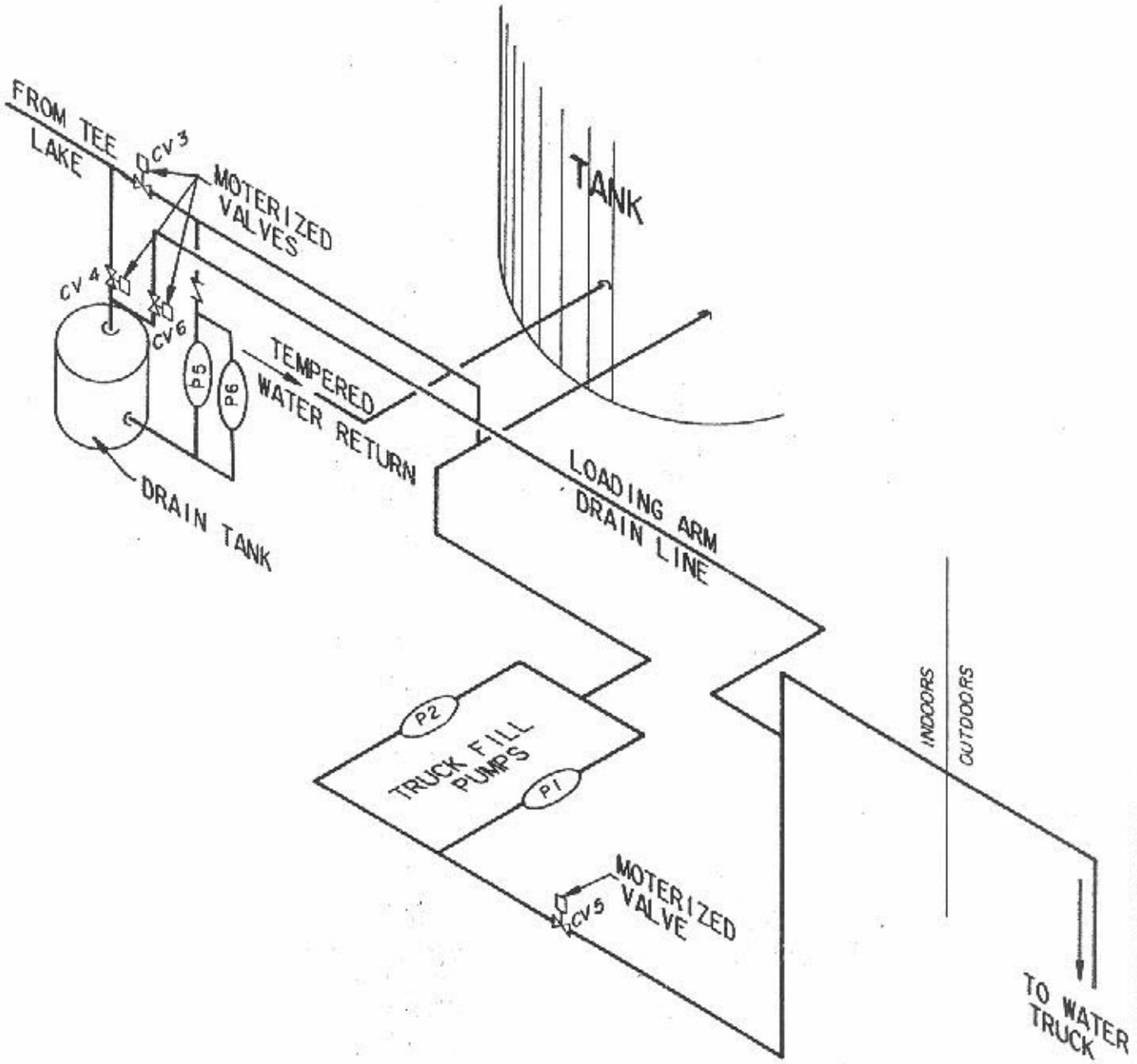
4.2 Refill Line Freeze Protection

Prevention of freeze-up of the refill line from Tee Lake requires that this main be drained at the end of each tank fill cycle. Due to the slope of this line, a large portion of the main will drain by gravity to the elevation of the high water level of the tank. At this point in time, the water must be removed from approximately 250 metres of the supply main.

The draining of the supply main is depicted schematically in Figure 6. With this arrangement, a drain tank is incorporated into the piping system. It is intended that after the level in the supply main has stabilized to the high water level of the tank, that a motorized valve open to drain the remaining segment of the supply main into the drain tank. The tank would then be emptied with a transfer pump into the storage tank. A tank which is approximately 1,500 litres in volume would provide a factor of safety of about 30 percent. With this drainage system, motorized valves may be selected which are self-opening on loss of power. This would assure drainage of the supply main following loss of power to the truckfill station. This arrangement as well provides a location where water may be drained for other operational purposes.

4.3 Truck Loading Arm

Truck loading arms are normally protected from freezing by permitting the contained water to drain by gravity back into the reservoir. This is not possible in this specific instance because the level in the storage tank will often be above the level of the loading arm. Thus a means for positive drain-down of this loading arm must be provided. The selection of a drain tank for the fill line from



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SCALE: N.T.S.	TITLE: CAPE DORSET TRUCKFILL STATION TRUCK LOADING ARM FREEZE PREVENTION	FIG. 7

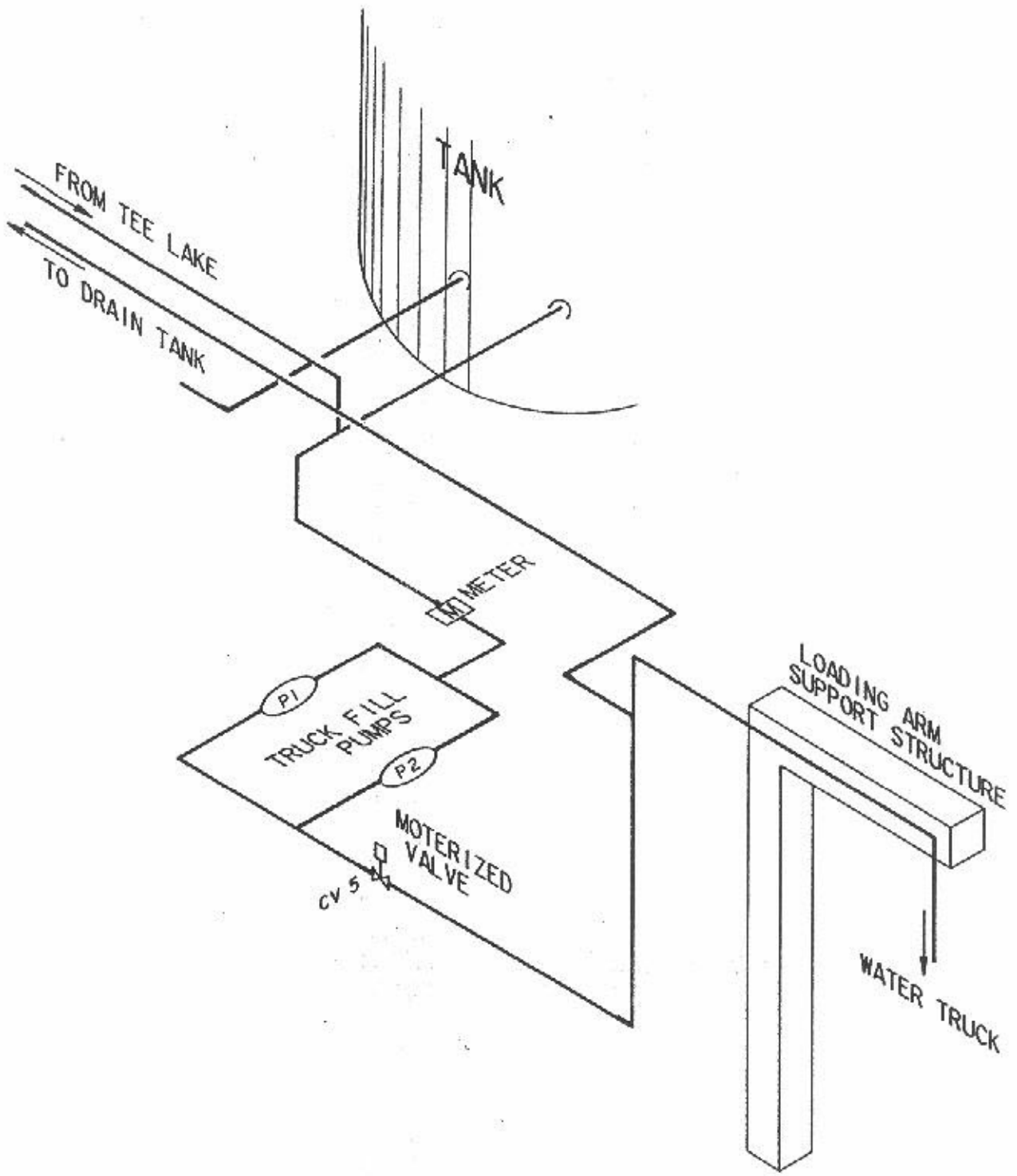
Tee Lake in the previous section provides a point where the loading arm may be drained by gravity through the addition of a limited amount of piping and motorized valves in a fashion as depicted schematically in Figure 7. As has been recommended for the drainage system for the fill line, the motorized valves should be selected with the feature of automatic operation on loss of power to assure draining of the loading arm and termination of water delivery following loss of electrical supply. Electrical heat trace must be provided on the truckfill piping.

5.0 TRUCK LOADING SYSTEM

The equipment required to load water delivery trucks includes transfer pumps, control valves, metering equipment and a loading arm. The following summarizes the equipment requirements for these purposes. The terms of reference require a truckfill rate of 1,000 litres per minute. There is a further requirement within the Terms of Reference for the provision of one duty and one standby transfer pumps to provide the continuous availability of service. Close coupled end suction centrifugal pumps of approximately 5 horsepower would be well suited for this service.

During normal operation, the storage tank level will be above the elevation of the truck loading arm. This will require a motorized valve downstream from the transfer pumps to provide positive shut-off of flow from the water storage tank. This valve must be selected to automatically close in the event of loss of electrical power.

Water meters are normally provided in truckfill stations to measure current flow rate, volume in current delivery and the total quantity of water which has been consumed. Commonly, paddle wheel type flow meters are used as they present no restriction to return flows for drainage purposes. The paddle wheel type flow meters present low head loss and provide both instantaneous flow rate and flow totalization. These meters as well provide information which is of use within the control systems including proof of flow and flow rate output which may be used to pace other equipment such as chemical feed.



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The loading arm penetrates the truckfill station wall and extends vertically and horizontally to reach the fill point on the water delivery truck. In that a pre-engineered building will be used for the truckfill station, additional building members are installed to provide sufficient support for the truck loading arm. Difficulties with long-term weatherproofing of a roof penetration dictate a wall penetration by the piping. This arrangement does provide for simplicity in the interconnections to the piping within the truckfill station.

Figure 8 depicts schematically the truck loading system.

6.0 CHEMICAL FEED

There is the requirement for chlorination and a potential for the application of fluoride to the drinking water supply in Cape Dorset. The selection of an appropriate application point and the equipment required to dispense chemicals is considered in the following sections.

6.1 Fluoride

Fluoridation of the drinking water in Cape Dorset is not within the scope of the current project. The terms of reference do, however, require provision for the future installation of fluoridation equipment. The point for future fluoride feed is into the water storage tank refill line.

6.2 Chlorination

Chlorination equipment is provided within the proposed truckfill station so as to assure disinfection of all drinking water prior to delivery.

Chlorine addition into the tank refill line has been provided

6.3 Chlorination Equipment

The water distribution and sewage disposal system standards as prepared by the Department of Public Works recommend the use of hypochlorite metering pumps together with a pair of solution storage tanks. One of these setups is provided in the proposed truckfill station. The hypochlorite feeder which is connected to the storage tank refill line has a capacity of approximately 100 litres per hour against a 10 metre head.

The installation includes a hypochlorite metering pump, a pair of polyethylene solution storage tanks, a solution mixer, low level shut-off switch, injector, back pressure valve and all necessary piping.

7.0 INSTRUMENTATION AND CONTROL

7.1 Introduction

Instrumentation and control is required for the various systems within the water truckfill station. These controls are required to cause sequences of events to occur; to provide information to the operator; to annunciate alarm conditions and to permit maintenance and repairs of the equipment within the building. The necessary controls include both manual and automated equipment.

The instrumentation and control systems satisfies the following broad principles:

- The desired sequence of events should be reliably executed.
- The control should be as simple and understandable as possible to operate.
- All necessary operational information should be annunciated to the operator.
- The selected system should be repairable by personnel in the Region.
- Standardized components should be selected where possible to minimize inventory and ease acquisition of spare parts.

The systems requiring instrumentation and control include the following:

- water storage freeze prevention
- storage tank refill
- truckfill system
- drain tank operation
- alarms including local and remote

The Water System Piping Schematic illustrates the various required controls which are discussed and should be reviewed in conjunction with the following sections.

7.2 Water Storage Freeze Prevention

The following section considers maintenance of the desired water temperature within the water storage tank. Freeze prevention of the tank refill line and the water truck loading system will be considered in subsequent sections.

The temperature of 5°C has been selected for the stored water. This temperature represents a compromise in that a higher temperature will lead to greater heat loss for the tank while reducing the stored water temperature, will reduce the time period available to respond to any equipment failures in the stored water reheat system. The heated return water normal operating temperature of 25°C and a high temperature limit of 30°C have been selected to prevent damage to high density polyethylene piping from high temperature.

To prevent freeze-up of the piping between the water storage tank and truckfill station, continuous flow will be maintained through the heat exchangers by the circulation pumps P3 and P4. These pumps will be manually alternated with one pump continuously available, with automatic start, as a standby.

Continuous operation of the circulation pumps has been selected for several reasons. Firstly, continuous assures ongoing mixing of the tank contents which assures ongoing water quality and prevents thermal stratification. Continuous circulation maintains flow past the temperature sensors which assures continuous accurate measurements. Finally, the risk of freeze-up due to operational error is reduced.

Control valves CV1 and CV2 will be modulated in response to the stored water temperature. The following sequence of operations will be required.

- Sensing temperature drop at aquistat T1 below 5°C permits heating fluid flow from boilers through control valve CV1 and CV2 into heat exchangers.

- Aquistat T2 modulates control valve CV1 and CV2 to maintain 25°C return temperature.

- Temperature rise above 5°C at aquistat T1 ceases heating fluid flow through heat exchangers.

- Temperature rise above 30°C at aquistat T5 ceases heating fluid flow through heat exchanger and annunciates alarm.

- Loss of circulation flow opens flow switch FS1, and annunciating alarm.

7.3 Water Storage Tank Refill

Prior to each storage tank fill cycle, the heat trace cable within the fill main must be operated for a period of one to two hours. This is followed by a tank refill period of approximately seven hours. Following completion of tank filling, a second heat trace cycle is required for drying of the piping system.

Automatic termination of the refill cycle has been provided because it leads to fewer timing restrictions to ensure termination of the fill cycle within the working day. Automatic termination reduces the risk of overflow should the operator forget that tank refill is in progress. This method as well reduces the risks of fill main freeze-up by ensuring that the appropriate sequence of events occurs. The principal disadvantage to terminating the reservoir fill cycle automatically is that the controls are more complex to ensure the correct sequences of events occur with the required time delays.

The large diameter connection which is used for tank refill and water truckfill experiences four operating circumstances. These are recirculation flow, tank refill, truck filling and simultaneous tank and truckfill. Each of these conditions represents different hydraulic conditions of velocity and friction head. Thus, any sensors connected to this pipe would be subject to erroneous measurements due to head variations.

The reheated water return line operate continuously at constant flow. Thus, head varies only in response to the storage tank level. Sensors do not experience errors due to changing hydraulic conditions. This pipe has been selected as the condition point for tank level sensors.

The control system provides for the following sequence of operations during the tank refill cycle:

- Pressure switch PS4 closes on storage tank falling to refill level.
- Alternatively, operator initiates tank refill site manually by pressing start button. Fill cycle initiation annunciated by signal light.
- Motorized valve CV3 closes
- Drain tank level switch LS1 confirms is sufficient volume available in the transfer tank to permit fill line emptying at the end of the cycle.
- Heat trace cables in refill main energized and time delay started (time delay reset monthly based upon prevailing weather).
- At the end of the time delay, lake pump starts; heat trace timer resets for fill main drain at end of cycle. Heat trace will remain energized if T1 senses a temperature of 5°C or less (adjustable).
- The water cut-off in Tee Lake pump house closes following filling of the water heaters by the lake pump energizing water heaters.

At the completion of the tank filling cycle the following sequence of operations occurs.

- Pressure switch PS5 closes on storage tank reaching high water level
- Tee Lake pump and water heaters de-energized; fill line heat tracers energized
- Initiate time delay to permit fill line from Tee Lake to drain to storage tank static level
- Motorized valve CV3 closes
- Motorized valve CV4 opens
- Level switch LS2 starts lead transfer pump on filling of drain tank from the refill line, level switch LS3 will start lag pump.
- Level switch LS1 stops transfer pump P3 and P4 following drainage of the fill main

- Fill line heat trace de-energized at the end of time delay and timer resets for next cycle.
- Level switch LS4 on the transfer tank annunciates an overflow alarm.

The control system annunciates the following information:

HIGH LEVEL WATER STORAGE TANK
TWO-DAY ALARM WATER STORAGE TANK
FIRE RESERVE WATER STORAGE TANK
LOW LEVEL CUTOFF WATER STORAGE
LOW TEMPERATURE RECIRC. WATER
NO FLOW RECIRC. WATER
HIGH TEMPERATURE RECIRC. WATER
BOILER TROUBLE
GLYCOL SYSTEM TROUBLE
HIGH LEVEL TRANSFER TANK
NORMAL POWER FAILURE
GENERATOR TROUBLE
GENERATOR SWITCH "OFF"
LOW LEVEL FUEL OIL
LOW SPACE TEMPERATURE
HIGH SPACE TEMPERATURE
HIGH LEVEL FUEL OIL
UPPER HEAT TRACE FAILURE
TEE LAKE PUMP FAILURE
TEE LAKE HEAT TRACE FAILURE
LOWER HEAT TRACE FAILURE
SPARE

7.4 Water Truckfill System

The truckfill system controls include both the controls required for delivery truck refill and those controls required to restrict access to the volume which is assigned for daily operational use so as to retain loss of supply and fire storage.

7.4.1 Delivery Truck Refill

The delivery truck refill cycle is initiated by the driver and terminated by the dispensing of a suitable volume of water or by manual stop. The control system must as well include all equipment required to assure freeze prevention. The sequence of operations associated with this system may be summarized as follows:

- Driver initiates cycle using key lock switch
- Pressure switch PS3 confirms that the water storage tank level is above the low water level for daily storage
- Motorized valve CV6 closes
- Motorized valve CV5 opens
- Transfer pump P1 or P2 starts (pumps manually alternated)
- Truckfill timer starts
- At end of truckfill timer run time, pump P1 or P2 stops
- Motorized valve CV5 closes
- Motorized valve CV6 opens to drain loading arm
- Level switch LS2 initiates the transfer of drain down water from drain tank back to water storage.
- Time delay permits heat trace operation for 30 minutes if ambient temperature is below -5°C

During the course of truckfill, meter M1 measures flow rate and provides an indication of total water quantity delivered at the operators panel.

7.4.2 Storage Management

The terms of reference establish storage requirements for this facility of 160.1 m^3 for daily operating storage, 320.2 m^3 as a two day loss of supply storage and 54 m^3 for fire storage. Compartmentalizing the storage tank to provide for these volumes is both structurally difficult and causes significant problems in maintaining the required circulation within the tank. Thus control equipment which is based upon the tank water elevation is required to reserve these volumes for their intended purposes. The following summarizes the various level sensing functions which will be required.

Previously in Section 7.4.1 reference has been made to pressure switch PS4. This switch is intended to confirm that the water level is within the daily operating storage volume. This switch prevents delivery following depletion of the daily storage.

In the event of a loss of supply, water delivery is prevented by pressure switch PS4. Additional water deliveries under these circumstances would require that this level switch be overridden by manual control. A key lock switch is provided within the building for this purpose. Operation of this manual control permits the depletion of the next 320 m^3. When low water level for this portion of the storage is reached, pressure switch PS3 opens preventing further deliveries and retaining the required volume for fire storage purposes.

During fire, the above low level cut-off switches must be overridden to assure access to the full storage tank volume. It is recommended that a pair of key lock switches be provided. One of these would be situated within the building and the second one would be mounted on the truck loading arm control panel. A final low water cut-off switch (PS1) would open when the tank has been completely emptied so as to prevent damage to the mechanical equipment within the truckfill station.

As has been discussed in the previous section, pressure switch PS6 is provided as an overfill alarm. The switch would take the form of an emersion type sensor mounted on the top of the tank. Overfilling of the tank to this level would shut down the Tee Lake pump, annunciate an alarm and lock out refill of the water storage tank.

7.5 Alarms

Appendix "C" provides a summary of alarm points annunciated.

7.6 Additional Valving and Controls

Various valves and controls are required to isolate equipment for maintenance and repair purposes and to override automatic controls following failures. These take the form of various manually actuated valves.

8.0 SUPPORT SERVICES

Several support services are required to successfully operate the propose facility. These include electrical power, communications, fuel and heating storage.

8.1 Electrical Power

Three phase electrical supply is available from the existing overhead line at the site perimeter.

A standby power source which is capable of maintaining the facility for a prolonged period of time has been provided.

Loss of electrical supply to the site would as well lead to loss of power at the lake pump house. Thus refill would not be possible and the heat trace within the refill line would not be required. Standby electrical power source is not sized to serve the lake pump house or fill line heat trace system. All other electrical loads are carried by the standby equipment including the pumping and heating equipment.

8.2 Communications

Communication lines are installed to telemeter control signals from the truckfill station to the Tee Lake pump house and to the pipe line mid point station. Currently this is accomplished using Northwest Telephone lines which are carried

on the overhead pole line adjacent to the site. The continued use of this Bell cable represents a simple way to telemeter the required signals.

8.3 Fuel Storage

Sufficient fuel is stored at the truckfill station site so as to assure ongoing tempering of the stored water and to maintain the environment within the truckfill station building. Additional fuel is as well on hand to power the standby diesel generator. The fuel storage of approximately 5,000 litres is satisfactory to provide 10 days operating storage at this facility. This storage takes the form of an exterior tank with a spill containment structure.

8.4 Heating

Heating is essential to prevent freeze-up of the water storage tank and the piping within the truckfill station building. It is economically desirable to match as closely as possible the heating requirements with the boiler size while ensuring that there is sufficient capacity to provide for the full heating requirements following the failure of a boiler. This facility experiences large variations in heating load. A heavy heating demand arises following refill of the water storage tank when the added water must be raised from approximately 2°C to 5°C. Following the tempering of this refill, the heating load is limited to losses from the building and the water storage tank which are expected to be low due to the insulation and building systems which are used.