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The City of Dawson

1991 Water and Sewer Study

(53)

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Shiltec Consultants Ltd.

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March 2, 1992
File: 101-02-01

The City of Dawson
P.O. Box 308
DAWSON CITY, Yukon
Y0B 1G0

Attention: **Ms. Carol Murray**
City Manager

Dear Carol:

Re: 1991 Water & Sewer Study

We respectfully submit five (5) copies of the final report on the above captioned project. As per your instruction we have forwarded three (3) copies to Mr. Mark Malinsky of the YTG for their information.

We appreciate the time and effort your staff has put into this study, especially Mr. Norm Carlson, Works Superintendent. We look forward to implementing the recommendations as adopted by the City.

If you require clarification or additional information please contact the writer.

Yours truly,

Edward Shillington, P.Eng.
Principal

*mas
cc: Norm Carlson
Works Superintendent

DW59

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CONVERSION FACTORS

1 hectare	= 2.471 acres
1 kilometre	= 0.621 miles
1 kilopascal	= 0.145 pounds per square inch
1 litre	= 0.220 imperial gallons
1 litre per hectare day	= 0.089 imperial gallows per acre day
1 litre per capita day	= 0.220 imperial gallons per capita day
1 litre per day	= 0.220 imperial gallons per day
1 litre per second	= 13.198 imperial gallons per minute
1 Mega litre	= 219 million imperial gallons
metre	= 3.280 feet
cubic metre	= 35.315 cubic feet
cubic metre	= 219.977 imperial gallons
cubic metre per day	= 219.977 imperial gallons per day
metre per second	= 3.280 feet per second
milimetre	= 0.039 inches
tonne	= 1.102 tones

SECTION 1 INTRODUCTION

1.1 Study Program

The City of Dawson is the service centre for the placer mining industry and is a major tourist centre in the Yukon. Over the last 15 years the community has had a continuous population growth. This growth has brought portions of the water and sewer system to within their capacity.

Between 1978 and 1980 the complete water and sewer system was upgraded to service a population of 2000 within the main community core area. The City of Dawson must now consider how to handle the forecasted population growth.

The purpose of this report is to provide guidelines for planning orderly development within the present and future growth areas. The study will address only the water and sewerage systems, other infrastructure have already or will be reviewed in other studies.

The study also identifies costs, sizes and locations of major improvements applicable to growth areas.

Updated land use and population growth is based on the 1990 Official Community Plan as prepared by IMC Consulting Group Inc. and adopted by Council.

1.2 Authorization and Terms of Reference

The City of Dawson authorized the study in a letter of October 30, 1990.

The terms of reference were basically outlined in Mr. Shillington's letter of October 2, 1990 as follows:

1. Gather all data and information to date on the water and sewer systems. Get operator input on the system to determine weaknesses and strengths. Have operators put together their requirements.

2. Determine the design criteria for water and sewer flows based on past records and future population. Evaluate the bleeding concept and the waste water flow. Review the water quality and sewage effluent criteria for the future population.

3. Water system upgrading to include:

    - review water supply needs and the present system capabilities. Determine the water supply for future requirements;

    - heating requirements of the system;

- fire fighting capabilities;
- storage requirements and chlorination system
- the pumphouse components and instruments;
- the water distribution piping system will be analyzed for flow criteria and future expansion.

4. Sewage system upgrading to include:
   - the collection system will be analyzed for flow criteria and future expansion;
   - the pumpstation and screening plant to be examined for upgrading;
   - the outfall line;
   - investigation of future sewage treatment requirements.

5. Cost estimates for all upgrading will be done as well as an implementation schedule for any recommended works.

6. Report preparation will include overall systems diagrams with the existing and future expansions outlined.

SECTION 2 BACKGROUND INFORMATION

2.1 Introduction

This section outlines the background information and the data which were used as a basis for our analysis of the water and sewer systems.

2.2 Study Area

The boundaries for the City of Dawson extend from the Yukon River into the hinterlands to the east and south from Klondike City to the north of Fifth Avenue pit as defined in the OCP. This study only covers the core service area as outlined on Figure 2.1, Study Area and Land Use.

2.3 Previous Reports

Several previous reports were utilized as background for this study.

The first is the "Water and Sewage Design Summary, 1978-89" prepared by Stanley Associate Engineering Ltd. (SAEL). This report formed the basis for the water and sewer construction of 1980.

The "Sewage System Post-completion Report, June 1982" by SAEL examined the sewer line problems during the initial years of operation and recommended new construction methods and materials for future construction.

The "Water and Sewer Extensions Feasibility Study, November 1983" by SAEL reviewed the expansion to the north of the community.

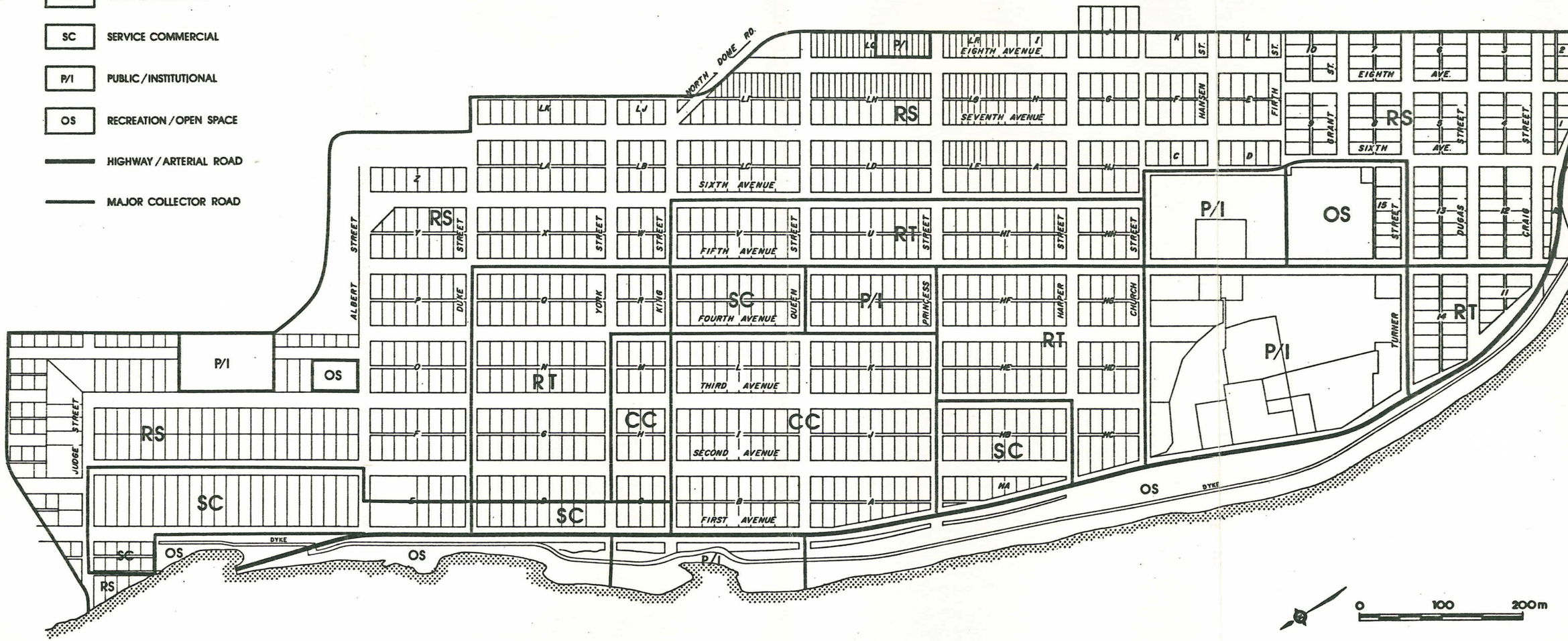
The "Klondike Valley Water Quality Assessment, January 1991" by Klohn Leonoff Yukon Ltd. reviewed the existing and potential contaminants within the Klondike Valley and their impacts on the City's water supply.

The "Official Community Plan, February 1991" by IMC Consultants which developed the community objectives and forecasted the population for the next twenty year period.

The "Northern Expansion Study, June 1991" by Shiltec Consultants Ltd. which examined the redevelopment of the northern area of the existing town site.

Legend

- RS — URBAN RESIDENTIAL • Single
- RT — URBAN RESIDENTIAL • Single multiple transition
- CC — CORE COMMERCIAL
- SC — SERVICE COMMERCIAL
- P/I — PUBLIC / INSTITUTIONAL
- OS — RECREATION / OPEN SPACE
- HIGHWAY / ARTERIAL ROAD
- MAJOR COLLECTOR ROAD



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Study Area and Land Use

figure **2.1**

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2.4 Population

IMC Consultants prepared population growth projections for a twenty year period. These are presented together with the historical population data in Figure 2.2.

In long term planning for infrastructure expansion it is not absolutely necessary to project growth in a fixed time frame and for purposes of this study population levels were used.

The population during the course of a year fluctuates greatly due to the impact of tourists during June, July and August. The populations as shown on Figure 2.2 are the forecasted permanent population. The impact of the tourist population does not greatly impact the water and sewer due to the use of bleeders in the system, as shown later in the report.

The population as projected includes the rural residential as well as the urban areas, however the serving area for water and sewer only includes the urban area. Therefore, the population for the urban area is assumed to be approximately 3000 for the twenty year forecast period and is shown on Figure 2.2.

2.5 Land Use

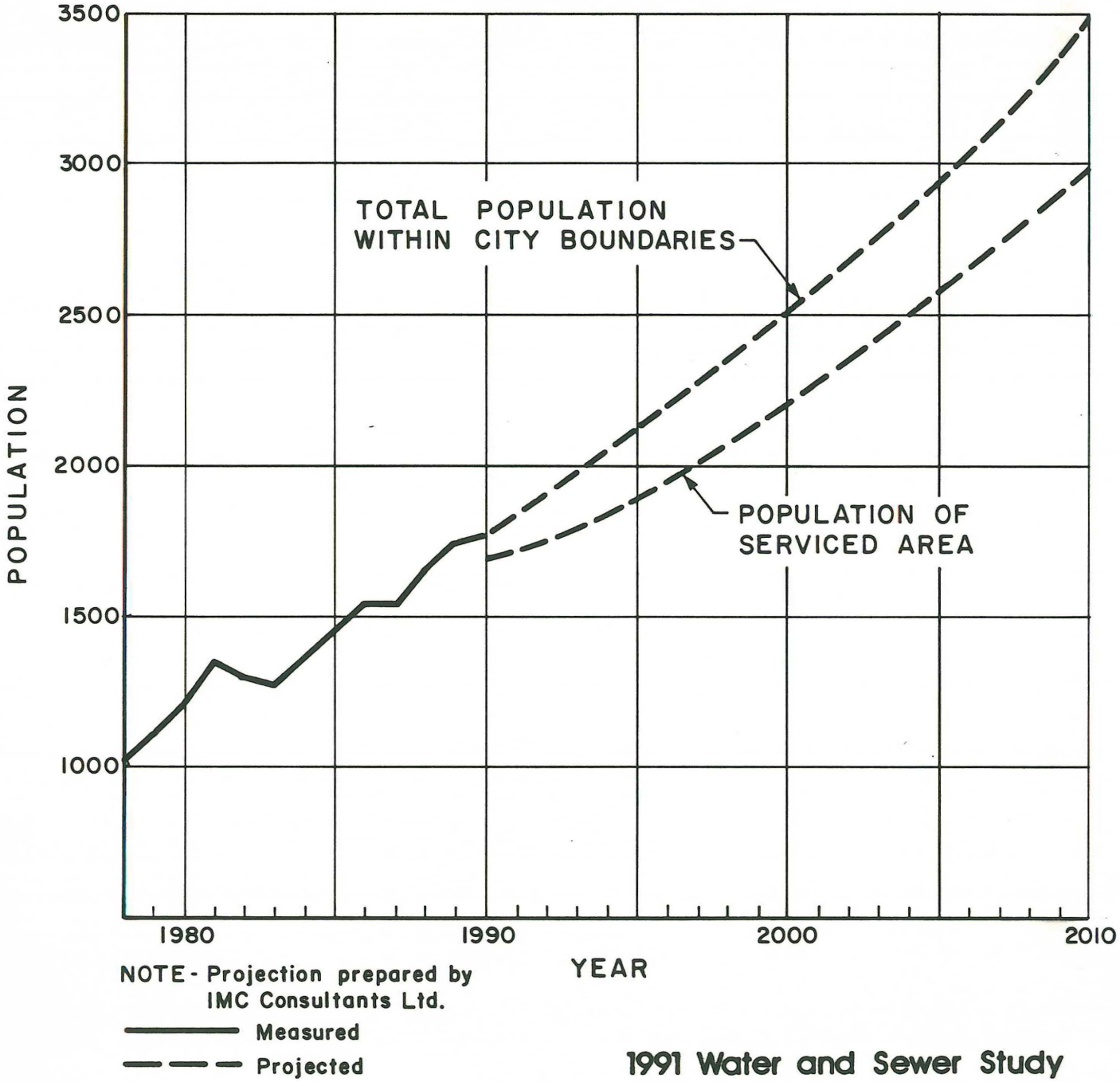
An updated land use plan was developed by IMC Consultants as shown on Figure 2.1, Study Area and Land Use.

The land use plan defines what the flow criteria for these areas such as fire flow, and daily usage should be.

To accommodate the future growth considerable infill throughout the City will be required and should follow the OCP guidelines.

The only area which requires full development to handle the expansion is the north area of the community. This area, referred to as Northern Expansion Area, will require water, sewer, road upgrading, street lights and power; a development report was done in June, 1991 for the City. The configuration of the development has not been finalized, however, for report purposes we have shown Alternative "A" for the water and sewer expansion.

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NOTE - Projection prepared by
IMC Consultants Ltd.

Measured

Projected

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Population Projections

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figure 2.2

SECTION 3 WATERWORKS SYSTEM

3.1 Introduction

This section addresses the City's supply system and water distribution water distribution by formulating a set of design criteria and then assessing the system's ability to provide normal water demands and sufficient fire flows to comply with the Insurers' Advisory Organization's recommendations. It identifies water pressures and available fire flows at different locations under varying demands.

The supply system was analyzed to meet the future demand and to deliver a good quality of water to the system.

3.2 Design Criteria

The total water requirement is normally determined by the product of population and per capita demand. The per capita demand in Dawson does not follow the normal average ratios of demand due to the water bleeding system.

3.2.1 Water Bleeders

The water system in Dawson is partially constructed in a permafrost area which dictated that the water system must be a recirculating system and that all service connections be circulating. To enable the services to circulate, a decision was made in the 1978 upgrading system that a bleeder configuration would be used. Three different circulation systems at that time were considered; bleeders, pit orifices, and a recirculating pump. A bleeder system was chosen for economics as well as the fact that the supply system could provide the necessary flows.

During the time the system has been in operation the bleeders have worked adequately in keeping the services from freezing, however, there are associated problems with them as follows:

- the copper bleeder line wears out fairly frequently;
- the bleeders are misused by the residents; keeping taps open to keep their internal plumbing from freezing. This would be done regardless of the circulating system employed;
- some dwellings are not shut off in the summer;
- larger bleeders are installed by the residence thereby using a greater flow than is necessary;

- commercial establishments which shut down during the winter leave bleeders on as well as other valves to keep their premises water system from freezing up. This should be discouraged.

Based on the past performance of the bleeders and since the system is designed for bleeders and is not readily converted the future services should continue with a bleeder system, however, the controls on bleeders should be more stringent. This will impact the per capita water usage.

The 1978 system was designed with water meters in all buildings, however they have been disconnected due to silt in the system plugging them up. This silt is from the use of the Klondike River water intake in the spring of the year to assist in meeting the water needs. If a new system of wells are installed this will alleviate the problem and meters can be put back in service. A restructuring of the water charges would assist in water conservation.

Therefore, to calculate winter per capita flow, the following assumptions are made:

- a bleeder system will continue to be utilized;

- bleeding will be brought down by metering the water and revising the water charges;

- it will be sometime before the residents adopt to new changes and water conservations therefore the per capita flow rate will reflect the high usage for the next few years. If water conservation can be achieved then certain major components can be down-sized and even delayed thereby keeping the capital and operating costs down.

The flow criteria will be calculated with the use of bleeders.

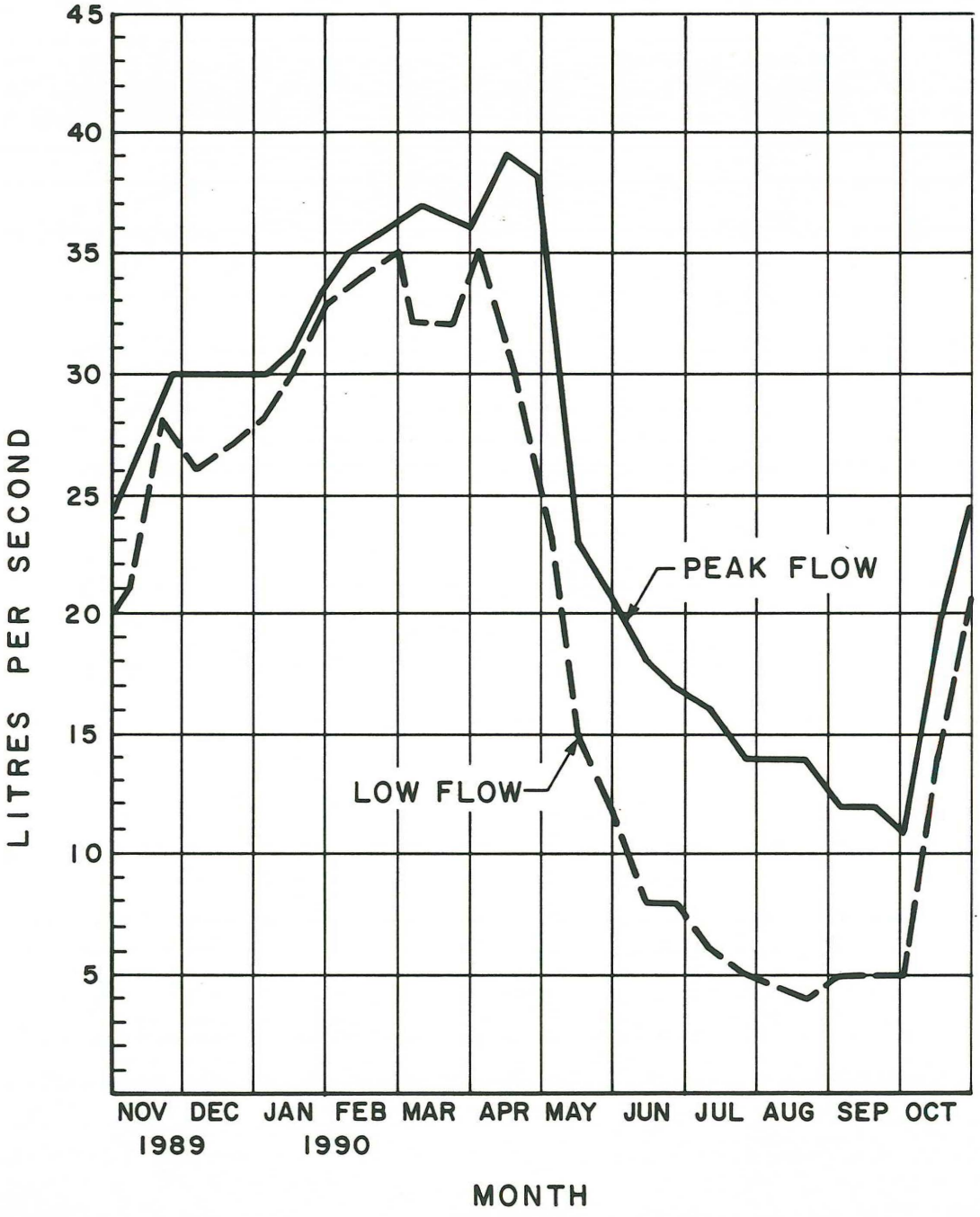
3.2.2 Per Capita Water Demands

Historical per capita day demand has been reviewed and a forecast of future per capita water consumption made.

There are two per capita day demands; one for winter and one for summer. The winter per capita demand includes the bleeder system (and other unauthorized bleeding) and the summer per capita which is only consumption and other uses.

Due to the large differences in the two seasonal demands there is no maximum day or peak hourly demands which the supply system must meet independently. Figure 3.1, Monthly Water Usage, indicates the total water usage from November 1989 to October 1990. There are two flows indicated, peak flow and low flow, and there is a small variation between the two in the winter months and a much more appreciative difference in the summer months. These peaks only signify a need for pumping control in the summer and do not affect the peak design flow appreciably.

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Monthly Water Useage

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figure 3.1

The average per capita flows based on a population of 1800 permanent population for winter would be 1870 litres and for summer would be 700 litres. The summer per capita flow includes the tourist population. The ratio between the per capita winter and summer flows is 2.7 which accounts for the bleeding. This ratio is much larger than it should be based on the population which indicates the residents are bleeding to excess. Therefore, the design flows are 700 lpcd projected for summer and 1870 lpcd for winter.

The water demands for the City of Dawson is shown in Table 3.1 and illustrated in Figure 3.2.

Table 3.1
Water Demands

Popu-lation	Summer Use			Winter Use		
	ADD3 (lpcd)	Flow (l/s)	Daily (Ml/day)	ADD3 (lpcd)	Flow (l/s)	Daily (/day)
1800	700	14.5	1.26	1870	40.0	3.37
2000	700	16.2	1.40	1870	43.2	3.74
2500	700	20.2	1.75	1870	54.2	4.68
3000	700	24.3	2.10	1870	64.9	5.61

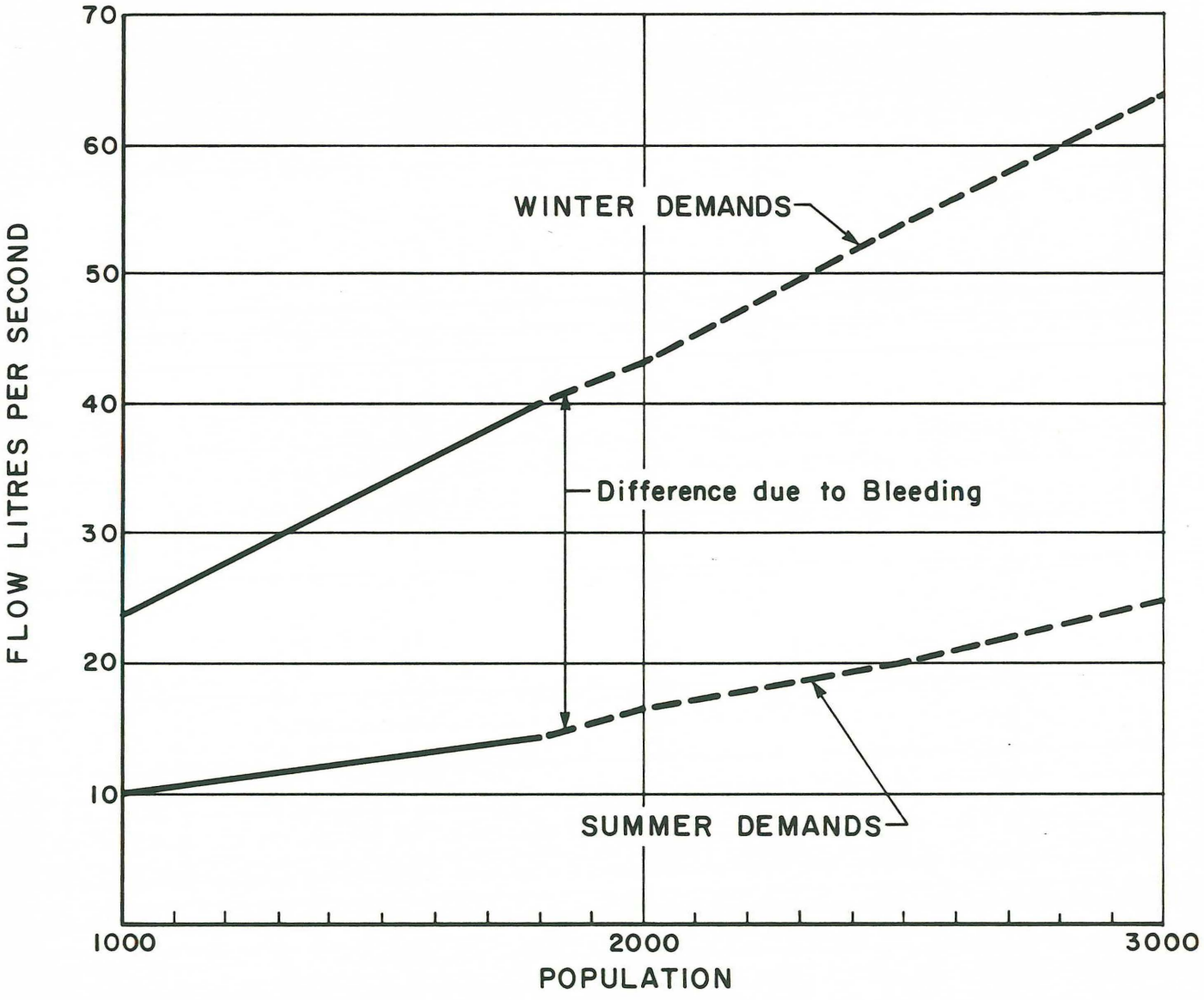
Notes:
1. Existing flows and usage as provided by City of Dawson
2. Winter use is based on controlled bleeding for future projections, not to exceed 1870 lpcd.
3. ADD - Average Day Demand

3.2.3 Fire Flow Requirements and Water Storage

One probable maximum demand condition is the occurrence of fire flows at critical points in the distribution system in conjunction with the maximum day demand. In the Guide to Recommended Practice for Fire Protection produced by Fire Underwriters Survey, 1981, they recommend flows for different buildings, etc., a copy is attached in Appendix "A".

The required fire flow for a building is determined using building type, size, materials of construction and proximity to other buildings. It must be possible to draw off the required fire flow at any point in the water distribution system and the

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Water Demands

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figure 3.2

largest required flow, if it is not an anomaly, determines the fire storage requirements.

In the analysis of the distribution system, fire flows of up to 220 l/s including daily usage are used. The fire flow was determined to be 151 l/s (2000 igpm). The original system fire flow was determined to require 90 l/s (1200 igpm) based on the existing buildings (excluding the museum) at that time. Since then several larger buildings now exist which require the additional fire flow.

The new school and the new hotels require the larger fire flows. The residential areas will continue to have 60 l/s (800 igpm). The larger fire flows are located in the central core area and the proposed northern expansion commercial area.

These larger fire flows have been determined by assuming all buildings will be equipped with fire sprinkler systems.

The water storage is based on the fire flow demands as well as emergency storage and peak hourly demands. It was determined in 1976 that emergency storage was not required since the supply is very near the pumping facilities and the supply can be put directly into the pumphouse. The peak hourly demands do not exist due to the bleeding system which is accounted for in the daily usage, therefore only the fire storage requirements must be met.

The storage requirements must meet 151 l/s (2000 igpm) for a period of 2 hours which is 1,000,000 litres (240,000 gallons). The additional 40 to 60 l/s for consumption will be handled by the supply system feeding the reservoir.

3.2.4 Water Distribution System

The Dawson City water distribution system is presently using polyethylene pipe with a series rating of 100 psi. The system will continue to use this pipe as manufactured by Dupont of Canada.

The distribution system is sized for fire flows of 60 l/s for residential system and now will be sized to accommodate flows of 220 l/s for the commercial areas. The computer program WATER was used to analyze the system, refer to Appendix "B".

The water distribution system is an insulated return loop pattern which ensures that water is being constantly returned to the pumphouse. In this way the water is always flowing and does not require mainline bleeding. The water is returned to the pumphouse and repumped and re-heated to provide constant circulation through the system.

3.3 Water Supply and Pumping Facilities

3.3.1 Existing Supply System

The existing supply system has two sources for raw water. The main supply being an infiltration well and the back-up being the river pumphouse drawing water from the Klondike River.

Well System

This well produces an excellent quality of water and has been the main source for many years. However, the quantity of water from the well varies depending on the time of year. The well yield is estimated as follows:

Table 3.2
Existing Well Production

Time Period	Estimated Yield
May thru October	From as high as 80 in summer to 35 l/s in October
November thru April	From as low as 30 in December to 40 l/s in May

Note: The temperature of the well varies from 1.5 degrees in February to 6 degrees in August.

This well was modified in the 1978 expansion of the system, the existing pumps were utilized and two new pumps added. No work was done on the cripping within the well. Over the last few years when the flow yield has diminished the cripping has been cleaned to assist in the infiltration capabilities. However, the continuous yield can not keep up with the winter flows and the well is now downgraded to 28 l/s in the winter months.

The structure has been well kept up by City staff and has several years of life left. The largest problem with this well is its location to the power plant diesel storage tanks. If these tanks ever failed or leaked the aquifer would be ruined and the City water supply through these wells ended.

River Pumphouse

The river pumphouse is connected to the Klondike River by a direct bank intake consisting of old boiler plates and a screen mechanism. The building is in very poor condition and has come to the end of its usefulness.

The water supply is much poorer than the well due to the silt load in the river. Experience has shown that the silt clogs the meters and wears the pumps down. As well the river is susceptible to surface pollution up stream from such areas as Callision subdivision and other developments. The well yield is dependent on the river channel staying next to the river bank. To ensure this is the case the City requires to channelize the river flow in the fall by the use of bull dozers.

The water temperature from the Klondike River drops to 0.5 in the winter months and requires extra heat for the distribution system. When the water is mixed with the well water the quality diminishes substantially.

3.3.2 Future Water Supply

To meet the future water needs of 65 l/s it will require the additional water supply of 37 l/s. The water supply system should be free from potential pollution such as the fuel storage of the power plant. If possible, the new supply should be able to provide all the water needs. There are two alternatives to provide this water:

Alternative 1 - Expand the Well System;

Alternative 2 - Klondike River System.

3.3.3 Alternative 1 - Expand Well System

In March 1989 an existing 250 mm dia. well was tested for yield. This well was drilled in 1987 to a depth of 40 feet at which point it hit refusal. The well is estimated to produce 4.5 l/s (57 igpm), however, if a larger diameter and deeper well was installed the yield could be significantly greater.

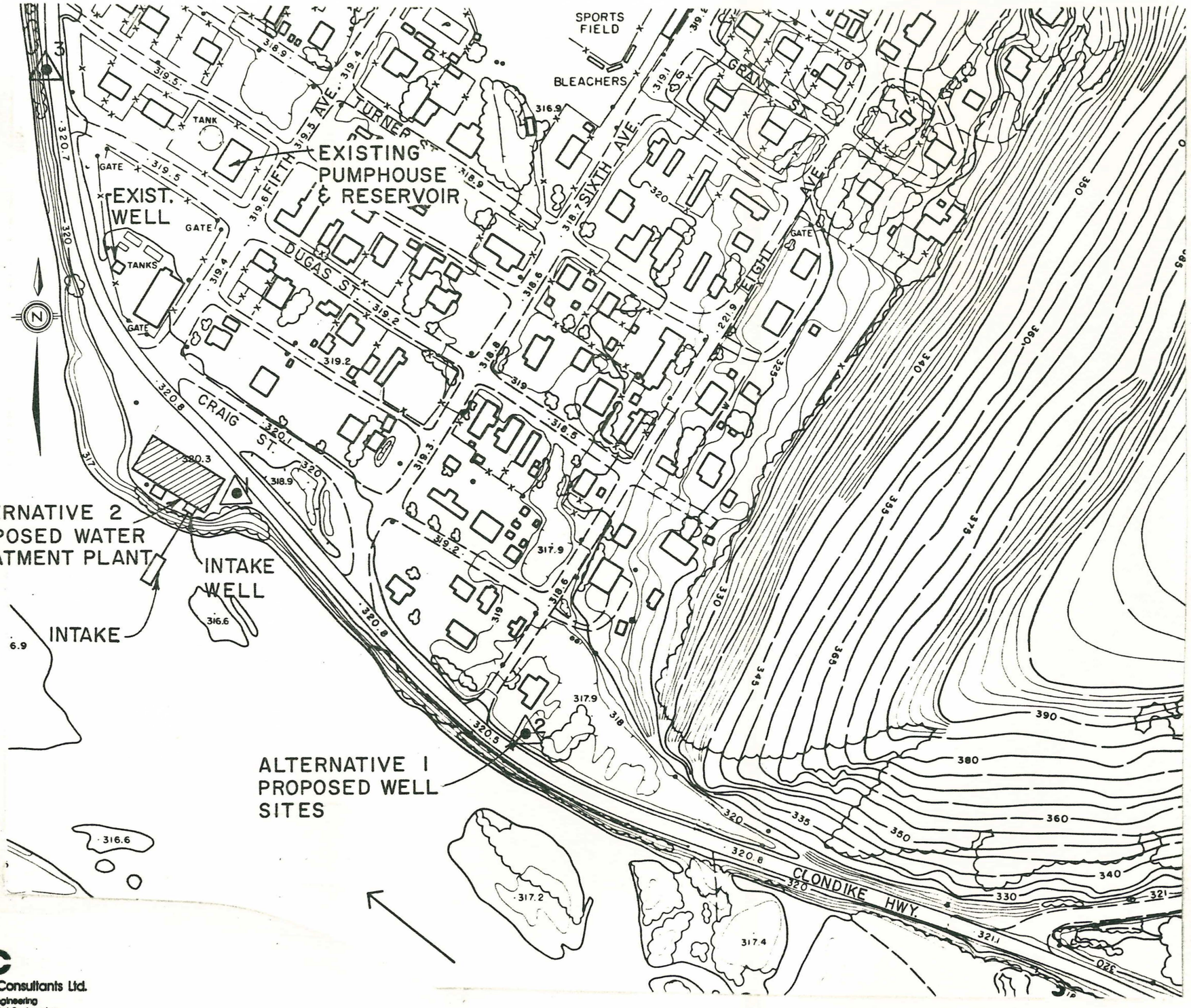
A program of aquifer analysis is required to determine where and how many wells need to be drilled. For the purpose of this study three wells are assumed to be adequate and the locations are shown on Figure 3.3.

The system would include the following:

- drilled wells complete with screen and casing;
- submersible pump complete with a portable generator hook-up extension;
- a well house which is approximately 3 meters by 3 meters;
- 100 dia. to 200 dia. insulated P.E. pipeline to the reservoir pumphouse.

The water quality would be excellent and not as susceptible to contamination since it is a ground water source. As well, the water would be approximately 1.5 degrees and would require less heat for the distribution system.

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Water Supply Alternatives Location Plan

figure **3.3**

These wells would tie into the existing reservoir. Depending on the yield, the existing well would be used continuously or used as a back-up source. Cost estimates for this alternative are shown on Table 3.3.

TABLE 3.3
Cost Estimates
Alternative 1 - Expand Well System

A. Capital Cost Estimates			
Aquifer Analysis and Drilling			$90,000
Well Development		$150,000	
Pumps, Piping and Pumphouses		$130,000	
Pipelines		$100,000	
Contingencies		$40,000	
	Subtotal	$510,000	
	Hydrogeologist	$60,000	
	Engineering	$50,000	
	Total	$620,000	
B. Operating Cost Estimates Per Annum			
Power		$15,000	
Labour		$10,000	
Parts & Equipment		$10,000	
	Total	$35,000	

3.3.4 Alternative 2 - Klondike River Source

The only viable surface water supply is the Klondike River since it has much better water quality than the Yukon River. However, this water still has excessive silt loadings and turbidly and since it is a surface supply the possibility of Giarda

Lambia does exist. This supply requires full treatment throughout the year and consists of the following components:

- river intake structure and pipeline;
- low lift pumpstation;
- conventional treatment which includes flash mixing, sedimentation, filters, alum, polymer and chlorination;
- clearwell;
- transfer pumps and pipeline to the existing reservoir.

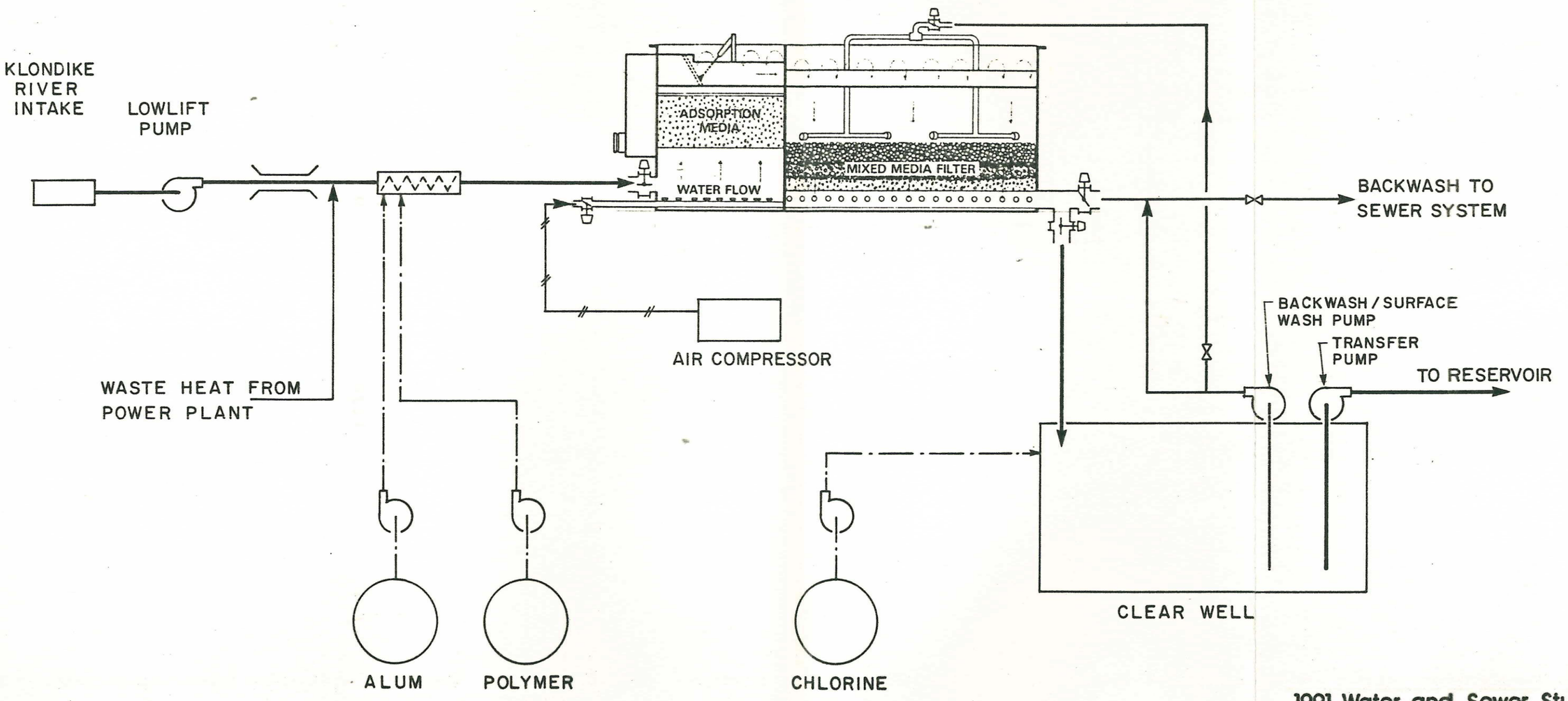
The river intake is proposed to be located near the existing well intake complete with low lift pumphouse. The treatment plant building would be constructed adjacent to the low lift station beside the dyke, refer to Figure 3.3.

The treatment plant would be designed to house two Trident Model TR.210A treatment units. The trident system was selected based on the water quality to treat and it has been proven to be an effective system against Giarda Lambia. Refer to Figure 3.4 for the process schematic.

The transfer pumps would then pump the water to the existing reservoir pumphouse where it would require additional heat and would then be distributed into the system. The cost estimate for this system is shown in Table 3.4.

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TRIDENT SYSTEM



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Alternative No. 2
Process Schematic

figure **3.4**

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TABLE 3.4
Cost Estimates
Alternative 2 - Klondike River Source

A. Capital Costs Estimate		
Intake and Pipeline		$80,000
Low Lift Pumpstation		$75,000
Treatment Plant		
Building		$250,000
Treatment Units		$580,000
Chemical System		$40,000
Transfer Pumping		$40,000
Pipeline		$30,000
Contingencies		$100,000
	Subtotal	$1,155,000
	Engineering	$140,000
	Total	$1,385,000
B. Operating Cost Estimates Per Annum		
Power		$70,000
Labour		$45,000
Parts and Equipment		$18,000
	Total	$133,000

It is apparent from the above capital and operating costs that the well system is the most attractive alternative. The wells offer a warmer water supply (refer to Section 4.0) which means much less heating and are less susceptible to pollution. An aquifer evaluation should be started to determine the best location of the new wells.

3.3.5 Distribution Pumping and Reservoir

To be able to meet the system pressures in the north end of the community the pressure discharge from the pumphouse will have to be increased to 200 feet (85 psi). The existing pumps are unable to handle this additional pressure and will be required to be changed when the northern end of town is constructed. As well, the efficiency of the pumps can be increased now that we have a firm understanding of the flows. It is proposed that the three distribution pumps be replaced with three variable speed pumps.

The fire pump will also need to be replaced to meet the new fire flows plus system usage. This will be a 226 l/s pump at a pressure of 85 psi. This pump will be larger than the existing but will be able to fit into the existing piping configuration.

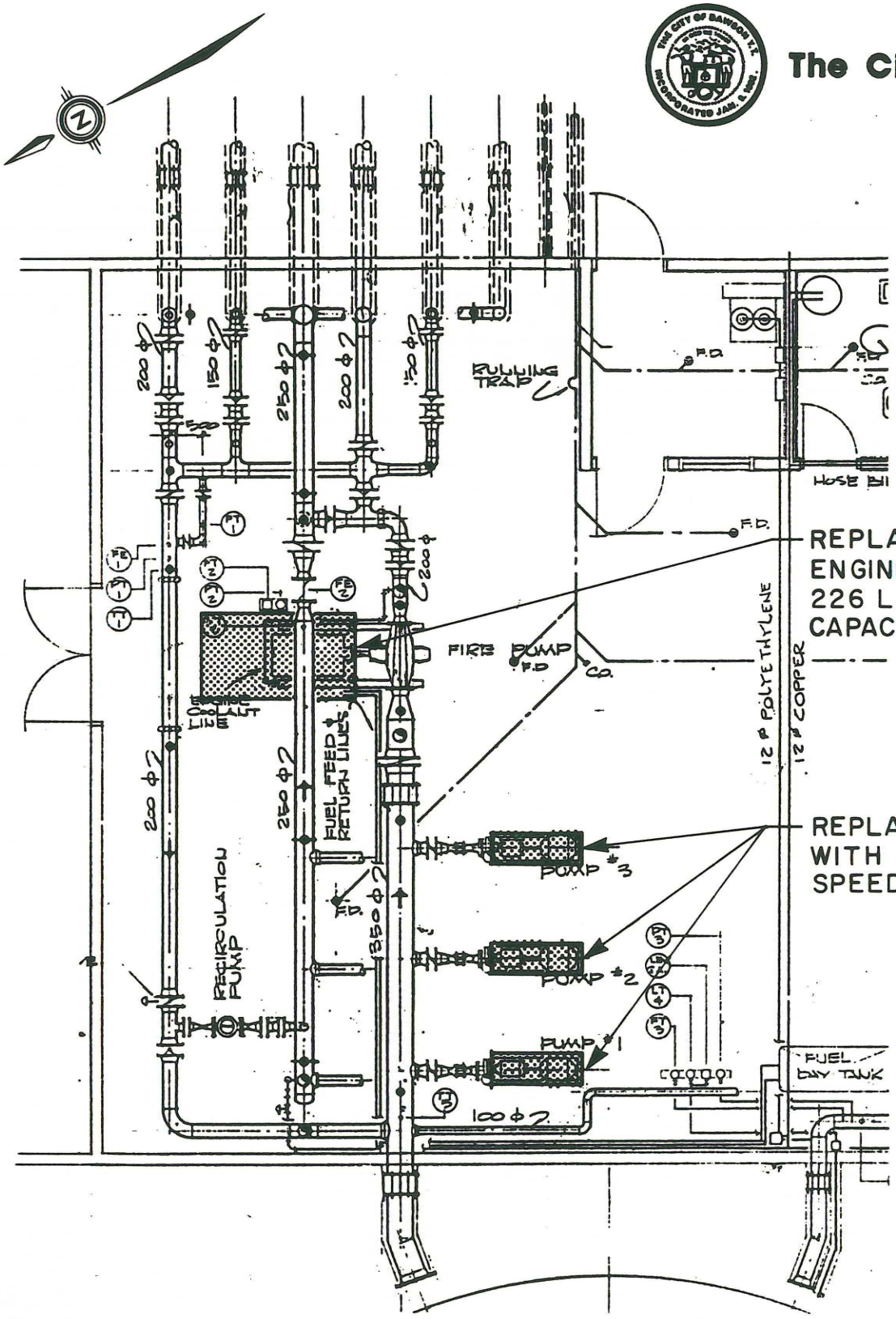
The remaining portion of the piping in the pumphouse will not be affected and will continue to be recirculated as it is presently being operated.

The controls for the new variable speed pumps will replace the existing starters and controls. New recording equipment will be added as well as computer control logic and operations system. Refer to Figure 3.5 for an outline of the pumphouse modifications.

TABLE 3.5
Capital Cost Estimates
Pumphouse and Reservoir Modification

A. Capital Cost Estimates		
Variable Speed Distribution Pumps		$70,000
Fire Pump		$80,000
Piping Changes		$60,000
Controls and Recording		$70,000
Building Modifications		$60,000
Reservoir Addition		$120,000
Contingencies		$50,000
	Subtotal	$510,000
	Engineering	$60,000
	Total	$570,000

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1991 Water and Sewer Study

Pumphouse Modifications

figure **3.5**

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The reservoir will need to be increased in size to be able to provide a two hour fire fighting storage. This will require 1,000,000 litres (240,000 gallons) of usable storage. The existing reservoir supplies 714,000 litres (170,000 imperial gallons) of usable storage. Therefore, the additional usable storage is 286,000 litres (70,000 imperial gallons). This will require a new tank that is a minimum of 8 meters in diameter and 9.75 meters in height. The height must match the existing tank, refer to Figure 3.6 for reservoir site plan. Table 3.5 outlines the estimated cost for the required pumphouse and reservoir modifications.

3.4 Water Distribution Systems

The distribution system is a looped recirculating system and as expansion continues the return loop system will be increased. The system will grow from a defined looped system to a inter-looped system where one loop will join another loop within the distribution system. Refer to Figure 3.7.

The valve chamber will continue to control the rate of flow to each loop within its control area as will the pumphouse control valves. The system pressure will be increased so that the northern end of the community will receive sufficient pressure. The system is capable of this pressure increase.

A computer simulation of the system was done for the worst case scenario of fire flow plus daily usage for the far northern end of the system. This indicated that the system could handle the increased flow and pressure for the community. Refer to Appendix "B" for a printout of the system. The program used was "Water".

The extension of the system to the north area is outlined in detail in the study "Northern Expansion Area 1991". The water distribution system will not need to be expanded beyond the northern area according to OCP since the remaining population growth will be accommodated by infill and multiple housing units. The only addition to the system will be minor extensions to handle the lots located on Eighth Avenue and Seventh Avenue.

There are certain parts of the existing system which will require upgrading over the next few years. They are as follows:

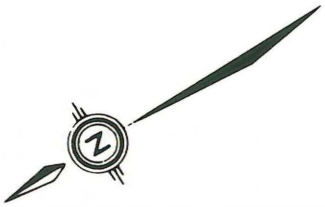
- when a hydrant is being repaired or dug up it should be reinstalled according to the new design presently in use;

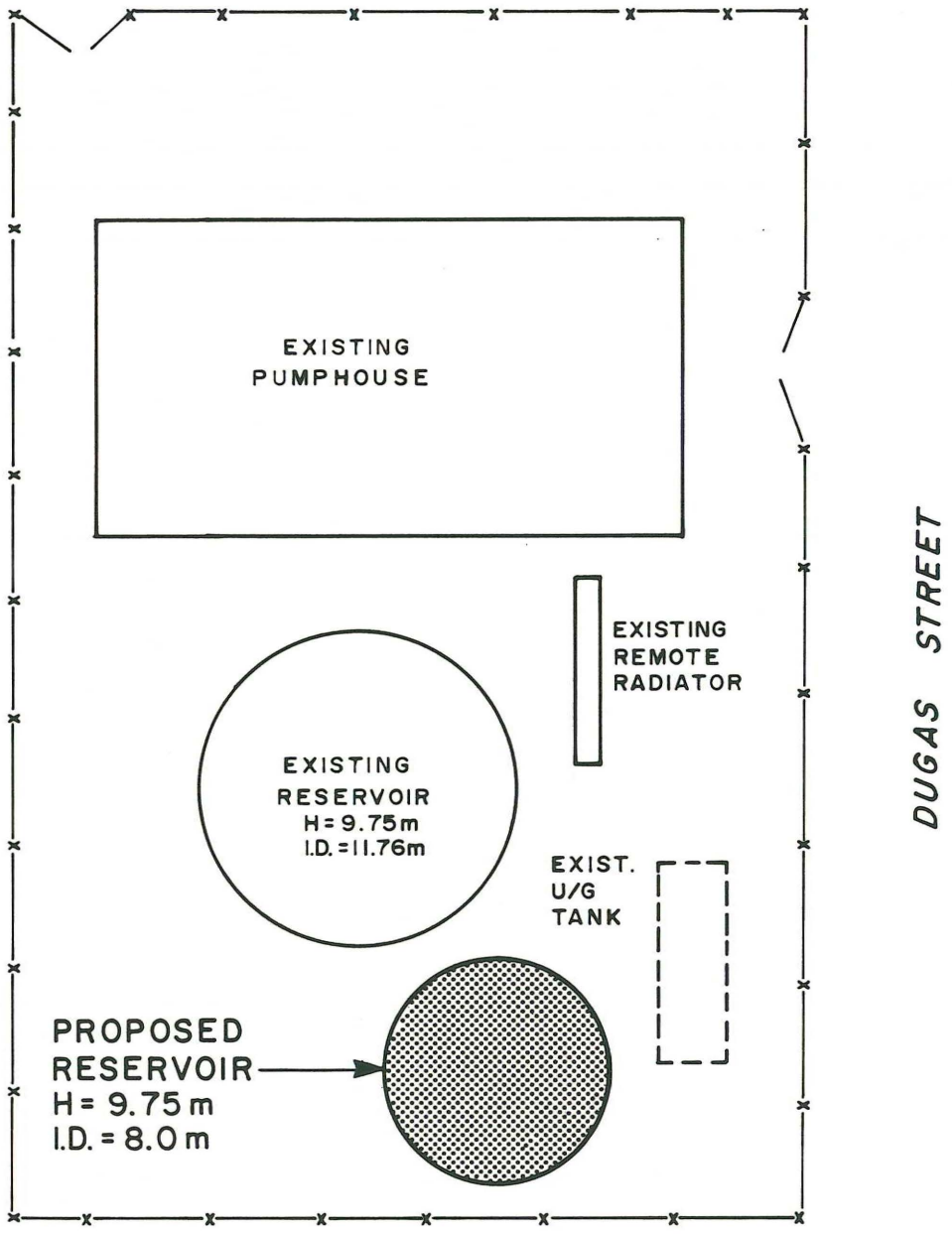
- the piping going into the valve chamber should be dug up and the steel pipe extended and adequately supported. The pipe has been shifting considerably due to the drainage problems and the continued degradation of the permafrost;

- when new house connections are installed the limiting heat trace should be installed and the new design for the service connections used;

Listed in Table 3.6 is the Capital Cost Estimates for the Northern Expansion Area and infill for Seventh Avenue and Eighth Avenue. These costs include water, sewer, utilities where required and road work.

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1991 Water and Sewer Study

Reservoir Addition Site Plan

figure 3.6

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TABLE 3.6
Capital Cost Estimate
System Expansion

A. Northern Expansion Area	
1. Trenching	$21,8000
2. Sanitary Sewers	$254,000
3. Watermain	$279,000
4. Services	$421,000
5. Roads	$150,000
6. Drainage	$260,000
7. Legal Survey	$55,000
8. Power and Telephone	$50,000
9. Administration	$60,000
10. Engineering and Contingencies	$403,000
Total	$2,150,000
B. Eighth Avenue Extension	
1. Water/Sewer Mains	$50,000
2. Water Main Only	$15,000
3. Service/Misc.	$31,000
4. Engineering and Contingencies	$15,000
Total	$111,000
C. Seventh Avenue Extension	
1. Water and Sewer Main	$150,000
2. Services	$50,000
3. Engineering and Contingencies	$40,000
Total	$240,000

3.5 Cost Estimates

Cost estimates are summarized from the previous sub-sections with the recommended alternatives.

TABLE 3.7
Summary Recommended
Estimated Capital Costs

A. Expand Well System	$620,000
B. Distribution Pumping and Reservoir Modification	$570,000
Subtotal	$1,190,000
C. Water/Sewer Distribution System	
(i) Northern Expansion Area	$2,150,000
(ii) Eighth Avenue Extension	$111,000
(iii) Seventh Avenue Extension	$240,000
Subtotal	$2,501,000

3.6 Conclusion

The following conclusions have been made from this study:

1. The water usage is higher than it should be due to excessive bleeding and no control over water use;

2. Fire flows have increased due to construction of larger buildings;

3. The water system will be extended to the north with acceptable water pressure and flows;

4. The future water needs to be obtained from wells.

3.7 Recommendation

1. When the Klondike River is not required as a back-up water source, meters should be installed to keep water use in check. A sliding scale of water charges should be adopted for charge-out rates.

2. A study be undertaken to determine the cost of reinstalling the water meters, type of meters and to recommend a new rate recovery charge.

3. All commercial and industrial buildings be required to install sprinkler systems.

4. A well development program be initiated immediately to determine the well supply capabilities.

5. A new fire pump be installed.

6. New service pumps be installed over the new next few years as the northern areas are developed.

7. A reservoir addition be completed to bring the storage capacity up to the needed requirements.

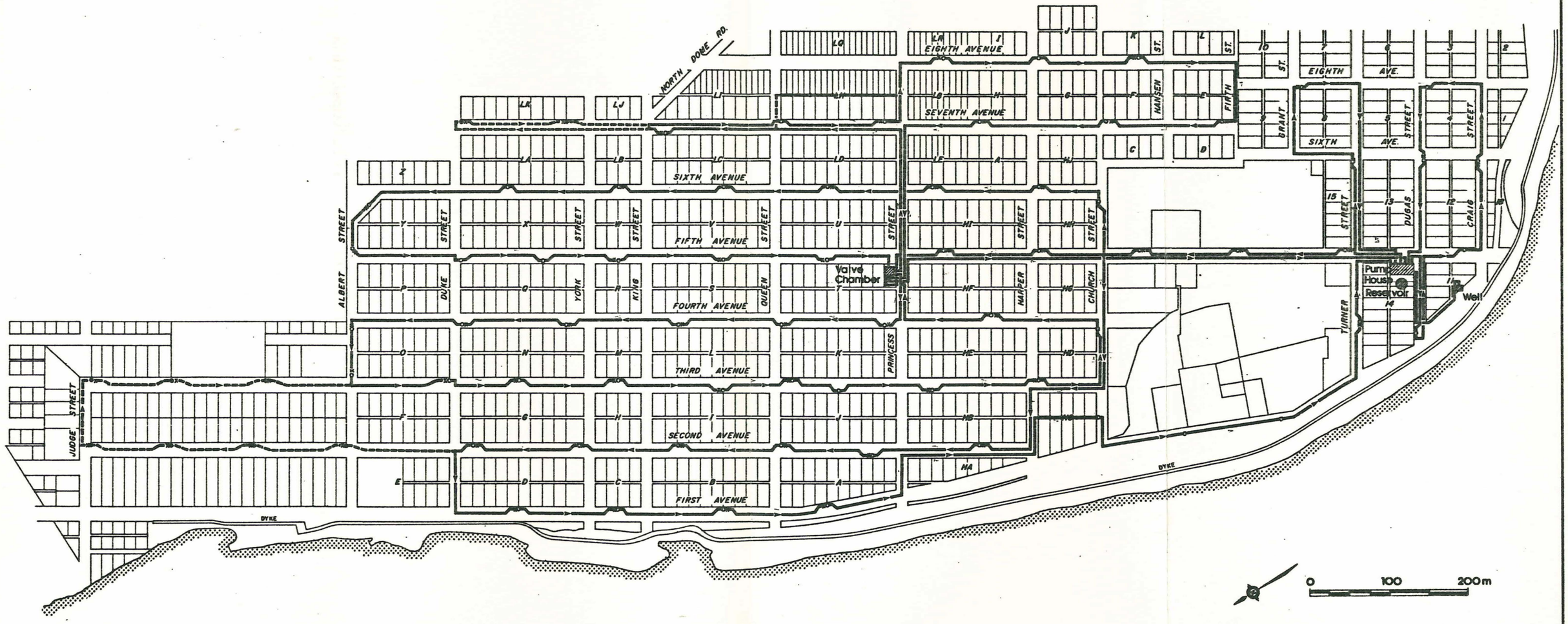
8. Water expansion within the system be done along with sewer extensions as required for growth. The immediate areas being Seventh Avenue and Eighth Avenue extensions. Northern Expansion Area planning and design to be done in 1992.

Legend

Existing Distribution System

Future Distribution System

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1991 Water and Sewer Study

Water Distribution System

figure **3.7**

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SECTION 4 WATER DISTRIBUTION HEATING

4.1 Introduction

During the course of the study and based on the heat supply during the 1990/1991 winter season it became apparent that the system was not getting the needed waste heat from the power plant. Therefore the City expanded the study to evaluate the existing heat supply from the power plant and to determine if it could meet the future water demands. As well, the heating system evaluation was to consider the case where the power plant was taken out of operation due to the power supply being brought over from Mayo.

Attached in Appendix "C" is the master agreement and the subsidiary agreement of April 1983. Based on the information presented in the following section discussions with Yukon Electric and NCPC will need to take place so as to provide the needed waste heat in the future years.

4.2 Objectives

This section of the 1991 water and sewer study has the following objectives:

(a) to evaluate the existing heat exchange system between the Power Plant and the pumphouse reservoir, and determine why the present flows through the water system cannot be heated to the required 4.0 C.;

(b) to evaluate the available waste heat at the Power Plant and outline proposed modifications to the existing heat exchange system to make more waste heat available for heating the water system. This is referred to as Heating Alternative No.H1;

(c) to evaluate use of heating boilers for heating the water system without waste heat from the Power Plant and demonstrate the energy impact and estimated operating cost of fuel. Identify other potential sources of heat for further study. This is referred to as Heating Alternative No.H2.

The following list of figures and schematics are referred to within this section of the report and are not listed separately in the index.

LIST "A"

Figure No.1a / Table No.1a

Figure No.1b / Table No.1b

Figure No.2a / Table No.2a

Figure No.2b / Table No.2b

Figure No.3a / Table No.3a

Figure No.3b / Table No.3b

Figure No.4 / Table No. 4

Schematic No.1 Existing Power Plant

Schematic No.2 Existing Pumphouse

Block Schematic No.3 Alternative No.H1-Option "A"

Block Schematic No.4 Alternative No.H1-Option "B" Sheet 1 of 2

Block Schematic No.4 Alterative No.H1-Option "B" Sheet 2 of 2

Block Schematic No.5 Alternative No.H2 1.

LIST "B"

Figure Titled DAWSON GENERATION

Figure Titled DAWSON GENERATION

Figure Titled DAWSON DEMAND

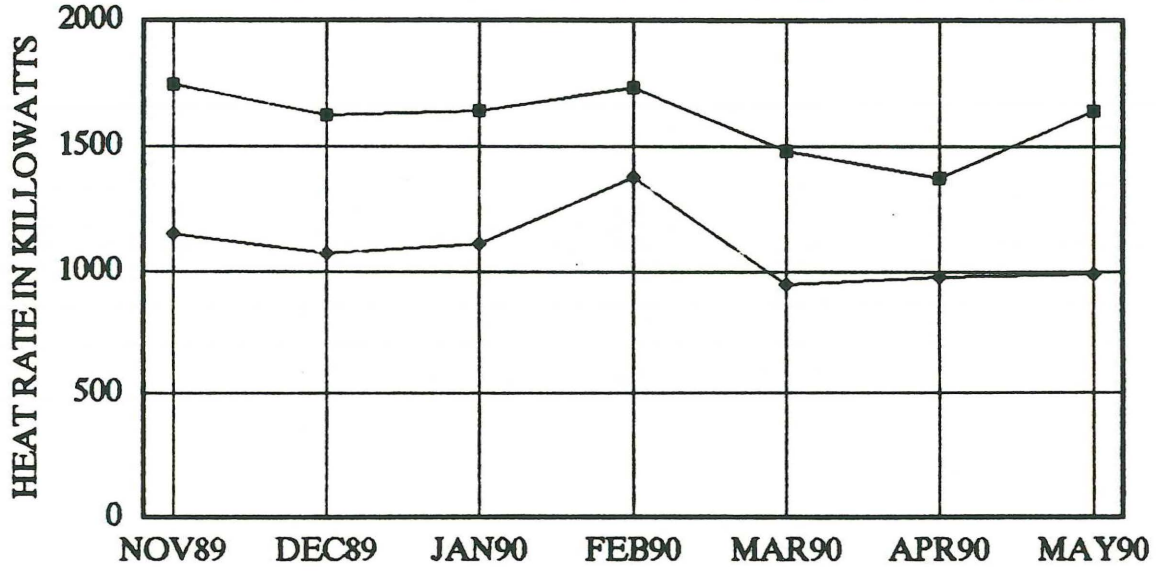
Figure Titled DAWSON PEAK DEMAND

Figure Titled DAWSON FUEL EFFICIENCY

Figure Titled DAWSON FUEL EFFICIENCY

FIGURE No.1a

POWER PLANT – HEAT REJECTION TO ENGINE COOLANT



Heat Rejection During Peak Power Demand

Average Heat Rejected Based on Power Generated

Estimated Heat Rejected To Engine Coolant Based On Peak Power Demand and Generation Data (November 1989 to October 1990)

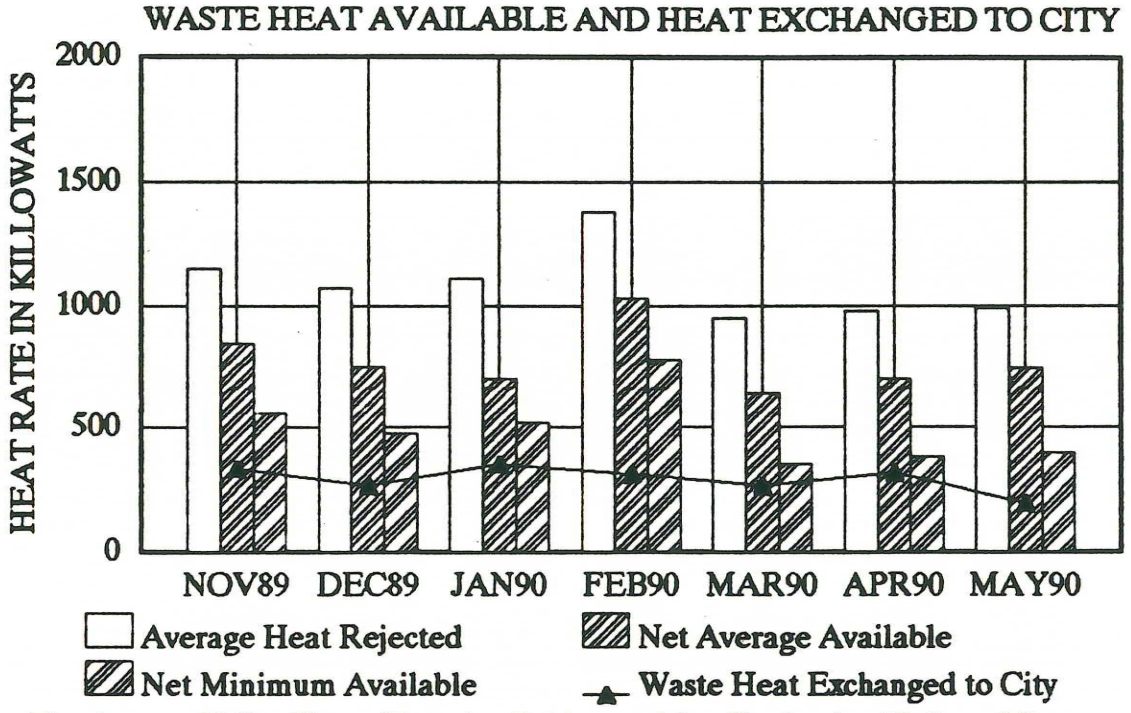
TABLE No.1a - DATA SHOWN BY FIGURE No.1a

Month / Year:	NOV89	DEC89	JAN90	FEB90	MAR90	APR90	MAY90
HEAT REJECTION DURING PEAK DEMAND (KW):	1742.6	1623.5	1641.2	1729.4	1482.4	1376.5	1641.2
AVG. HEAT BASED ON (kWhrs) GEN'D (KW):	1152.0	1073.3	1114.8	1380.0	948.8	977.9	992.6

a) Average Heat Nov89 to May90 (KW): 1091.3

b) Max. Heat Nov89 to May90 (KW): 1380.0

FIGURE No.1b



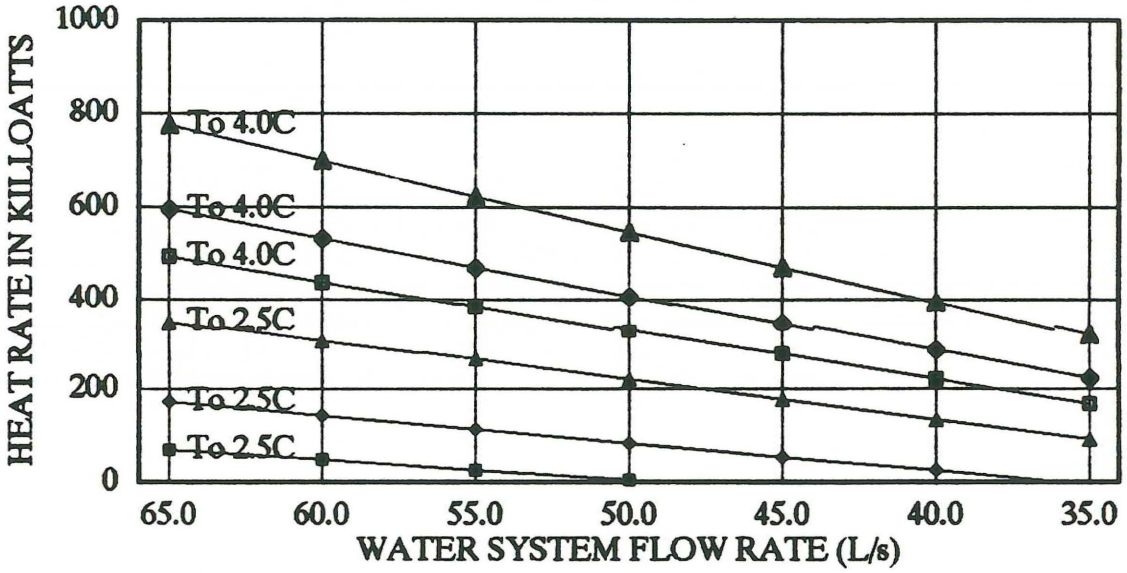
Net Avg. and Min. Waste Heat Available are After Deducting Estimatd Power Plant Needs For Warming "OFF–LINE" Engines, Radiators and Building Heat.

TABLE No.1b - DATA SHOWN BY FIGURE No.1b

Month / Year:	NOV89	DEC89	JAN90	FEB90	MAR90	APR90	MAY90
AVG. HEAT BASED ON (kWhrs) GEN'D (KW):	1152.0	1073.3	1114.8	1380.0	948.8	977.9	992.6
EST. NET AVG. HEAT AVAILABLE (KW):	846.2	746.2	702.3	1031.5	635.9	700.6	743.8
EST. NET MIN. HEAT AVAILABLE (KW):	554.6	475.9	517.4	782.6	351.4	380.5	395.2
EST. HEAT EXCHANGED TO CITY:							
a) AVERAGE (KW):	333.5	263.9	347.5	311.2	263.1	316.5	194.1
b) MAXIMUM (KW):	395.7	273.7	429.3	344.8	295.2	415.9	384.9
c) MINIMUM (KW):	251.5	254.1	264.3	279.2	232.9	258.8	63.6
NOV89 TO MAY90 MEAN (KW):	296.0						

FIGURE No. 2a

ADDITIONAL HEAT REQ'D FOR 2.5C OR 4.0C WATER



NEW WELL 1.5C BLENDED 1.1C RIVER WELL 0.5C

NEW WELL 1.5C BLENDED 1.1C RIVER WELL 0.5C

Heat Required In Addition to Estimated Average of 296 KW
of Waste Heat Presently Obtained From The Power Plant

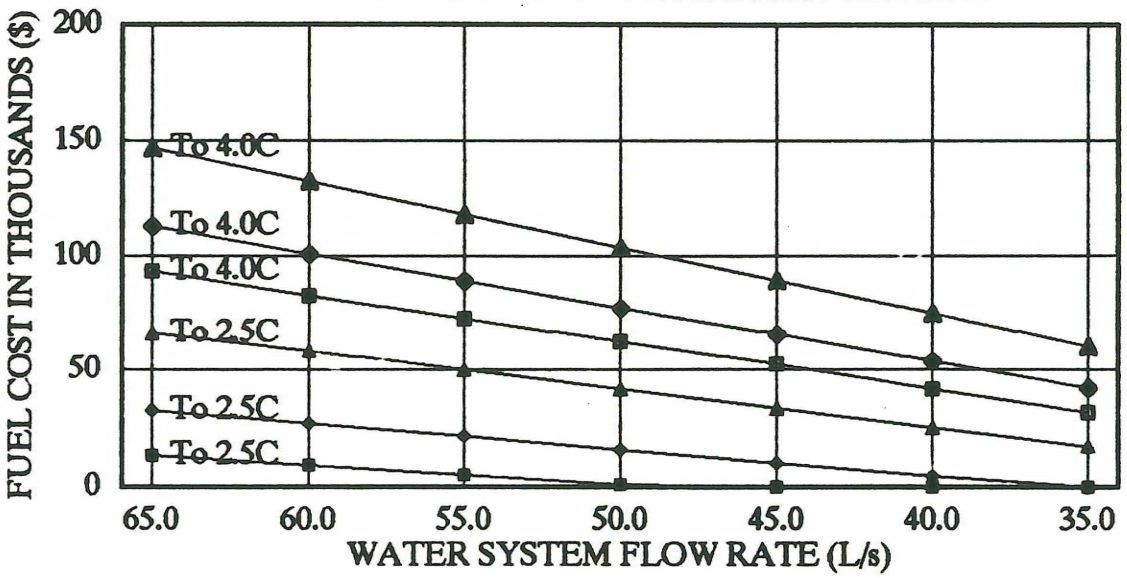
TABLE No.2a - DATA SHOWN BY FIGURE No.2a

ADDITIONAL HEAT REQ'D WITH 296(Kw) FROM
EXISTING POWER PLANT

Water System Flow (L/s):	65.0	60.0	55.0	50.0	45.0	40.0	35.0
New Well 1.5C to 2.5C (KW):	68.6	47.0	25.3	3.6	0.0	0.0	0.0
Blended 1.1C to 2.5C (KW):	171.4	141.8	112.3	82.7	53.1	23.6	0.0
River Well 0.5C to 2.5C (KW):	350.2	306.9	263.6	220.2	176.9	133.6	90.3
New Well 1.5C to 4.0C (KW):	491.8	437.7	383.5	329.4	275.2	221.1	166.9
Blended 1.1C to 4.0C (KW):	594.6	532.6	470.5	408.5	346.4	284.3	222.3
River Well 0.5C to 4.0C (KW):	773.4	697.6	621.8	546.0	470.2	394.4	318.6

FIGURE No. 2b

ANNUAL FUEL COST FOR ADDITIONAL HEAT



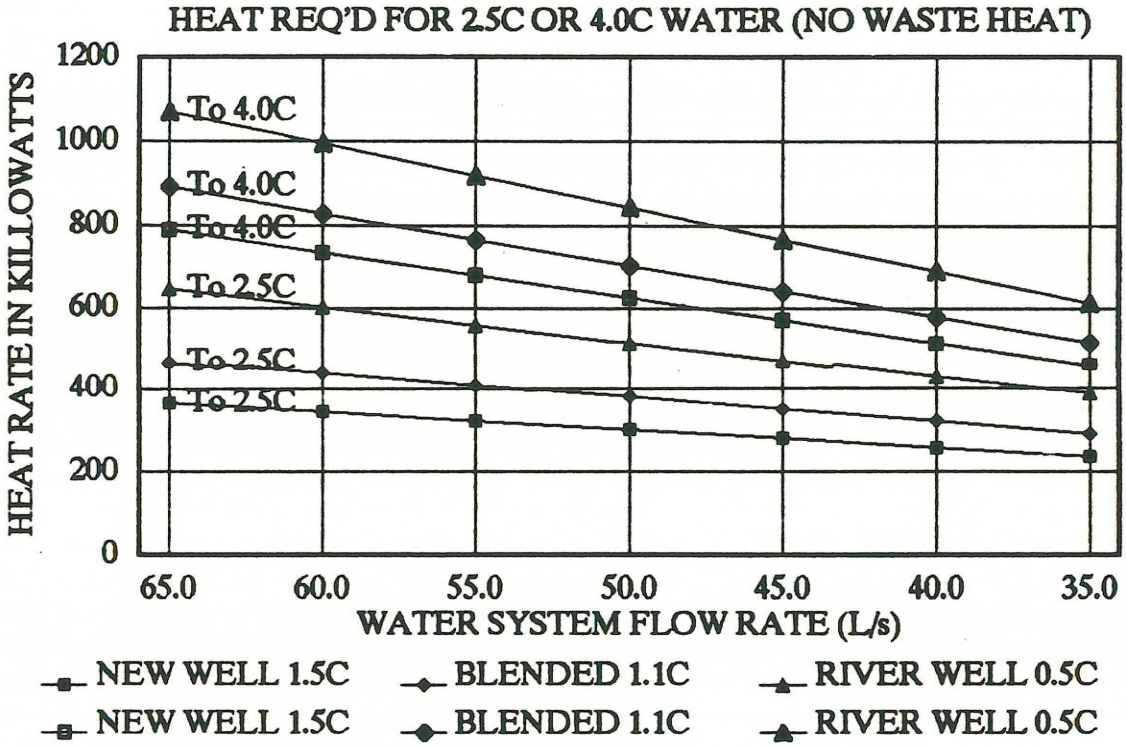
Based On 196 Days Heating Season (End Oct to Mid-May)
And Fuel Oil Cost $0.37 per Litre

TABLE No.2b - DATA SHOWN BY FIGURE No.2b

ADDITIONAL COST REQ'D WITH 296(Kw) FROM EXISTING POWER PLANT

Water System Flow (L/s):	65.0	60.0	55.0	50.0	45.0	40.0	35.0
New Well 1.5C to 2.5C ($):	13020.3	8910.2	4800.1	690.0	0.0	0.0	0.0
Blended 1.1C to 2.5C ($):	32522.7	26912.4	21302.1	15691.8	10081.5	4471.2	0.0
River Well 0.5C to 2.5C ($):	66451.6	58231.4	50011.2	41791.0	33570.8	25350.6	17130.4
New Well 1.5C to 4.0C ($):	93327.8	83052.6	72777.3	62502.1	52226.8	41951.5	31676.3
Blended 1.1C to 4.0C ($):	112830.3	101054.8	89279.4	77503.9	65728.5	53953.0	42177.6
River Well 0.5C to 4.0C ($):	146759.1	132373.8	117988.4	103603.1	89217.7	74832.4	60447.0

FIGURE No. 3a



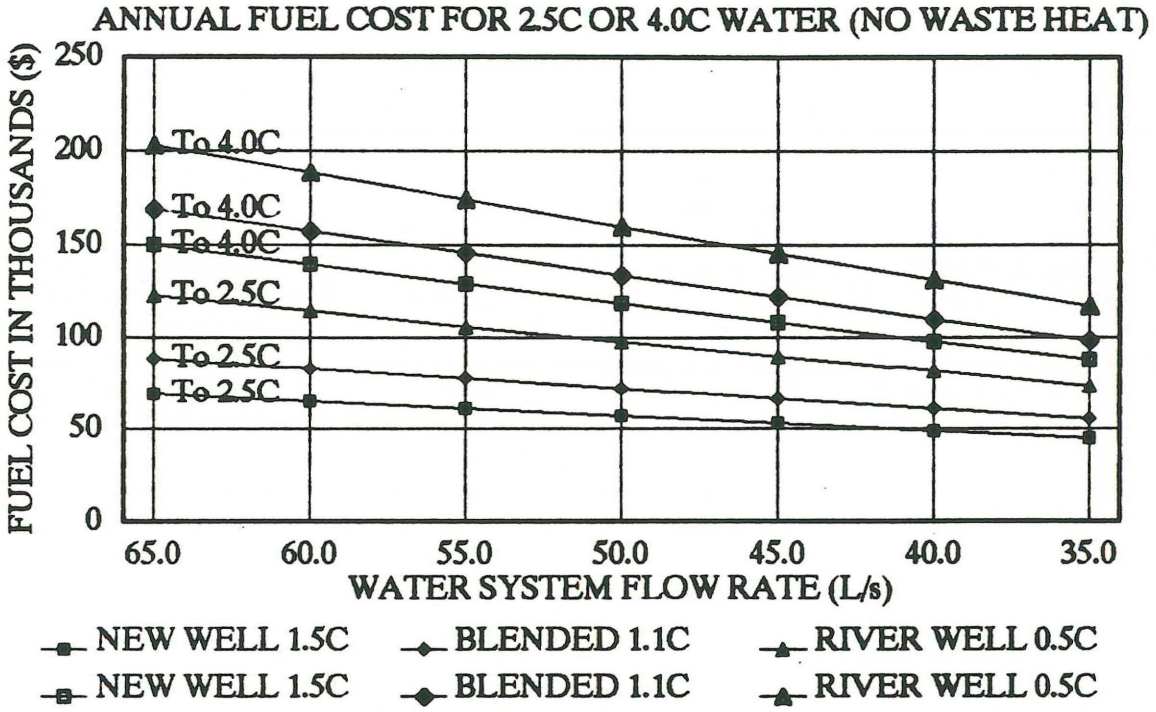
Heat Required Is Without Waste Heat From Existing Power Plant

TABLE No.3a - DATA SHOWN BY FIGURE No.3a

ADDITIONAL HEAT REQ'D WITHOUT WASTE HEAT
FROM EXISTING POWER PLANT

Water System Flow (L/s):	65.0	60.0	55.0	50.0	45.0	40.0	35.0
New Well 1.5C to 2.5C (KW):	364.6	342.9	321.3	299.6	278.0	256.3	234.6
Blended 1.1C to 2.5C (KW):	467.4	437.8	408.3	378.7	349.1	319.6	290.0
River Well 0.5C to 2.5C (KW):	646.2	602.9	559.6	516.2	472.9	429.6	386.3
New Well 1.5C to 4.0C (KW):	787.8	733.7	679.5	625.4	571.2	517.1	462.9
Blended 1.1C to 4.0C (KW):	890.6	828.6	766.5	704.4	642.4	580.3	518.3
River Well 0.5C to 4.0C (KW):	1069.4	993.6	917.8	842.0	766.2	690.4	614.6

FIGURE No. 3b



Annual Fuel Cost Is For Heating Without Waste Heat From Existing Power Plant. Based On 196 Days Heating (End Oct to Mid–May). Fuel Oil Cost $0.37 /Litre.

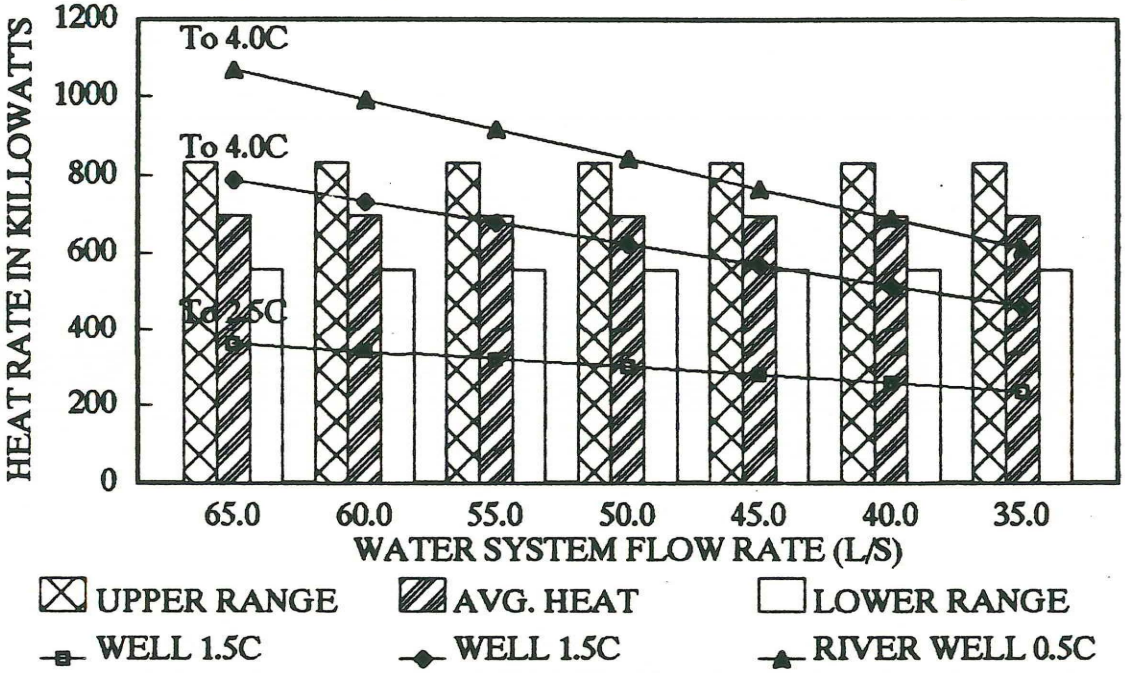
TABLE No.3b - DATA SHOWN BY FIGURE No.3b

ADDITIONAL COST REQ'D WITHOUT WASTE HEAT
FROM EXISTING POWER PLANT

Water System Flow (L/s):	65.0	60.0	55.0	50.0	45.0	40.0	35.0
New Well 1.5C to 2.5C ($):	69184.9	65074.8	60964.7	56854.6	52744.5	48634.4	44524.3
Blended 1.1C to 2.5C ($):	88687.4	83077.1	77466.8	71856.5	66246.2	60635.9	55025.6
River Well 0.5C to 2.5C ($):	122616.3	114396.1	106175.9	97955.7	89735.5	81515.3	73295.0
New Well 1.5C to 4.0C ($):	149492.5	139217.3	128942.0	118666.7	108391.5	98116.2	87841.0
Blended 1.1C to 4.0C ($):	168994.9	157219.5	145444.1	133668.6	121893.2	110117.7	98342.3
River Well 0.5C to 4.0C ($):	202923.8	188538.5	174153.1	159767.8	145382.4	130997.0	116611.7

FIGURE No.4

AVERAGE NET WASTE HEAT VERSES HEAT REQUIRED



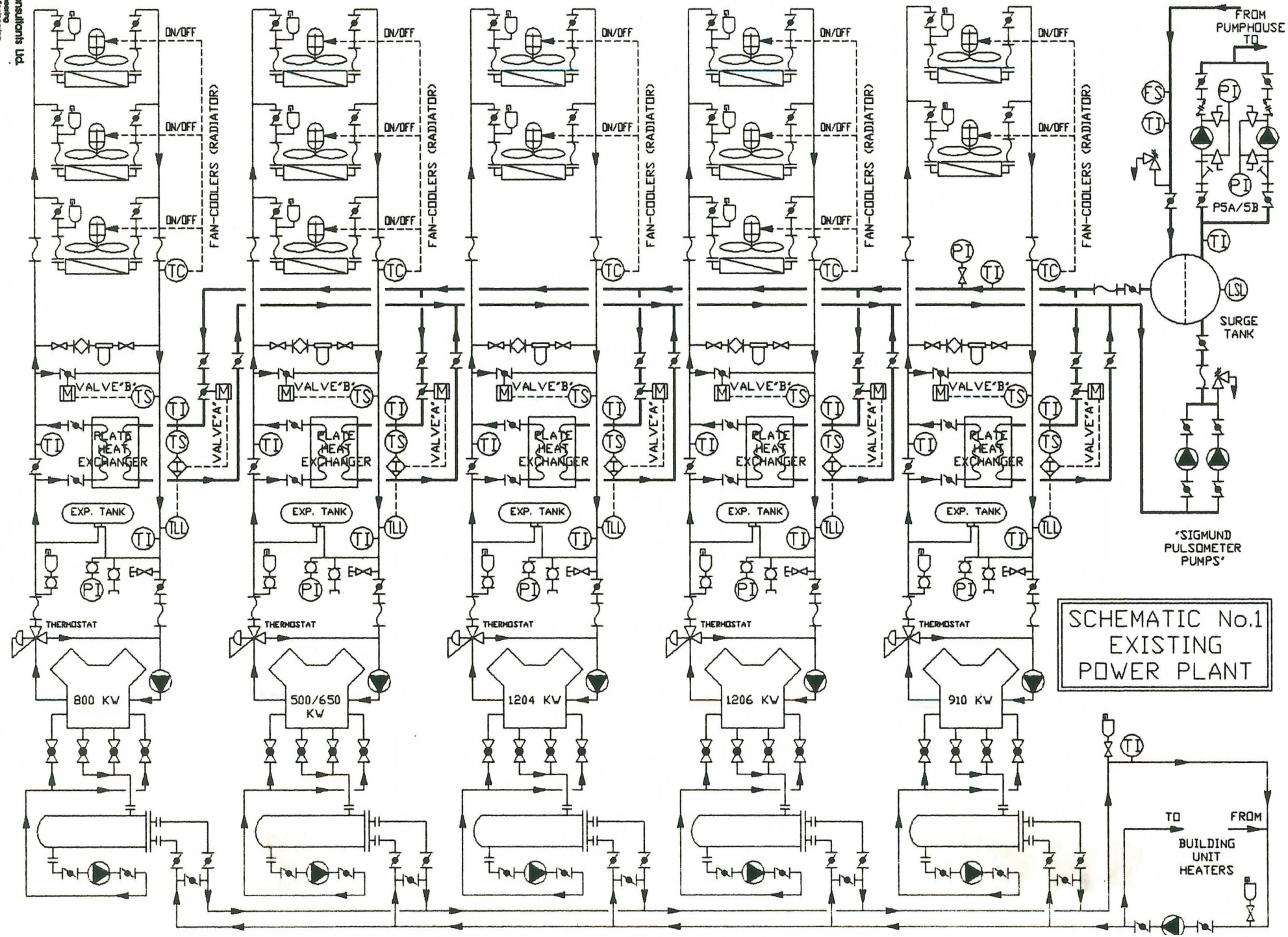
Upper Range and Lower Range Are Statistical Limits. Net Waste Heat Is (kW) That Would Be Made Available After System Modified.

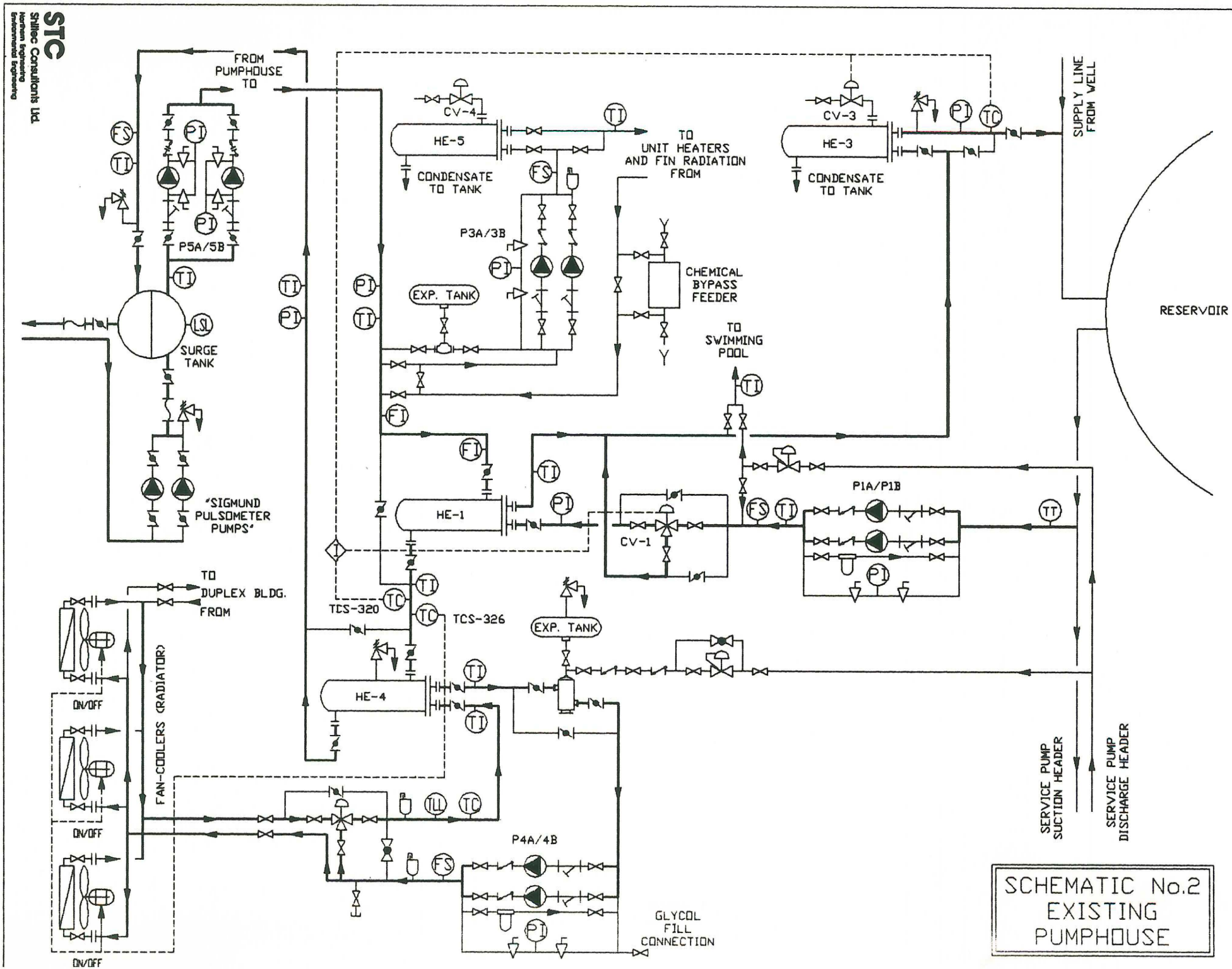
TABLE No.4 - DATA SHOWN BY FIGURE No.4

AVERAGE NET WASTE HEAT THAT COULD BE MADE AVAILABLE FROM FROM EXISTING POWER PLANT WITH PROPOSED MODIFICATIONS

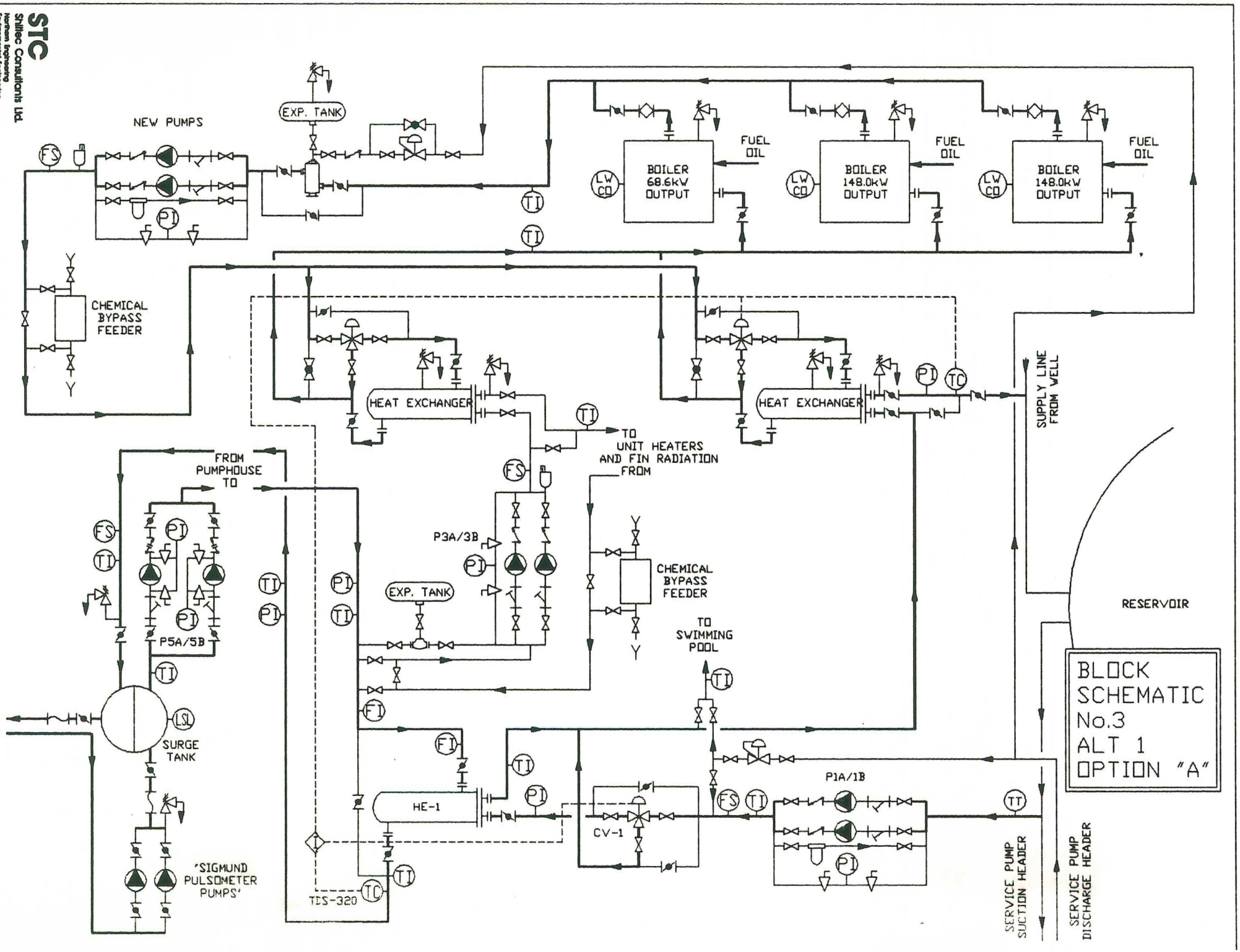
NET WASTE HEAT:							
AVERAGE HEAT (KW):	696.2	696.2	696.2	696.2	696.2	696.2	696.2
UPPER RANGE (KW):	832.8	832.8	832.8	832.8	832.8	832.8	832.8
LOWER RANGE (KW):	559.6	559.6	559.6	559.6	559.6	559.6	559.6
WATER SYSTEM REQUIREMENT:							
Water System Flow (L/s):	65.0	60.0	55.0	50.0	45.0	40.0	35.0
New Well 1.5C to 2.5C (KW):	364.6	342.9	321.3	299.6	278.0	256.3	234.6
New Well 1.5C to 4.0C (KW):	787.8	733.7	679.5	625.4	571.2	517.1	462.9
River Well 0.5C to 4.0C (KW):	1069.4	993.6	917.8	842.0	766.2	690.4	614.6

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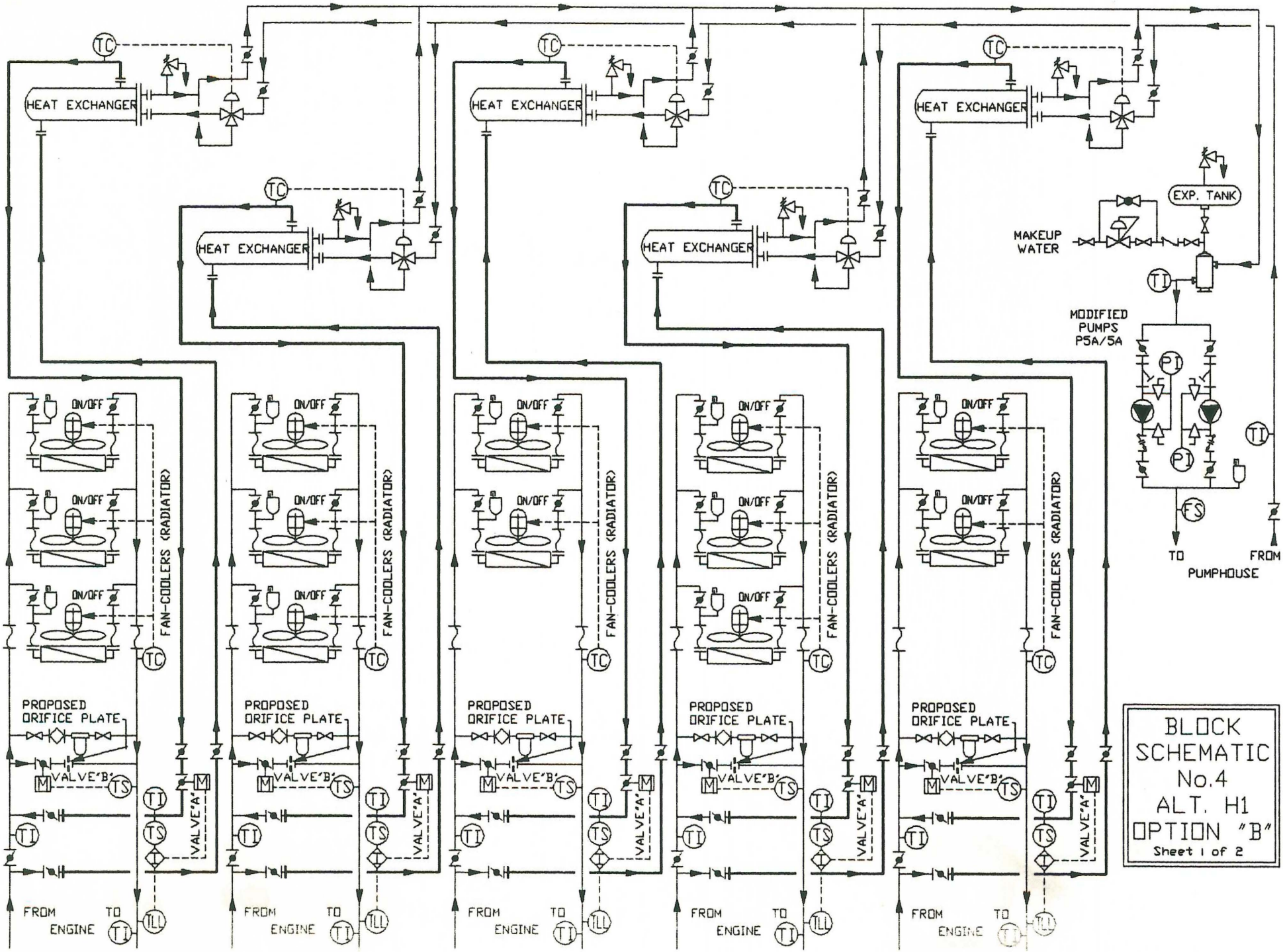



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FROM PUMPHOUSE
TO
P5A/5B
SURGE TANK
"SIGMUND PULSOMETER PUMPS"
CV-4
HE-5
CONDENSATE TO TANK
TO UNIT HEATERS AND FIN RADIATION FROM
P3A/3B
EXP. TANK
CHEMICAL BYPASS FEEDER
CV-3
HE-3
CONDENSATE TO TANK
SUPPLY LINE FROM WELL
RESERVOIR
TO SWIMMING POOL
HE-1
CV-1
P1A/P1B
TO DUPLEX BLDG.
FROM
TCS-320
TCS-326
EXP. TANK
HE-4
FAN-COOLERS (RADIATOR)
ON/OFF
ON/OFF
ON/OFF
P4A/4B
GLYCOL FILL CONNECTION
SERVICE PUMP SUCTION HEADER
SERVICE PUMP DISCHARGE HEADER
SCHEMATIC No.2
EXISTING PUMPHOUSE

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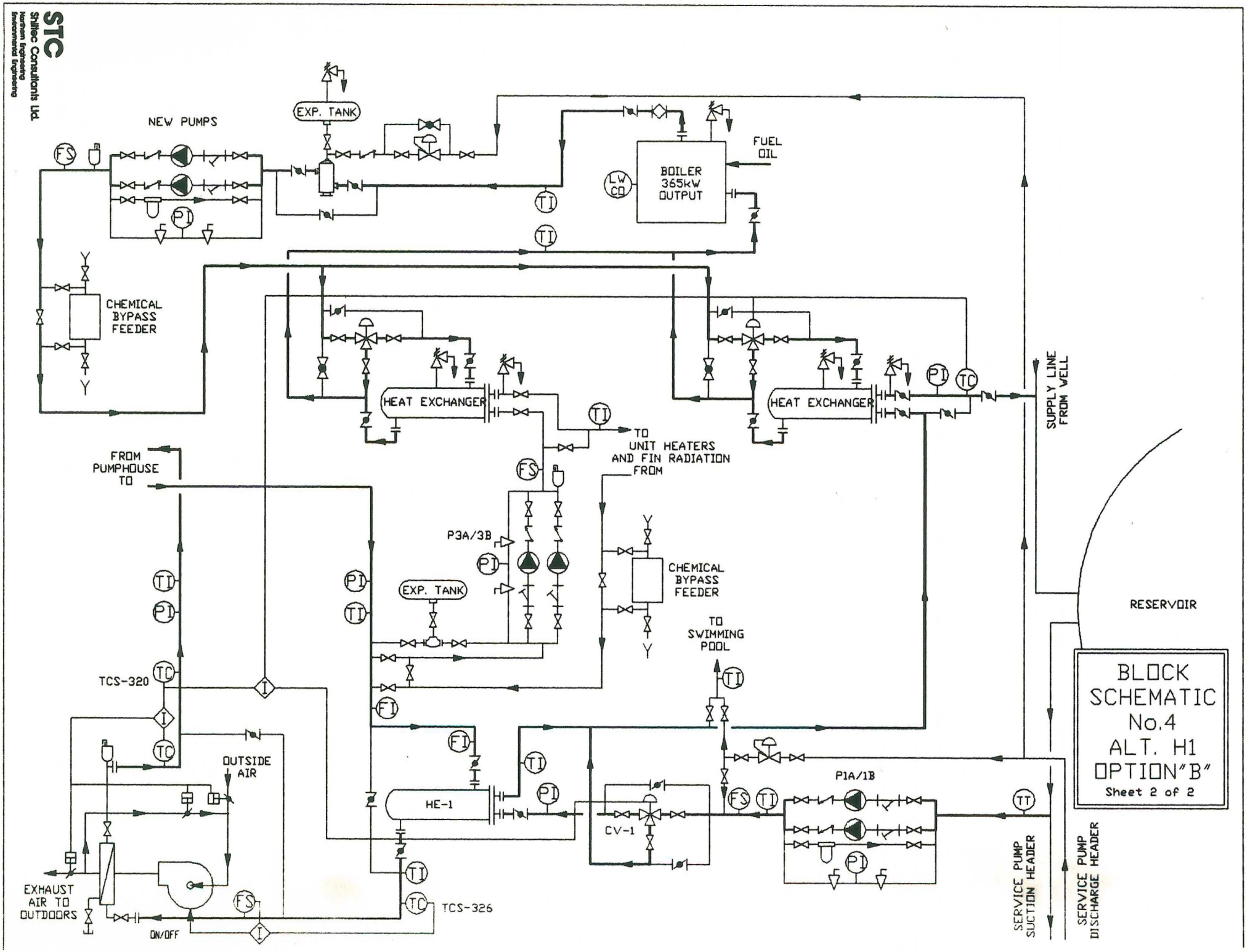


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Environmental Engineering

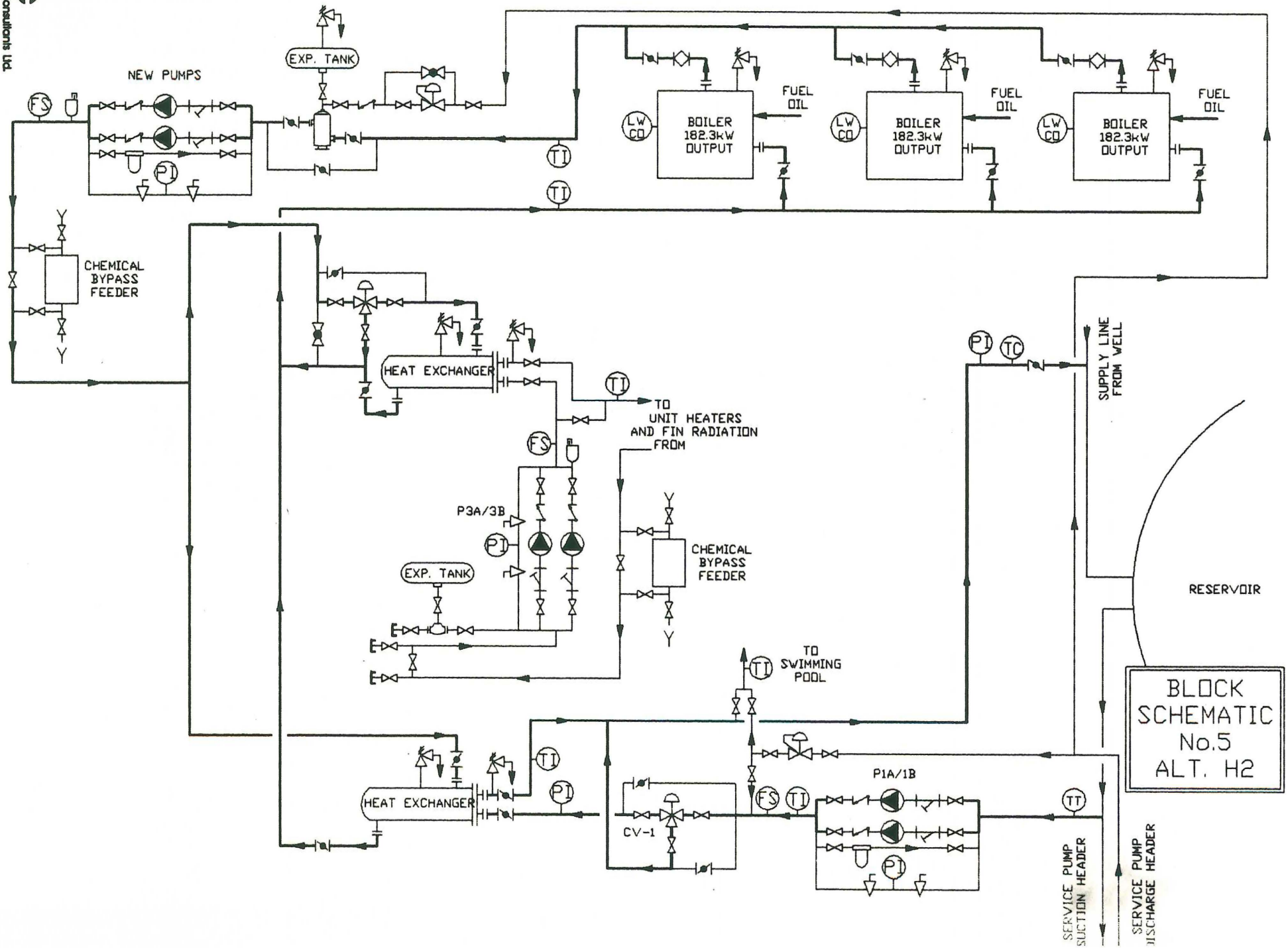


BLOCK SCHEMATIC No.4 ALT. H1 OPTION "B"

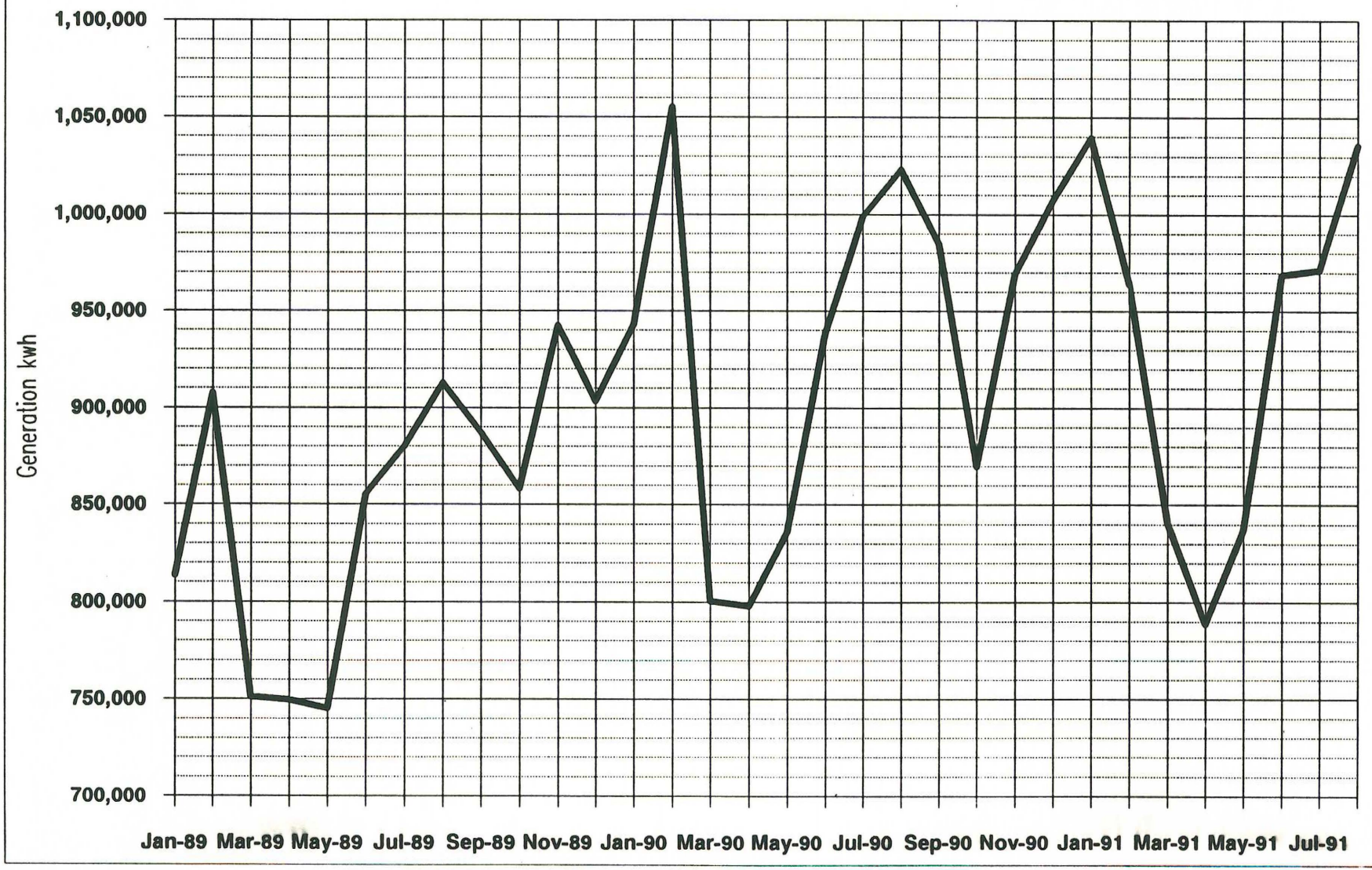
Sheet 1 of 2

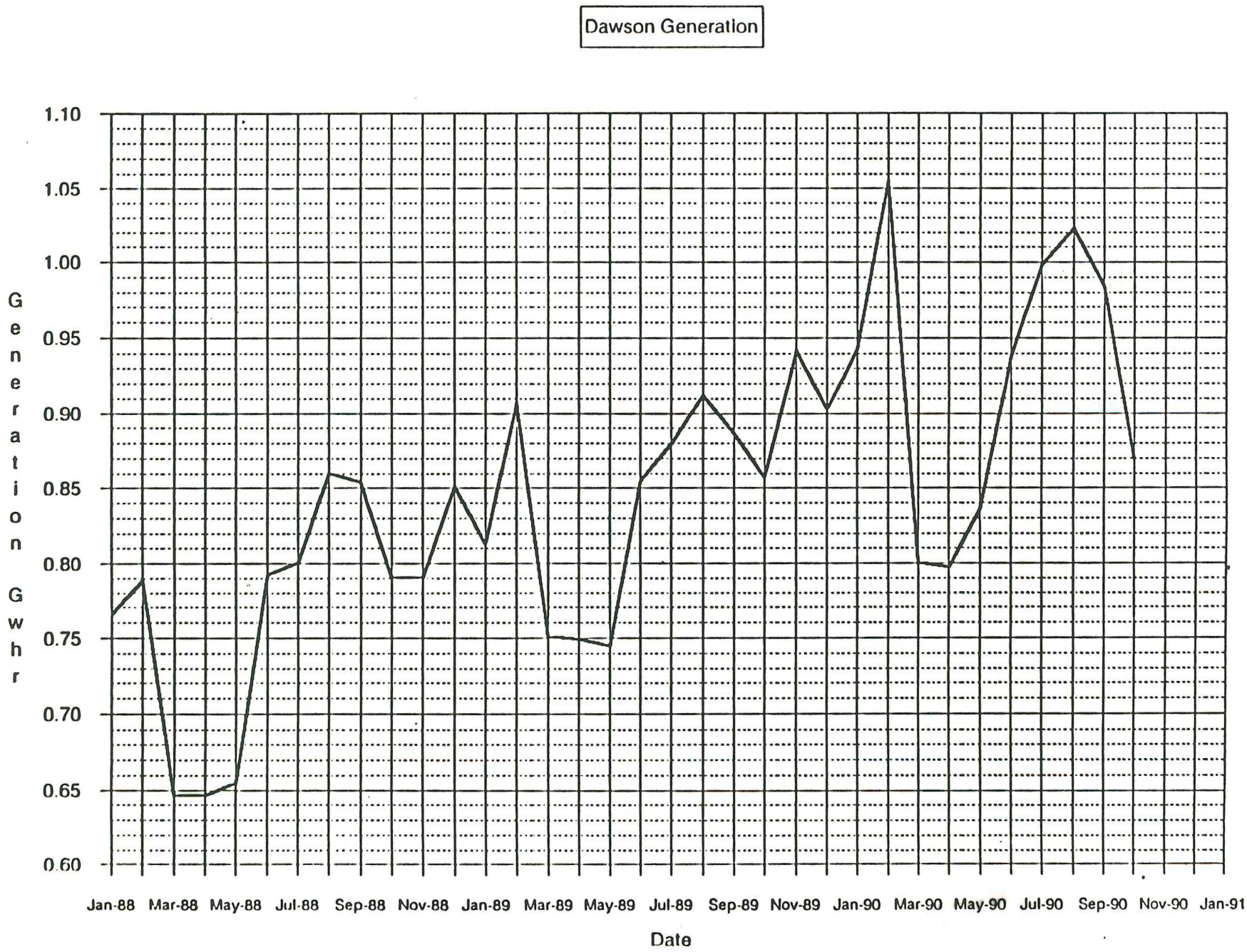

STC
Shilltec Consultants Ltd.
Northern Engineering
Environmental Engineering
NEW PUMPS
EXP. TANK
FUEL OIL
BOILER 365kW OUTPUT
LW CO
FS
PI
TI
CHEMICAL BYPASS FEEDER
HEAT EXCHANGER
HEAT EXCHANGER
TC
SUPPLY LINE FROM WELL
TO UNIT HEATERS AND FIN RADIATION
FROM
FROM PUMPHOUSE TO
P3A/3B
EXP. TANK
CHEMICAL BYPASS FEEDER
TO SWIMMING POOL
RESERVOIR
TCS-320
OUTSIDE AIR
HE-1
CV-1
P1A/1B
EXHAUST AIR TO OUTDOORS
ON/OFF
TCS-326
SERVICE PUMP SUCTION HEADER
SERVICE PUMP DISCHARGE HEADER
BLOCK SCHEMATIC No.4 ALT. H1 OPTION "B"
Sheet 2 of 2

STC
Shiltec Consultants Ltd.
Northern Engineering
Environmental Engineering



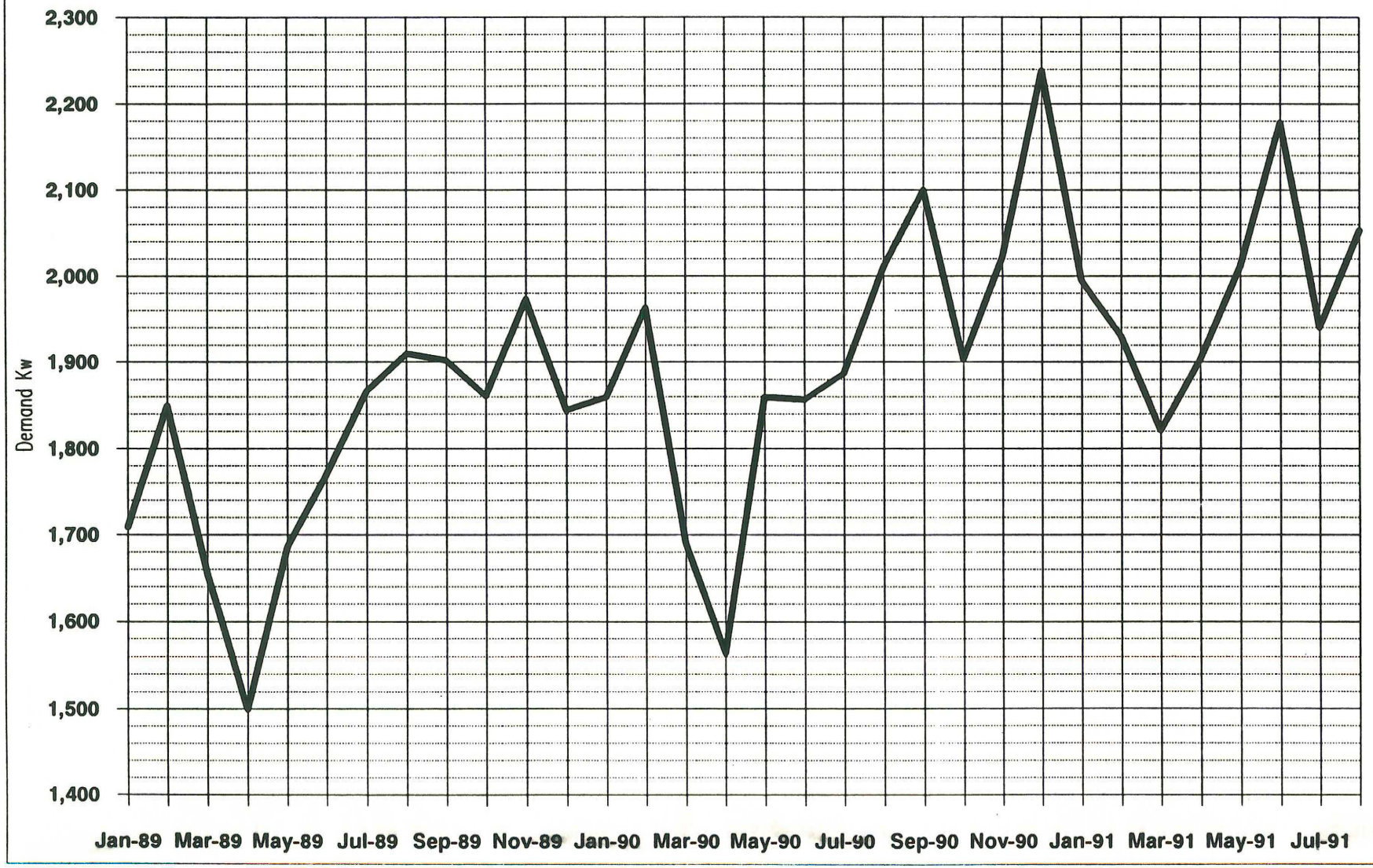
Dawson Generation

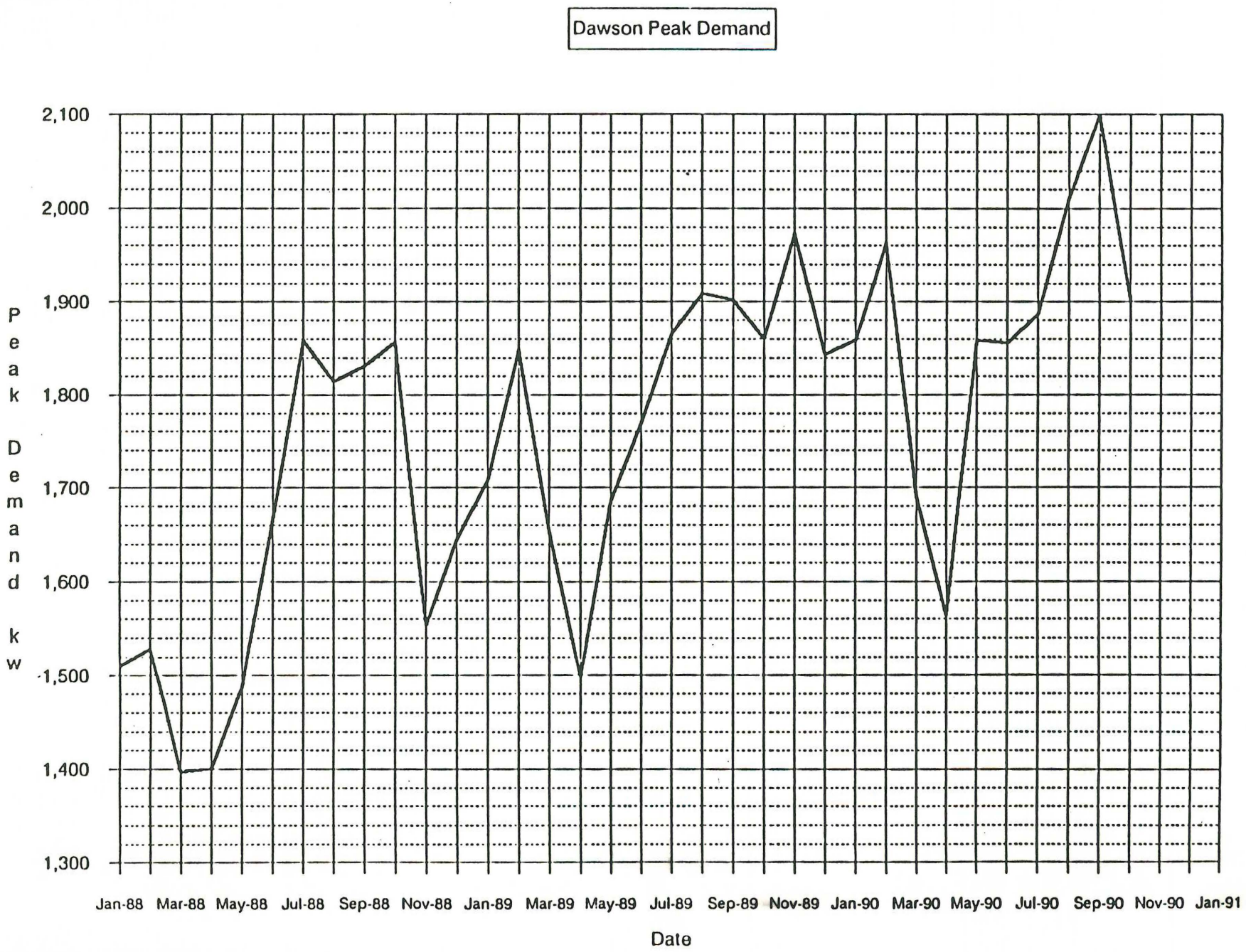



Dawson Generation
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Generation Gwhr
Jan-88
Mar-88
May-88
Jul-88
Sep-88
Nov-88
Jan-89
Mar-89
May-89
Jul-89
Sep-89
Nov-89
Jan-90
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Jan-91
Date

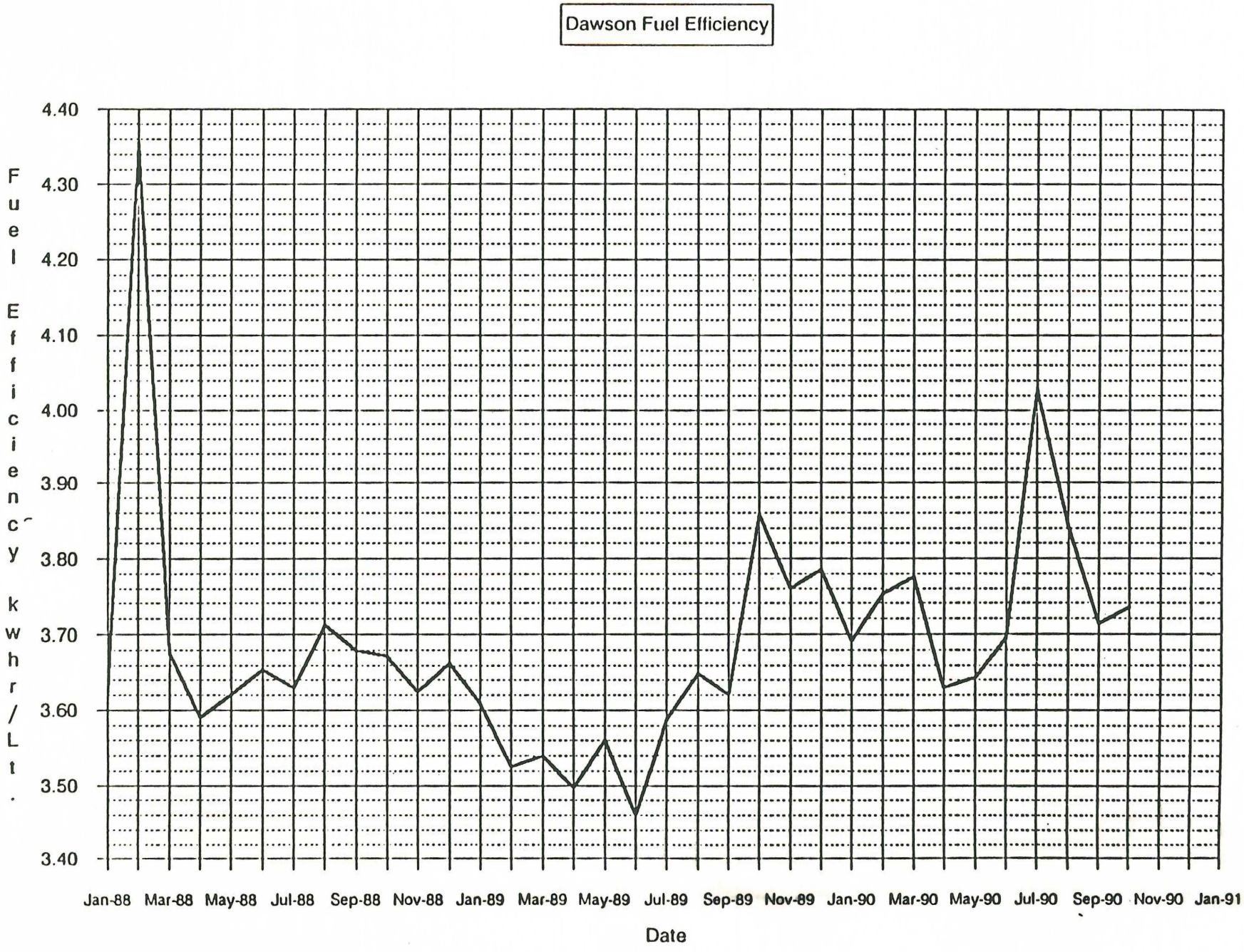
DAWGEN.XLC

Dawson Demand

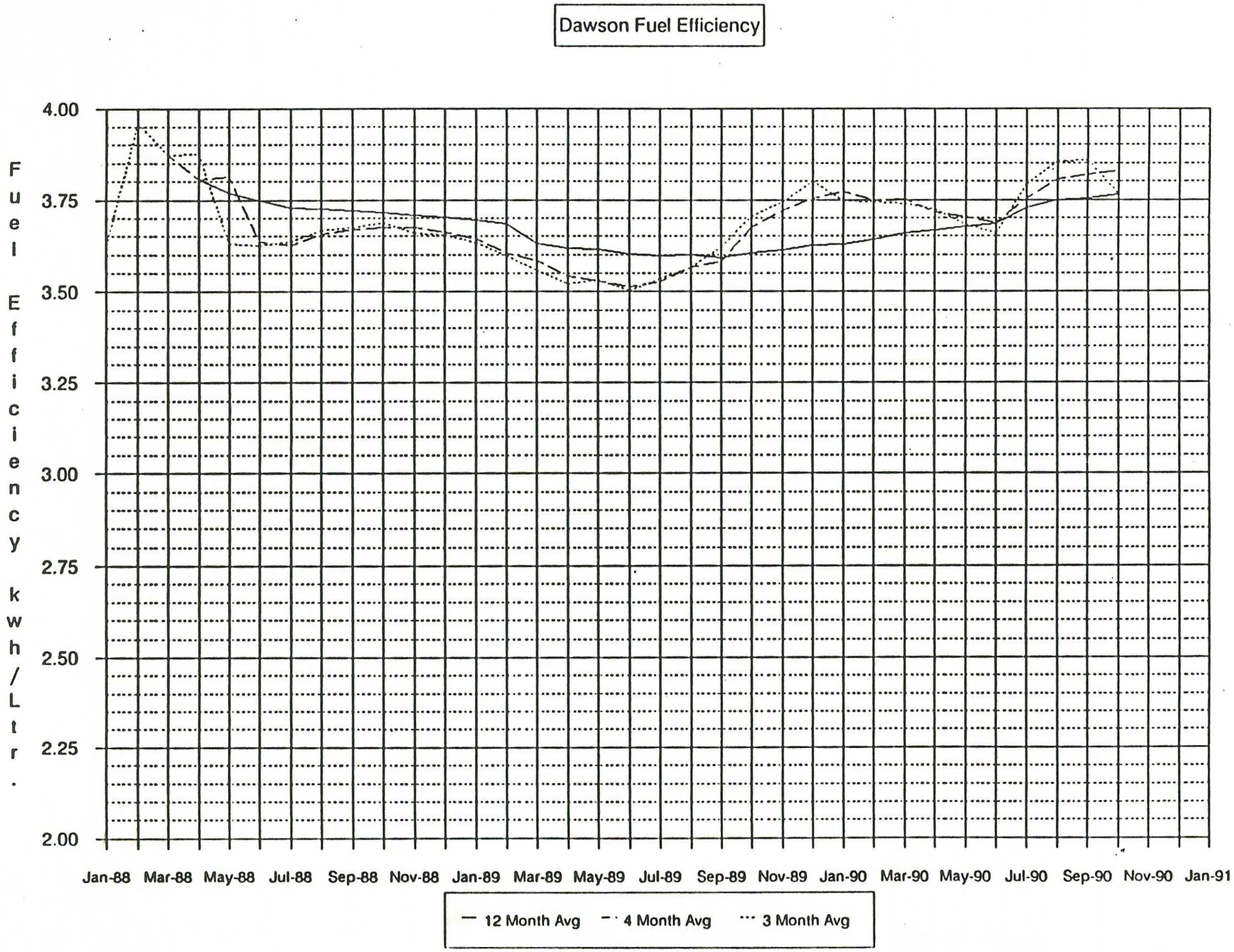



Dawson Peak Demand
2,100
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
Peak Demand kw
Jan-88
Mar-88
May-88
Jul-88
Sep-88
Nov-88
Jan-89
Mar-89
May-89
Jul-89
Sep-89
Nov-89
Jan-90
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Jan-91
Date

DAWPEAK.XLC


Dawson Fuel Efficiency
Fuel Efficiency kwhr/Lt.
4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
3.50
3.40
Jan-88
Mar-88
May-88
Jul-88
Sep-88
Nov-88
Jan-89
Mar-89
May-89
Jul-89
Sep-89
Nov-89
Jan-90
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Jan-91
Date

DAWEFF.XLC


Dawson Fuel Efficiency
Fuel Efficiency kwh/Ltr.
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
Jan-88
Mar-88
May-88
Jul-88
Sep-88
Nov-88
Jan-89
Mar-89
May-89
Jul-89
Sep-89
Nov-89
Jan-90
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Jan-91
12 Month Avg
4 Month Avg
3 Month Avg

DAWEFF.XLC

4.3 Study Criteria

The following criteria has been used for Heating Alternative No.H1 and No.H2:

(a) heat the present flow rate of 38 l/s well water from 1.5 C. to 4.0 C.;

(b) heat the future design flow rate of 65 l/s well water from 1.5 C. to 2.5 C.; and

(c) provide standby/supplemental heating boiler capacity.

The following criteria has been used only for Heating Alternative No.H2:

(a) Electrical power service to Dawson City after 1995 will be via a proposed transmission line from the Hydroelectric Power Generating Plant located near the Village of Mayo, Yukon Territories. Yukon Electrical advised that the cost of this proposed transmission line is roughly estimated at 25 million dollars.

The Yukon Electrical Company Limited advised that service from this proposed power line would replace power generation in Dawson City in the year 1995 or later. The existing diesel engine Power Plant in Dawson City would definitely become automatic standby operation. Waste heat from the existing Power Plant at Dawson City would not be available for heating the City water system because the diesel generators would operate only during power outages in the service from Mayo.

Relocation of the existing Power Plant to another site and a new Hydroelectric Power Plant at Dawson City are other alternatives also being considered by The Yukon Electrical Company Limited as of the date of this report.

The existing Power Plant at Dawson City is owned by The Northern Canada Power Commission and is operated/maintained by The Yukon Electrical Company Limited.

4.4 Technology

4.4.1 General

Figure No.1a in List "A" is based on Dawson Power Plant historical data for the period November 1989 to May 1990 provided in graph format titled as *Dawson Demand, Dawson Generation, Dawson Peak Demand and Dawson Fuel Efficiency*. This data was provided by Yukon Electrical Company Limited and is included in List "B" of this report.

A Power Plant fuel efficiency of 3.75 kWhr per litre of fuel based on the *Dawson Fuel Efficiency* data and a Fuel Heating Valve of 11.03 kWhr per litre of fuel have been used in calculations to estimate the heat flow rate (kW) rejected into the diesel engine jacket cooling fluid. Yukon Electrical Company Limited advised that the grade of fuel used for combustion in the diesel engines at Dawson Power Plant varies, however, the fuel normally used has a (-6.6 degrees C.) indicates that the fuel oil used would typically have a Fuel Oil Heating Value of normally 10.79 kWhr per litre of 11.27 kWhr per litre. Therefore, a Fuel Heating Value of 11.03 kWhr per litre of fuel has been used for calculations.

The curve titled Average Heat Rejected Based on Power Generated shown by Figure No.1a is the estimated average heat flow rate (kW) rejected during the month into the diesel engine jacket cooling fluid circuits assuming the Power Plant to be generating the kWhrs of power recorded for the month at a uniform continuous load. The actual heat flow rate (kW) rejected at any specific at any specific time of day or day of the month would vary above or below this estimated average heat flow rate due to both the magnitude and duration of Peak and Minimum Power Demands under which the Power Plant was usually operating.

Figure No.1a also shows the estimated heat flow rate (kW) rejected to the diesel engine jacket coolant when the Power Plant was generating the Peak Power Demand for the month.

The average heat flow rate (kW) rejected during the month into the diesel engine jacket cooling fluid circuits is a significant parameter in this report because the cooling fluid is the heat source for both the City Water System and Yukon Electrical's heating requirements. Yukon Electrical's heating requirements referred to as secondaries, include heat required to:

(a) maintain the "OFF-LINE" diesel engines warm to facilitate easy starting;

(b) maintain the glycol fluid in the outdoor radiators warm so as to prevent cooling of the "OFF-LINE" engine and gelling of the 60% glycol/40% water solution during cold weather, and;

(c) provide building heating for the Power Plant and the on-site office and warehouse complex.

4.4.2 Estimated Power Plant Secondary Requirements For Waste Heat

Calculations for Figure No.1b in List "A" assume that the motor driven cooling fans integral to the radiators at the Power Plant are "FAN-OFF".

Net Minimum Available shown in Figure No.1b is the waste heat available after deducting allowances for the requirements (a), (b), and (c) below that are estimated to occur at an outdoor air temperature at (-50 degrees C.). This is the worst case scenario indicated by calculations for these Power Plant secondary heating requirements.

Net Average Available shown in Figure No.1b is the waste heat available after deducting allowances for the requirements (a), (b) and (c) below that are estimated to occur at an average outdoor temperature for the month (for example (-24 degrees C.) has been used in the estimate for January.)

Figure No.1b shows the estimated net waste heat flow rates in kW (averages and minimums) available at the Power Plant after deducting from the monthly average heat rate rejected to the diesel engine coolant the estimated Power Plant secondary heat rate required for:

(a) maintaining the "OFF-LINE" diesel engines warm and ready to start.

This is estimated to require a heat flow rate of 20kW to warm 4 "OFF-LINE" engines to 35 C. The fifth engine normally being required to run continuously in order to generate the minimum Power Demand;

(b) maintaining the glycol fluid in the outdoor radiators at a minimum temperature of 35 C. so as to prevent cooling of the "OFF-LINE" engine and gelling of the 60% glycol/40% water fluid at an outdoor ambient air temperature of (-50 C.).

The five existing outdoor radiators comprise a total of 13 fan-coolers. Each fan-cooler consists of a motor driven fan which when "ON" draws outdoor air at the prevailing outdoor temperature through its respective cooling coil, thereby cooling the hot glycol fluid circulating through the coil from the diesel engine.

All of fan-coolers are assumed to be "FAN-OFF" for the purpose of estimating the heat flow rate (kW) required by the Power Plant to prevent cooling of the "OFF-LINE" engine and gelling of the 60% glycol/40% water fluid in the radiators at an outdoor ambient of (-50 C.). Calculations indicate that at the 2 1/2% January Outdoor Design Temperature of (-50 C.) for Dawson City, the heat flow rate required to warm 13 fan-coolers is approximately 440kW. At an average outdoor air temperature of, for example, (-24 C.) for a normal January, the heat flow rate required to warm 13 fan-coolers is approximately 305kW;

(c) Building heating for the Power Plant and the on-site office and warehouse complex.

Calculations indicate that at the 2 1/2% January Outdoor Design Temperature of (-50 C.) for Dawson City a total heat flow rate of approximately 138kW is required, primarily for heating the office and warehouse complex. The estimated radiant heat rejection from engines running in the Power Plant Building results in an estimated

18kW being required for heating the Power Plant Building. The 18kW for heating in the Power Plant is included in the total of 138kW. At an average outdoor air temperature of, for example, (-24 C.) for a normal January, the heat flow rate required to heat the Power Plant and the on-site office and warehouse complex is approximately 88kW.

4.4.3 Effectiveness Of The Existing Waste Heat Exchange System

The waste heat exchanged to the City heats primarily the water system flow and the relatively small secondary heating requirement for the pumphouse when required and compensates for heat losses from the above ground storage reservoir.

Over the period beginning November 1989 to the end of April 1990, the existing heating system appears to have exchanged to the City during the various months, approximately 30% to 50% of the monthly Net Average Available waste heat from the Power Plant diesel engines. Net Average Available waste heat being the estimated heat available from the engine cooling systems minus the estimated Power Plant heating requirements for secondaries, and assuming the radiator fan coolers to be "FAN-OFF". It appears that 50% to 70% of the waste heat from the Power Plant diesel engines was rejected during the various months to the Outdoor Air by the radiator fans operating "FAN-OFF".

The Average Heat Rejected Based on Power Generated shown in Figure No.1a and Figure No.1b (refer to Section 3.1 General) is used for evaluating the effectiveness of the existing heat exchange system between the Power Plant and the City water system.

The Waste Heat Exchanged to City shown in Figure No.1b are calculated average waste heat flow rates (kW) exchanged to the City pumphouse and reservoir for each of the months November 1989 to May 1990 inclusive. Calculations are based on data recorded on water system flow rates, reservoir and well water temperatures for the months November 1989 to May 1990 and estimates of the heat losses from the pumphouse and reservoir. Calculations indicate that the waste heat exchanged to the City averaged at a heat flow rate of approximately 296kW over the months November 1989 to May 1990. Calculations also indicate that the waste heat exchanged to the City was at a peak heat flow rate of approximately 416kW in April 1990; at a low heat flow rate of 233kW in March 1990. Heat flow rates of 385kW and 64kW calculated for May 1990 reflect the fact that heating of the water system has not historically been required after mid-May.

Figure No.1b shows a relative comparison between the calculated monthly average Waste Heat Exchanged to City and the estimated net waste heat flow rate (kW) available for each month shown as (Net Average Available and Net Minimum Available) to the power plant after deducting from Average Heat Rejected the estimated power plant secondary heat flow rate (kW) requirements. Net Average Available and Net Minimum Available assume that the cooling fans which are integral with the outdoor radiators at the power plant would be "FAN-OFF".

Apparently the radiator fans do, in fact, run when more heat could be used for water system heating.

Net Average Available waste heat is the estimated heat flow rate (kW) available during the month at the power plant after deducting the estimated heat flow rate (kW) for power plant secondaries required at an average outdoor air temperature for each month, for example (-24 C.) has been used as the average outdoor temperature for a normal January.

Net Minimum Available waste heat is the estimated heat flow rate (kW) available at the power plant during the month after deducting the estimated heat flow rate (kW) for power plant secondaries required at the 2 1/2% January Outdoor Design Temperature of (-50 C.) for Dawson City as given in the National Research Council of Canada publication *Climatic Information for Building Design in Canada*. The 2 1/2% January Outdoor Design Temperature is defined as the temperature at or below which a small percentage (in this case 2 1/2%) of the hourly outside air temperatures during January occur. Net Minimum Available is the worst case scenario studied in that it is the lowest estimated waste heat flow rate (kW) available at the power plant and is relative only on the coldest (-50 C.) day assuming the power plant to be generating the kWhrs of power recorded for the month at a uniform continuous load. The actual heat flow rate (kW) rejected of the coldest day would vary above or below this estimated Net Minimum Available heat flow rate due to both the magnitude and duration of peak and minimum power demands under which the power plant was actually operating on the coldest day. The extreme outdoor condition of (-50 C) is not applicable to the months November, March, April or May. The waste heat flow rate (kW) for the months November 1989 to May 1990 inclusive would be expected to be nearer the value for Net Average Available periods during December, January and February when (-50 C) outdoor air temperature conditions may have occurred.

Over the period beginning November 1989 to the end of April 1990, the effectiveness of the existing system exchanging heat form the power plant diesel engine coolant circuits to the City (ie: Waste Heat Exchanged to City) appears to have been approximately:

39.4% of the Net Average Available in November;

35.4% of the Net Average Available in December;
55.5% of the Net Minimum Available in December;

49.5% of the Net Average Available in January;
67.2% of the Net Minimum Available in January;

30.2% of the Net Average Available in February;
39.8% of the Net Minimum Available in February;

41.4% of the Net Average Available in March;

45.2% of the Net Average Available in April.

4.4.4 Existing Power Plant Cooling System Description

A. Existing System

Schematic No.1 in List "A" of this report shows the existing engine jacket cooling system in the power plant as noted during a site visit to the power plant on September 10, 1991 and discussed with Yukon Electrical in Whitehorse on September 13, 1991. In approximately 1981 the system was modified so that the cooling circuit of each engine is separated from the cooling system of other engines. The Stanley Associates Engineering Ltd. record of construction drawing No. 1060-8-4-140 (DC-A1-308) titled "Utilities Stage II Contract 3 - Reservoir and Pumphouse Heating and Ventilation - Flow Schematic" is obsolete with respect to the existing power plant and does not show changes done in the pumphouse to disconnect heat exchanger No.HE-2.

As shown by Schematic No.1, the basic cooling system for each of the engines are similar. Significant differences are the number of fan-coolers integral with the radiator provided for a particular engine and the engine power rating. The heat flow rate (kW) rejected into the engine jacket cooling fluid is different for the different engine power ratings shown by Schematic No.1. The system of heat exchangers and circulating pumps shown below the engines in Schematic No.1 provide building heat and heat to maintain the "OFF-LINE" engines and radiators warm. This secondary system is installed such that any engine may extract heat from the system when "OFF-LINE" or contribute heat to the system when "ON-LINE".

B. Engine Cooling

The engine jacket cooling fluid is an antifreeze solution of 60% glycol/40% water and is circulated by an engine mounted pump through the oil cooler and cooling jacket of the engine to the engine thermostat. The thermostat cycles between "OPEN" and "CLOSED" to maintain the engine outlet cooling fluid temperature at approximately 88 C. Whenever the engine outlet temperature is less that 88 C. the thermostat diverts 100% of the cooling fluid flow directly back to the engine mounted pump. Whenever the engine outlet temperature is at or above 88 C. the thermostat opens and diverts 100% of the cooling fluid flow through the plate heat exchanger and through all coils of the fan-coolers integral to the radiator. The plate heat exchanger heats water for circulation to the City pumphouse. The plate heat exchanger cannot extract all of the heat being rejected by the engine into the cooling fluid when the fan motors of the fan-coolers are started in sequence by the cooling fluid temperature sensor "TC". Temperature sensor "TC" step controls the fan motors to start and run in sequence on increasing coolant temperature and cycles the fan motors "ON-OFF" to maintain its temperature setpoints. Depending on whether there are two or three fan-coolers at the radiator, the temperature sensor which is specific to the radiator arrangement provides either "LOW-HIGH" or "LOW-MEDIUM-HIGH" rates of heat extraction from the engine coolant. The heat extracted by running the fan-cooler motor is rejected to the outdoor air.

The radiators are rated to cool the engine during the summer using 21 C. outdoor air in controlled step-up increments of 50% or 33% of the radiator total rated cooling capacity. The increments of 50% or 33% depend on whether the specific radiator includes two or three fan-coolers. The actual heat rejection by a fan-cooler increases as the outdoor air temperature drops below 21 C. The fan-coolers are therefore step controlled so as to compensate somewhat for the fan-cooler heat rejection rate increasing with dropping outdoor air temperature. Since the heat rejection by the fan-cooler(s) generally does not equal the specific cooling requirement of the engine, the temperature of the coolant leaving the radiator is typically lower than required at the inlet to the engine pump for the specific cooling requirement of the engine. In order to maintain the engine outlet temperature at approximately 88 C. the engine thermostat compensates for the lower coolant temperature by cycling between:

(a) diverting 100% of the cooling fluid flow directly to the suction inlet of the pump; and then

(b) diverting 100% of the cooling fluid through the plate heat exchanger and radiator coils.

The frequency of this thermostat cycle increases as the outdoor air temperature at the radiators decreases.

The City requirements including building heating and reservoir heat losses are: 495.4kW for the present water system flow rate of 38 l/s heated from 1.5 C. to 4.0 C. and, 307.7kW for heating 38 l/s of blended water from 1.1 C. to 2.5 C. To heat 38 l/s of blended water from 1.1 C. to 4.0 C. would require approximately 555.5kW. Based on the power plant records for kilowatt-hours of power generated for the period November 1989 to end April 1990 and deducting allowance for the estimated average monthly heating required by power plant secondaries, the average net waste heat flow (kW) available at the power plant during this period was approximately:

November 1989	846.2kW
December 1989	746.2kW
January 1990	702.3kW
February 199	1,031.5kW
March 1990	635.9kW
April 1990	700.6kW

The heating requirement at the city pumphouse historically did not equal and will seldom if ever equal the specific cooling requirement of the engine or group of engines actually "ON-LINE" at the power plant. Safeguards are in place in the power plant cooling system to prevent the pumphouse demand for heat from exceeding the cooling requirement of the engine(s). This is done by temperature sensors and a motorized control valve at each plate heat exchanger. The "ON-LINE" engine(s) require continuous cooling. With the heat exchange system as it exists between the power plant and the pumphouse, it appears that because the

pumphouse demand for heat historically never equals the specific cooling requirement of the engine(s); the fan coolers must run in order to provide engine cooling. This rejects heat to the outdoor air, cooling the engine but wasting heat that the pumphouse could otherwise use for heating the water system. Modifications are proposed to the existing system to exchange the specific cooling requirement of the engine or selected group of engines actually "ON-LINE", to the pumphouse for heating to the desired water system temperatures and reject the excess heat that the water system does not need.

Valve "A" shown on Schematic No.1 at each plate heat exchanger opens only if both:

(a) the temperature of the engine jacket cooling fluid returning to the engine circulating pump is above the setpoint of temperature sensor "TLL"; and

(b) the temperature of the heating water returning form the pumphouse is greater than the setpoint of temperature sensor "TS" sensing this return water temperature. If neither of these control conditions are met then flow of heating water through the plate heat exchanger is closed of by the motorized valve and no heat is extracted from the engine cooling circuit for use at the pumphouse. Temperature sensor "TTL" ensures that:

(i) the engine is at operating temperature, rejecting heat to its cooling circuit (ie: is "ON-LINE"; and

(ii) the cooling fluid returning to the engine circulating pump is not less than typically 80 C. which could occur if the radiator or plate heat exchanger acting either individually or at the same time were to extract significantly more heat than the cooling requirement of the engine.

Yukon Electrical advised that flow control valve "B" shown by Schematic No.1 in each engine cooling circuit was installed originally to bypass the radiator whenever the plate heat exchanger was extracting all of the heat being rejected by the engine to the jacket cooling fluid. Control valve "B" has been manually overridden at each engine cooling circuit such that the valve is closed. Except for the cooling circuit of Unit No.3 (engine power rating 1206kW) where the valve's actuator is missing, these control valves could be reactivated at a push button switch integral with the valve actuator. As discussed above, the pumphouse demand for heat seldom if ever will equal the specific cooling requirement of the number of engines "ON-LINE" at anytime.

Opening valve "B" would however also appear to cause a problem with potential low coolant flow through the radiator coils because the pressure drop through the valve "B" and its associated bypass piping would be significantly less than the pressure drop though a coil of the radiator and its associated piping. To ensure

that enough coolant flow would circulate through the radiator coils to keep them warm at (-50 C.) outdoor air temperature with the bypass control valve "B-OPEN", additional pressure drop through the bypass piping would be necessary. This additional pressure drop could be provided by an orifice plate in the bypass piping.

C. Heating of Water Circulated to The City Pumphouse

Hot heating water from the five existing plate heat exchangers shown by Schematic No.1 is circulated by two pumps of the power plant system into a pressurized surge tank located in the addition onto the power plant building. The surge tank absorbs volumetric surges caused by opening or closing flow control valves in the power plant labelled as "Valve A" and shown by Schematic No.1.

The hot heating water is re-pumped by City owned pumps No. 5A/5B from the surge tank to the City Pumphouse where it is circulated through heat exchanger No.HE-1; returned to the surge tank and then circulated through any combination of plate heat exchangers providing that flow control valve "A" on the inlet to the heat exchanger is "OPEN".

Valve "A" shown on Schematic No.1 and located at each plate heat exchanger opens only if both:

(a) the temperature of the engine jacket cooling fluid returning to the engine circulating pump is above the setpoint of temperature sensor "TLL"; and

(b) the temperature of the heating water returning from the pumphouse is greater than the setpoint of temperature sensor "TS" sensing return water temperature.

4.4.5 Existing Water Heating System Description

A. Service System Description

Waste heat generated in the power plant is used as a base heat source and can be augmented with the steam boiler No. B-1. The heating rate of boiler B-1 is 74.6 kW firing with No.2 grade fuel oil and is rated at 105 kPa steam pressure.

Schematic No.2 in List "B" shows the existing heating system. Reservoir water to be heated is circulated from the service pump header by pumps No. P1A/P1B (duty/automatic standby operation) through the heating system and is discharged into the 200mm diameter fill line to the reservoir.

Pumps No. P1A/P1B circulate water to flow control valve No. CV-1. Valve CV-1 modulates to divert the pumped flow through the tube side of heat exchanger No.HE-1 and/or through the piping bypass past HE-1. The total flow from pumps P1A/P1B then circulates through either the steam to water heat exchanger No.HE-3 or the valved manual bypass past HE-3 and is discharged into the 200mm diameter fill line to the reservoir.

Hot heating water from the power plant is circulated by pumps No. P5A/P5B (duty/automatic standby operation) located in an addition onto the power plant building. The power plant diesel engines themselves circulate a toxic cooling fluid solution of 60% glycol/40% water through the engine jackets and plate type heat exchangers located in the power plant. The heating water circulated by pumps No. P5A/P5B to the pumphouse is heated in these plate type exchangers and is circulated through the shell side of heat exchanger No. HE-1. the reservoir water to be heated is circulated through the tube side of HE-1. The heating water pumped loop (pumps 5A/5B) and heat exchanger system (plate exchangers and HE-1) establish a buffer loop which isolates reservoir water from the diesel engine jacket cooling fluid thereby preventing contamination of drinking water by the toxic cooling fluid of the power plant engines.

The hot heating water pumped from the power plant (at normally 60 C.) by pumps No. P5A/P5B is circulated at the pumphouse through the shell side of heat exchangers No.HE-1 (for reservoir water heating) and No.HE-4 (old radiator system for providing the power plant with summer cooling). The heating water is then returned to the power plant at normally 57 C. to 58 C. (minimum 50 C.). The old radiator system has not been used since approximately 1981 when outdoor radiators were installed at the power plant.

B. Water Heating System Control

The temperature controller (TC shown on Schematic No.2) senses heated potable water temperature at the outlet of heat exchanger No.HE-3 prior to the discharge of the heated potable water at approximately 40 C. into the 200mm diameter fill line to the reservoir.

Pumphouse operating personnel set the desired predetermined temperature for the heating system discharge water temperature at Temperature Controller TC. Temperature Controller TC controls both flow control valves CV-1 and CV-3 to try to maintain the setpoint temperature by:

(a) modulating control valve CV-1 towards full flow through heat exchanger HE-1 thereby drawing as much heat as temperature sensor TCS-326 will permit from the hot heating water circulating from the power plant; and then

(b) modulating the steam flow control valve CV-3 open to provide additional heat from boiler No.B-1 to supplement the heat being supplied from the power plant. Boiler No.B-1 has not been operated due to the cost of fuel.

Temperature sensor TCS-326 limits the return temperature of the heating water circulating back to the power plant to not less than its setpoint of 50 C. by limiting the percent of full open position (ie: full flow through heat exchanger HE-1) to which Temperature Controller TC can modulate control valve CV-1. If TCS-326 senses 50 C. return water temperature it overrides controller TC such that CV-1

diverts 100% flow past heat exchanger No.HE-1 and no heat is exchanged to the water system.

Temperature sensor TCS-320 controlled operation of the old radiator at the pumphouse so as to reject the excess heat flow rate (kW) that the reservoir did not require from the power plant.

C. Pumphouse Heating

The hot heating water is circulated in the pumphouse by secondary pumping arrangement of pumps No. 3A/3B (duty/automatic standby operation) for pumphouse heating by unit heaters and finned tube radiation. Steam from boiler B-1 can be supplied to a standby steam to water heat exchanger for pumphouse heating should the hot heating water flow from the power plant be interrupted or the building heating water temperature be too low. Steam flow to the standby heat exchanger HE-5 is controlled by valve CV-4 such that building heating water temperature from HE-5 is scheduled with outdoor ambient temperature. As water from HE-5 is lowered to satisfy the decreasing building heating requirement.

D. Swimming Pool Heating

Water for heating and filling the Dawson City swimming pool is supplied from a hand operated valve manifold in the pumphouse. How water is supplied from HE-1 and is manually blended at the hot and cold water valves to mix water to lower temperatures suitable for the swimming pool.

4.4.6 Existing Heat Exchange System Capacity and Performance Restrictions

A. Mandatory Restriction on Heat Exchanged

The power plant must use waste heat from "ON-LINE" engine(s) to:

(a) maintain the "OFF-LINE" diesel engines warm to facilitate easy starting;

(b) maintain the glycol fluid in the outdoor radiators warm so as to prevent cooling of the "OFF-LINE" engine and gelling of the 60% glycol/40% water solution during cold weather; and

(c) provide building heating for the power plant and the on-site office and warehouse complex.

These mandatory heating requirements are provided by the system of heat exchangers and circulating pumps shown on the engines at the bottom of Schematic No.1 in List "B". Refer to section 3.2 for the estimated heat flow rate (kW) required for (a), (b) and (c).

Existing Heat Exchange System Performance Restrictions

The primary reason why the city requirement for heat flow rate (kW) to achieve a 4.0 C. water system temperature is not presently being obtained appears to be as discussed in 3.4.2, that the city demand for heat has not historically equalled the specific cooling requirement of the engine(s) "ON-LINE" at the power plant. The city is extracting only part of the new waste heat at the engine(s) and since the engine(s) require continuous cooling; the fan-coolers integral with the power plant's radiators run "FAN-ON" to reject the remaining heat form the engine cooling system(s). The "FAN-ON" operation of the fan-coolers rejects heat to the outdoor air and rejecting heat that the pumphouse could use for heating the water system. The heat extracted by the plate heat exchanger would not appear to be at a constant rate since the fan-cooler(s) are running "FAN-ON" and the engine thermostat compensates by cycling between diverting 100% of the engine coolant flow to:

(a) the suction inlet of the engine cooling pump; and then

(b) to the plate heat exchanger and radiator.

With the resulting temperature change of the hot heating water leaving the plate heat exchanger, control valve CV-1 at the pumphouse "hunts" for the correct valve position, (the valve strokes between the positions which pass water to be heated:

(a) through heat exchanger HE-1; and

(b) bypass around HE-1.

B. Capacity Restriction on Existing Heat Exchange System

B.1 Heat Transfer Capacity of Existing Plate Heat Exchangers

The existing plate heat exchangers were apparently originally sized with heat transfer capacity to fully cool the associated engine by; transferring the heat to the city pumphouse. Yukon Electrical advised that although certain engines have been replaced with engines of higher power rating, the plate heat exchangers have not been modified or replaced to match the cooling requirement of the higher power rated engines.

An option looked at with Yukon Electrical in Whitehorse was to modify the existing plate heat exchangers by adding plates to the exchangers where required to increase the heat transfer rate. This option does not appear to be practical because the additional pump head loss imposed by adding plates to the exchanger would probably reduce the engine's coolant pump flow rate. Modifying the engine's coolant pump is not an acceptable solution.

The floor space available at the location of the existing plate heat exchangers is very limited by piping, building exterior wall and the engines. An acceptable alternative appears to be installing new heat exchangers of the shell and tube type design. This type of heat exchanger typically has a

lower pressure drop than the heat exchanger of the plate type design, however, requires more floor space. A shell and tube design heat exchanger for each engine could be installed in the area where the existing surge tank and pumps P5A/P5B are presently located and piped to the associated engine cooling circuit at the piping connections for the existing plate exchanger. The room would have to be increased in floor space to approximately 5 by 6 meters.

B.2 Maintenance

(a) The 150mm diameter heating water lines between he power plant and the city pumphouse are critical to the operation of the heat exchange system.

The system should be checked for internal build-up and deposits of scale particularly in the closely spaced plates of the plate heat exchangers and possibly in the bottom of the surge tank at the power plant. Scale deposits in the plate exchangers may be reducing the exchanger's heat transfer rate (kW). Strainers should be checked for scale deposits. Pump impellers should be checked for erosion. Erosion of impellers can result from scale deposits moving into the suction of the pump or can be an indication of pump cavitation.

A water treatment specialist should be consulted for recommendations on application of water treatment chemicals and/or corrosion inhibitors. This should be by analysis of water samples from the heat exchange system;

(b) The flow of pumps P5A/P5B should be checked by possibly performing an ultrasonic flow measurement. Three significantly different flow rates where indicated during the site visit of September 10, 1991 by various sources as:

283 Usgpm at 30 ft head per the pump name plate date on the pump;
343 Usgpm marked on the performance curve found in the maintenance manual;
150 Usgpm reported by city personnel.

These pumps were down-sized in the past and apparently were also installed backward. This was corrected;

(c) The tube side piping of heat exchanger No.HE-2 has been disconnected and is not being used. The shell side connections to HE-2 are piped into the heating water circulated from the power plant. The tube side connections of HE-2 could be piped in parallel with heat exchanger HE-1 tube side connections to provide if desired a standby for heat exchanger No. HE-1;

(d) The operation of control valve CV-1 should be checked. Temperature controller "TC" and temperature switch TCS-320 should be checked for calibration to setpoint.

(e) The pumps (manufactured by Sigmund Pulsometer Pumps Ltd.) are located at the ceiling in the power plant pump hot heating water from the plate heat exchangers to the surge tank. The city advised that the motors on these pumps are repeatedly being replaced, apparently due to motor failure in the high temperature ambient air at the ceiling level in the power plant. A review of the piping to these pumps as shown by Schematic No.1 in List "B" indicates that depending on how many, if any, of the valves labelled "Valve A" are open, these pumps may be operating at conditions including shut-in (zero flow rate) and the runout condition of maximum flow at the pump's lowest rated head. Operating a pump at runout can overload the motor if not sized for this pump operating condition and cause the motor to run excessively hot and eventually need replacement. This possibility will be reviewed in detail design if the heating alternative is decided upon requires these pumps be used in the system.

4.5 Estimated Operating Fuel Costs

Heating Fuels Available at Dawson City

ICG Propane Company in Whitehorse advised that propane fuel unit cost in Dawson is between $0.39 to $0.42 per litre. This rate is applicable to larger commercial consumers. At the propane heating value of 7.06kWhr per litre of propane (109,560 Btu/Imperial Gallon advised by ICG) the unit cost of $0.39 per litre is equivalent to 5.523 cents per kWhr of heat. Heating fuel oil grade No.2 having a heating value of 101.79kWhr per litre at a unit cost or $0.37 per litre is equivalent to 3.428 cents per kWhr of heat.

4.5.1 Heating Alternative No.H1

(A) Alterative No.H1-Option "A"

Heating Alternative No.H1-Option "A" is to provide the additional heat for the water system by operating a fuel oil fired heating boiler system assuming no improvement in the effectiveness of the existing heat exchange system between the power plant and the city pumphouse/reservoir.

Calculations indicate that the waste heat exchanged to the city (see Figure No.1b List "B") averaged at a heat flow rate of approximately 296kW over the months November 1989 to May 1990. Assuming this average heat flow rate of 296kW for waste heat is exchanged from the power plant and assuming no improvement in the effectiveness of the existing heat exchange system; additional heat (see Figure No.2a) will be required for the water system design criteria.

Assuming a water system heating season of 196 calendar days (end-October to mid-May); no improvement in the effectiveness of the existing heat exchange system; a fuel oil unit cost of $0.37 per litre of fuel; and an 85% boiler additional heat required; calculations indicate that:

(a) heating the present flow of 38 l/s well water form 1.5 C. to 4.0 C. requires a total boiler heating output capacity of 200kW at an estimated annual fuel cost of $38,000.00 (see Figure No.2b);

(b) heating the ultimate design flow of 65 l/s well water from 1.5 C. to 2.5 C. requires a total boiler heating output capacity of 70kW at an estimated annual fuel cost of $13,000.00 (see Figure No.2b);

(c) heating the ultimate design flow of 65 l/s well water from 1.5 C. to 2.9 C. is possible with a boiler system sized for present flows (heating output capacity of 200kw) and would incur an estimated annual fuel cost of $35,000.00.

The heating requirements including building heating and reservoir heat losses are:

495.4kW for the present water system flow of 38 l/s heated from 1.5 C. to 4.0 C. and;

364.6kW for the ultimate water system flow of 65 l/s heated from 1.5 C. to 2.5 C.

Should either the heat supply from the power plant be interrupted by a failure in the heat exchange system or should a boiler fail, the effect on water system temperature for the ultimate and the present water system flows are as shown in the Table 4.1 on the following page:

TABLE 4.1
Heating Alternative No.H1
Option "A"

HEAT SOURCE	AVAILABLE	HEATED WATER TEMPERATURE AND % OF HEAT SOURCE CAPACITY	
	kW	Temp. C. @ 65 l/s and % OF SOURCE CAP.	Temp. C. @ 38 l/s and % OF SOURCE CAP.
POWER PLANT HEAT	296	100%	100%
1-200kW BOILER	200	34%	100%
		2.5 C. 365kW	4.0 C. 496kW
NO POWER PLANT HEAT	0	0%	0%
1-200kW BOILER	200.0	2.0 C. 100% 200kW	2.3 C. 100% 200kW
POWER PLANT HEAT	296	100%	100%
BOILER FAILURE	0	0%	0%
		2.3 C. 296kW	2.8 C. 296kW
POWER PLANT HEAT	296	100%	100%
1-100kW BOILER	100.0	STANDBY	100%
1-100kW BOILER	100.0	69%	100%
		2.5 C. 365kW	4.0 C. 496kW
NO POWER PLANT HEAT	0	0%	0%
1-100kW BOILER	100.0	100%	100%
1-100kW BOILER	100.0	100%	100%
		2.0 C. 200kW	2.3 C. 200kW
POWER PLANT HEAT	296	100%	100%
1-182.kW BOILER	182.3	STANDBY	STANDBY
1-182.3 BOILER	182.3	38%	100%
		2.5 C. 365kW	3.9 C. 478kW
NO POWER PLANT HEAT	0	0%	0%
1-182.3kW BOILER	182.3	100%	100%
1-182.3kW BOILER	182.3	100%	100%
		2.5 C. 365kW	3.3 C. 365kW
POWER PLANT HEAT	296	100%	100%
1-68.6kW BOILER	68.6	100%	92%
1-148.0kW BOILER	148.0	STANDBY	92%
1-148.0kW BOILER	148.0	STANDBY	STANDBY
		2.5 C. 365kW	4.0 C. 496kW
NO POWER PLANT HEAT	0	0%	0%
1-68.6kW BOILER	68.6	100%	100%
1-148.0kW BOILER	148.0	100%	100%
1-148.0kW BOILER	148.0	100%	100%
		2.5 C. 365kW	3.3 C. 365kW

The above Table shows that either a single 200kW boiler or the combined output of two 100kW boilers would not heat the flows to the minimum of 2.5 C. if the heat supply from the power plant was interrupted. For heating at the ultimate water system flow rate a single 200kW boiler would operate at only 34% of the boiler rated capacity when supplementing the heat from the power plant. Two 182.3kW boilers would heat the ultimate and present water system flows to at least 2.5 C. if heat from the power plant was interrupted. However, operating a single 183.2kW boiler to supplement the heat supply from the power plant for heating the ultimate flow of 65 l/s would load the boiler to only 38% of the boiler's rated capacity. The seasonal fuel efficiency of a boiler will be optimized if the boiler is sized so that it can be operated near to its full load rating and "ON-OFF" cycling can be minimized.

The recommended boiler system is three boilers. One (1) boiler of 68.6kW and two (2) boilers of 148.0kW rated heating output each. The system is shown by Block Schematic No.3. This boiler system would heat the ultimate flow to 2.5 C. or the present flow to 3.3 C. if the heat exchange from the power plant was interrupted. This boiler system would operate between 92% and 100% of rated heating capacity at the design criteria for the present and ultimate water system flows.

Applying the same assumptions for duration of heating season; no improvement in the effectiveness of the existing heat exchange system; a fuel oil unit cost of $0.37 per litre of fuel; and, an 85% boiler efficiency for heating boilers burning No.2 fuel oil to generate the additional heat flow rate (kW) required. Figure No.2b and Figure No.2a show the estimated annual fuel cost and the additional heat flow rate (kW) required to heat the water system design flow range of 35.0 l/s to 65.0 l/s from the various sources of water as follows:

(a) water from the existing "New Well" at 1.5 C. to either 2.5 C. or 4.0 C.;

(b) water from a blended temperature of 1.1 C. to either 2.5 C. or 4.0 C.;

(c) water from the existing "River Well" at 0.5 C. to either 2.5 C. or 4.0 C.

The capacity of the proposed boiler system would not provide the heat rate required for the conditions of water source and final heated temperature shown by Figure No.2a requiring more than 365kW if the heat exchange system between the power plant and pumphouse failed.

Calculations indicate a blended (mixed) water temperature range of 0.8 C. to 1.1 C. during the periods when the River Well was in use to supplement the "New Well" capacity from November 1989 to May 1990. 1.1 C. blended water temperature at a flow of 38.0 l/s corresponds to the water system pumps mixing 13.9 l/s of river well water at 0.5 C. with 24.1 l/s of "New Well" water at 1.5 C. Calculations are based on bimonthly records for reservoir temperatures, well temperatures, pumphouse peak/low discharge flows and records showing wen the river well was in use from November 1989 to May 1990.

Figure No.2b and Figure No.2a include the heat flow rate (kW) required for the relatively small secondary heating requirement of the pumphouse and compensate for heat losses from the above ground storage reservoir.

B. Alternative No.H1-Option "B"

Heating Alternative No.H1-Option "B" is to provide the additional heat for the water system by proposed modifications to the existing heat exchange system and optimize the effectiveness of this system.

The proposed modifications are expected to increase the waste heat flow rate (kW) exchanged from the power plant from the estimated present 296kW to an estimated 696kW of net waste after deducting allowances for power plant secondaries.

The Average Heat Requirement Based on Power Generated (see 3.1 General) is used in estimating the waste heat that could be made available by proposed modifications to the existing heat exchange system to optimize the heat exchanged between the power plant and city water system (Figure No.4).

Calculations for Figure No.4 in List "B" assume that the motor driven cooling fans integral to the radiators at the power plant are "FAN-OFF".

Option "B" would eliminate the requirement for supplemental heat to be generated by operating a fuel oil fired heating boiler. The estimated optimum Net Average Heat flow rate of 696kW of waste heat that could be made available from the power plant to the city pumphouse would heat 65 l/s of Well Water from 1.5 C. to 3.7 C. The additional heat required to heat from 3.7 C. to 4.0 C. if desired, is approximately 92kW.

Figure No.4 shows the estimated net average, and upper/lower ranges of waste heat flow rate (kW) available from the power plant after deducting the estimated power plant secondary heating requirements from the heat flow rate (kW) rejected to the diesel engine coolant. Calculations are based on data for November 1989 to May 1990. Figure No.4 shows that the estimated net average waste heat that could be made available to the pumphouse for heating the water system is of sufficient heat flow rate (kW) to:

(a) heat 56 l/s of Well Water from 0.5 C. to 4.0 C.;

(b) heat 40 l/s of River Well Water from 0.5 C. to 4.0 C.

Calculations for Figure No.4 also indicate that 65 l/s of Well Water could be heated from 1.5 C. to 3.7 C.

The heating requirements including building heating and reservoir heat losses are:

495.4kW for the present water system flow of 38 l/s heated from 1.5 C. to 4.0 C.; and

364.6kW for the ultimate water system flow of 65 l/s heated from 1.5 C. to 2.5 C.

Should the heat supply from the power plant be interrupted by a failure in the heat exchange system the standby boiler capacity that would be required is 364.6kW to maintain the water system at 2.5 C. at the ultimate flow rate of the water system. The effect on water system temperature for the ultimate and the present water system flows are as shown in the following Table:

TABLE 4.2
Heating Alternative No.H1
Option "B"

HEAT SOURCE	AVAILABLE kW	HEATED WATER TEMPERATURE AND % OF HEAT SOURCE CAPACITY			
		Temp. C. @ 65 l/s and % OF SOURCE CAP.		Temp. C. @ 38 l/s and % OF SOURCE CAP.	
POWER PLANT HEAT	696		52.%		71%
1-364.6kW BOILER	364.6		STANDBY		STANDBY
		2.5 C.	365kW	4.0 C.	496kW
POWER PLANT HEAT	696		100%		95%
1-364.6kW BOILER	364.6		STANDBY		STANDBY
		3.7 C.	696kW	5.0 C.	661kW
NO POWER PLANT HEAT	0		0%		0%
1-364.6kW	364.6		100%		100%
		2.5 C.	365kW	3.8 C.	
365kW					

The recommended standby boiler heating capacity is one boiler of 364.6kW rated heating output to heat the water system ultimate flow of 65 l/s from 1.5 C. to 2.5 C.

The proposed modifications to optimize the heat exchange system capacity would not provide the heat rate required for the conditions of water source and final heated temperature shown by Figure No.4 requiring more than 696kW with the boiler in "STANDBY" mode.

The proposed modifications to the existing heat exchange system are shown by Block Schematic No.4 in Appendix "B". The modifications are:

(a) Provide a separate heat exchanger for each engine to replace the plate heat exchangers at the power plant (refer to 3.6.3.1). Provide control of the heat exchanger heat transfer rate to extract all the heat being rejected by the engine to the jacket cooling fluid, providing that the pumphouse requires additional heat. Heat transfer of the heat exchanger controlled by modulating the flow of heated water through the exchanger in order to return the cooling fluid to the engine circulating pump at a temperature setpoint determined by and under the control of the power plant operating personnel. If the pumphouse did not require more heat then the existing bypass valve "B" would be closed, the engine's associated radiator would cool the engine, and the exchanger would not extract heat from this engine's cooling circuit;

(b) Provide additional pressure drop through the bypass piping in the power plant at each of the control valves labelled "Valve B" on Block Schematic No.4. Provide additional pressure drop to ensure that enough coolant flow is circulated through the radiator coils to keep the coil warm when bypass valve "B" is open and the outdoor air temperature is (-50 C.). Provide the additional pressure drop by installing an orifice plate in the bypass piping. Reactivate the control valve(s) labelled "Valve B" on Schematic No.1 and Block Schematic No.4 to bypass most of the coolant flow away from the radiators;

(c) Provide rejection of excess heat transferred from the new heat exchanger(s) to be located at the power plant. As described in (a) above, the heat exchanger rate of heat transfer would be controlled at the power plant to extract all of the heat being rejected by an "ON-LINE" engine providing that the pumphouse requires additional heat. Depending on the pumphouse total requirement for heat it would be possible that more than one hat exchanger may be operating to cool its associated engine. The fan-coolers at the power plant and associated with the particular engine cooling circuit would be "FAN-OFF" thereby making all of the net waste heat available to the pumphouse. It is necessary to reject any excess waste heat at the pumphouse because the city water system requirement seldom if ever equals the specific cooling requirement of the engine(s). The excess heat would be rejected by a ducted fan cooler located at the pumphouse and controlled to return the water to the power plant at a constant temperature. The ducted fan cooler at the pumphouse would be located inside an enclosure heated so as to protect against freezing of heating system water inside the coil of the fan cooler. Glycol would not be used as an antifreeze solution in

the fan cooler in order that a second "pumped buffer loop" will not be required between toxic glycol and the drinking water;

(d) Provide standby heating boiler of 364.6kW heat output rating.

4.5.2 Heating Alternative No.H2

(A) Heating Alternative No.H2

Heating alternative No.H2 is to provide the heat flow rate (kW) for the water system and the relatively small secondary heating requirement for the pumphouse and compensate for heat losses from the above ground storage reservoir by operating fuel oil fired heating boilers assuming no waste heat from the power plant.

Assuming a water system heating season of 196 calendar days (end-October to mid-May); a fuel oil unit cost of $0.37 per litre of fuel; and an 85% boiler efficiency for heating boiler(s) burning No.2 Fuel Oil to generate the total heat required for:

(a) heating the present flow of 38 l/s Well Water from 1.5 C. to 4.0 C. requires a total boiler heating output capacity of 495kW at an estimated annual fuel cost of $94,000.00 (see Figure No.3b);

(b) heating the ultimate design flow of 65 l/s Well Water from 1.5 C. to 2.5 C. requires a total boiler heating output capacity of 365kW at an estimated annual fuel cost of $69,000.00 (see Figure No.3b);

(c) heating the ultimate design flow of 65 l/s Well Water from 1.5 C. to 2.9 C. is possible with boilers sized for present flows (heating output capacity of 495kW) and would incur an estimated annual fuel cost of $91,000.00.

The heating requirements including building heating and reservoir heat losses are:

495.4kW for the present water system flow of 39 l/s heated from 1.5 C. to 4.0 C.; and

364.6kW for the ultimate water system flow of 65 l/s heated from 1.5 C. to 2.5 C.

The required boiler output heating capacity is 495.4kW to heat the present water system flow of 39 l/s from 1.5 C. to 4.0 C. The water system temperature for the ultimate and the present water system flows are as shown in the following Table 4.3.

TABLE 4.3
Heating Alternative No.H2

HEAT SOURCE	AVAILABLE kW	HEATED WATER TEMPERATURE AND % OF HEAT SOURCE CAPACITY			
		Temp. C. @ 65 l/s and % OF SOURCE CAP.		Temp. C. @ 38 l/s % OF SOURCE CAP.	
1-495.4kW BOILER	495.4		74%		100%
1-495.4kW BOILER	495.4		STANDBY		STANDBY
		2.5	365kW	4.0	496kW
1-247.7kW BOILER	247.7		74%		STANDBY
1-247.7kW BOILER	247.7		74%		100%
1-247.7Kw BOILER	247.7		STANDBY		100%
		2.5	365kW	4.0	496kW
1-182.3kW BOILER	182.3		100%		91%
1-182.3kW BOILER	182.3		100%		91%
1-182.3kW BOILER	182.3		STANDBY		91%
		2.5	365kW	4.0	496kW
1-182.3kW BOILER	182.3		FAILED		FAILED
1-182.3kW BOILER	182.3		100%		100%
1-182.3kW BOILER	182.3		100%		100%
		2.5	365kW	3.3	365kW

The recommended boiler system is three (3) boilers each rated at 182.3kW rated heating output each. The system is shown by Block Schematic No.5 in List "B". This boiler system would heat the water system ultimate flow of 65 l/s to 2.5 C. or the present water system flow of 38 l/s to 3.3 C. with one boiler failed or out of service. This boiler system would operate between 91% and 100% of rated heating capacity at the design criteria for the present and ultimate water system flows.

Applying the same assumptions for duration of heating season; no waste heat from the power plant; a fuel oil unit cost of $0.37 per litre of fuel; and, an 85% boiler efficiency for heating boilers burning No.2 Fuel Oil. Figure

No.3b and Figure No.3a in Appendix "B" show the estimated annual fuel cost and the heat flow rate (kW) required to heat the water system design flow range of 35.0 l/s to 65.0 l/s from the various sources of water as follows:

(a) water from the existing "New Well" at 1.5 C. to either 2.5 C. or 4.0 C.;

(b) water from a blended temperature of 1.1 C. to either 2.5 C. or 4.0 C.;

(c) water from the existing "River Well" at 0.5 C. to either 2.5 C. or 4.0 C.

Figure No.3b and Figure No.3a include the heat flow rate (kW) required for the relatively small secondary heating requirement of the pumphouse and compensate for heat losses from the above ground storage reservoir.

The capacity of the proposed boiler system would not provide the heat rate required for the conditions of water source and final heated temperature shown by Figure No.2a requiring more than 365kW with one boiler in "STANDBY" mode.

4.6 COST ESTIMATES

4.6.1 General

The following equipment is available for use in the systems proposed for Heating Alternative No.H1 Option A and B and for Heating Alternative No.H2. The suitability of this equipment as to capacity rating, type and equipment condition and predicted life will be reviewed during detail design.

(a) Pumphouse Heat Exchanger No.HE-2 is available for use, however it must pass inspection by the Boilers Branch of the Yukon Territorial Government. HE-2 was disconnected 6 to 7 years ago;

(b) Pumphouse Heat Exchanger No.HE-3 and HE-5 are steam to water converters and might be suitable depending on their heat transfer capacity as water to water heat exchangers. These heat exchangers must pass inspection by the Boilers Branch before being reused;

(c) Heat Exchanger No.HE-4 is available for reuse and must pass inspection by the Boilers Branch;

(d) Pumps P1A/P1B are apparently in satisfactory operating condition. There have been no problems with these pumps. The capacity rating will be reviewed during detail design;

(e) Pumps P2A/P2B and P4A/P4B are available, however they have not been operated for a number of years and their condition is questionable;

(f) Pumps P3A/P3B would remain;

(g) Pumps P5A/P5B would remain for Heating Alternative No.H1-Option "A". The suitability as to capacity rating will be reviewed in detail design;

(h) The outdoor radiator has not been operated since radiators were installed at the power plant in approximately 1981. The condition of this equipment is questionable, however it might be considered for use in Heating Alternative No.1-Option "B" if it can be made operational and can be used as a ducted fan cooler. This will be reviewed in detail design;

(i) Steam Boiler No.B-1 is over 13 years old. Boilers of higher fuel efficiency are available for Heating Alterative No.1-Option "A" and for Heating Alternative No.2. The heating output of Boiler B-1 is too small for Heating Alternative No.1.-Option "B". The boiler, condensate pumps, condensate tank and piping would be removed;

(j) The condition of the underground fuel oil storage tank is assumed to be good and would remain.

The cost estimates assume that items (d), (f), (g) and (j) are to be reused or remain and that all other items listed above would not be reused.

4.6.1 Cost Estimates

The following cost estimates include:

(a) Materials, Labour and Freight;
(b) Testing, Start-up and Commissioning by the Contractor;
(c) Systems Balancing and documentation;
(d) Mobilization;
(e) Labour Productivity factor of 25% of Contractors total direct labour cost for work not performed in a major city such as Vancouver;
(f) consumables and small tools;
(g) Mechanical Contractor overhead and profit;
(h) Contingency;
(i) Engineering.

The following cost estimates do not include:

(a) Goods and Services Taxes.

Heating Alternative No.H1-Option "A"

Heating Alternative No.H1-Option "A" is to provide the additional heat for the water system by operating a fuel oil heating boiler system assuming no improvement in the effectiveness of the existing heat exchange system between the power plant and the city pumphouse/reservoir.

The estimated cost is:

Mechanical Total		$362,000
Contingency 20% of Total		$67,000
	Total	$429,000

Heating Alternative No.H1-Option "B"

Heating Alternative No.H1-Option "B" is to provide the additional heat for the water system by proposed modifications to the existing heat exchange system and optimize the effectiveness of this system.

The estimated cost is:

A. With Back-Up Boilers

Mechanical Total		$678,000
Contingency 20% of Total		$122,900
	Total	$800,900

B. Without Back-Up Boilers

Mechanical Total		$382,000
Contingency 20% of Total		$56,000
	Total	$438,000

Heating Alternative No.H2

Heating Alternative No.H2 is to provide the heat flow rate (kW) for the water system and the relatively small secondary heating requirement for the pumphouse and compensate for heat losses from the above ground storage reservoir by operating fuel oil fire heating boilers assuming no waste heat from the power plant.

The estimated cost is:

Mechanical Total		$373,000
Contingency 20% of Total		$68,500
	Total	$441,500

TABLE 4.4
Heating System Cost Estimates

Option	Capital Cost	Flow l/s	OPERATION COSTS Temp (deg.C.)	Cost (Fuel) Year	Comments	Rank
Alt. #H1 Option A	$429,000 - 3 boilers of	38	1.5-4.0	$38,000	Heat from plant is as present of 296kW, supplemented with	1
	1 @ 68.6kW 2 @ 148kW	65	1.5-2.5	$13,000	boilers for make up	
Alt. #H1 Option B	$800,900	38	1.5-4.0	-	Modify existing exchange	4
	- 1 boiler of	38	0.5-4.0	-	system in NCPC and City	
	364.4kW	40	0.5-4.0	-	buildings	
	$438,000	56	0.5-4.0	-	Heat from NCPC would go	2
	- without standby, keep existing boiler	65	1.5-3.7	-	from 296kW to 696kW. Standby of 364.6kW generator	
Alt. #H2	$441,500	38	1.5-4.0	$94,000	No waste heat Boilers to	3
	- 3 boilers	65	1.5-2.5	$69.000	provide heat of 495kW	
	@ 182kW each	65	1.5-2.9	$91,000		

Comparisons of Costs

Table 4.4 indicates that the capital costs between Alternative #1 Option "A" and Option "B" are similar, however Alternative #1 Option "A" requires an annual fuel cost of $35,000.00 while Option "B" has no fuel costs. If the fuel costs are projected over 15 years at $35,000.00 per year, the simplified present worth at 8% for Option "A" is $78,000.00 in fuel costs plus the capital cost of $429,000.00 for a total present worth of $507,000.00. Option "B" at a capital cost of $438,000.00 is now the less expensive of all the alternatives.

4.7 Discussions - Agreement

In April 1983 an agreement was signed between NCPC and Yukon Territorial Government to allow the City of Dawson to utilize the waste heat from the diesel plant, refer to agreement in Appendix "C". Since that agreement NCPC has turned the operations of the plant over to Yukon Electrical Company, however, the agreement is still in place. There has been modifications in this plant by NCPC over the years which has limited the waste heat transfer to the city water system. The water system at present has the minimum waste heat required to keep the system in operation, as the usage increases addition heat will be required.

The agreements, master and subsidiary, allow for Yukon Territorial Government to extract all of the heat they require provided Yukon Territorial Government pays for the capital costs.

4.8 Conclusions

The following conclusions have been drawn from this study:

1. The electric power supply for Dawson will continue to be the diesel pant until 1995. This will be a political decision, however, based on the estimated capital cost of 25 million dollars for the supply from Mayo the diesel plant probably will continue to be used for the foreseeable future.

2. There is sufficient waste heat being produced from the existing power plant to heat the future water needs of the City of Dawson.

3. The term of the agreement expires on April 1, 1993.

4. Modifications to the existing NCPC power plant and the City pumphouse will provide the required heat for the system for a population of 3000.

5. The existing equipment presently being used, such as the transfer piping, requires to be cleaned and tested.

6. The cost to modify the system to get sufficient waste heat is estimated at $438,000.

4.9 Recommendations

1. The City enter into discussions with Yukon Territorial Government to negotiate the agreement with NCPC for future use of the waste heat.

2. The City to enter into discussion with Yukon Territorial Government/NCPC on the life of diesel plant in view of the possible transmission line from Mayo. This will determine the extent of the modification to the diesel plant for waste heat.

3. Pre-design be undertaken so proposals can be presented to NCPC for the required work within their plant if a well system supply is not used. If the wells system provides adequate supply at a reasonable temperature the work required in the NCPC power plant can be delayed or even deleted.

4. The existing pipes and pumps be checked and cleaned during the summer of 1993.

SECTION 5 SEWAGE SYSTEM

5.1 Introduction

This section addressed the City's sewage collection and treatment system by reviewing the water usage and past sewage flows. The system includes the sewer collection system, pump stations, screening plant and future treatment requirements.

5.2 Design Criteria

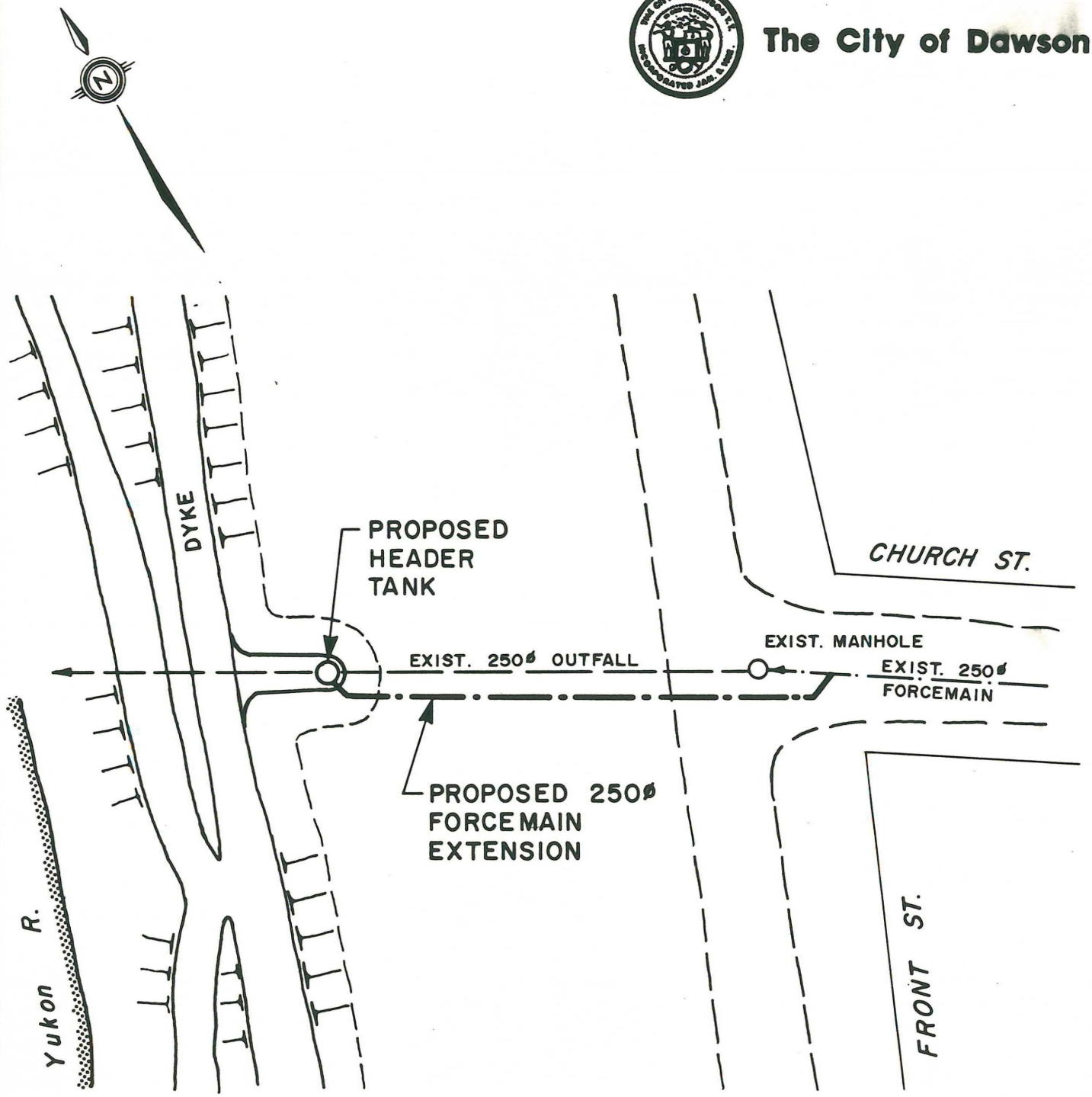
The sewage flows are accepted to be equal to the water usage since it is a bleeding system and the effluent flows are very similar to water consumption rates.

The peak sewage flows will follow the water usage since the peaks, both daily and hourly, are not significant due to the high bleeding rate. When there is no bleeding in the summer all facilities can still cope with the peaks since they are designed for the winter high water usage.

5.3 Effluent Quality

Data has been collected over the past few years by city staff and sent out for analysis. There are two sets of average effluent quality, one being summer flows and one the winter flows as shown on Table 5.1. This data is taken at sampling station DC.3 which is at the screening plant immediately following screening. There is no data for "raw wastewater" at this time. A program will be put in place to collect this data.

The City of Dawson



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Outfall Modifications

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figure 5.1

TABLE 5.1
Effluent Data of Screened Wastewater

Parameter	Summer Average	Winter Average
BOD5	59 mg/l	27 mg/l
SS	93 mg/l	41 mg/l
pH	7.4	7.1
Oil and Grease	12.0	8.3
Total Phosphate	No Results	1.18
Ammonia	11.9 mg/l	2.7 mg/l
Fecal Coliforms	255,000 MPN/100ml	4,250 MPN/100ml
Bioassay Concentration (LC 50)	No Results	100% (Based on Oct)

The above results have been based on tests taken in 1991 and are attached in Appendix "D".

The Yukon Territorial Water Board has set effluent standard guidelines for all municipal waste water discharges. These guidelines have been divided into four different categories depending on the type of water environment which will receive the treated effluent, each with its own set of parameters. With the city being situated adjacent to the Yukon River, the effluent guidelines which apply are dependent on the effluent dilution ratios provided by the River.

Data obtained from the Water Survey Canada is presented in Table 5.2 and indicates the mean monthly river flows, in cubic meters per second. Dilution ratios have been calculated relative to the current average daily sewage flow of 38 l/s and the future average daily flows of 65 l/s.

TABLE 5.2
Yukon River Dilution Ratios

Month	Mean Flow (m3/s)	Calculated Rations Current	Future
January	541	14,236	8,323
February	465	12,236	7,153
March	427	11,236	6,569
April	501	13,184	7,707
May	3,290	86,578	50,615
June	5,880	154,736	90,461
July	4,850	127,631	74,615
August	3,790	99,736	58,307
September	2,870	75,526	44,153
October	1,970	51,842	30,307
November	1,020	26,842	15,692
December	667	17,552	10,261

It is noted, in addition to the mean monthly flows tabulated above, the lowest recorded flow was 350 m3/s in the month of January. The calculated dilution ratio between the minimum river flow and the maximum sewage discharge flow rate is therefore 5,384:1 The dilution ratio falls into the Yukon Water Board category of greater than 1000:1, therefore, the minimum guideline parameters requirement for present and future discharge are presented in Table 5.3. These are the guidelines which are outlined in the present water license.

TABLE 5.3
Sewage Effluent Quality Guidelines
Present and Future Flows

Design Parameters	Allocable Effluent Quality with dilution ratio > 1000:1
BOD	150 mg/l
SS	150 mg/l
pH	6 to 9
Oil/Grease	5 mg/l
Phosphorous	5 mg/l
Fecal Coliform	16.0 x 10^5 counts/100ml
Bioassay Concentration	100% (LC 50)
Toxic Organic Substances	Nil

The guidelines also state that the discharge of raw sewage into any receiving waters is prohibited. Therefore, some form of treatment of the effluent will be required. Further, the Yukon Water Board sets out that the minimum standard for municipal wastewater treatment is the requirement to provide the best practical technology (BPT) available that reflects both economic and environmental impact.

5.4 Receiving Waters

The receiving waters is the Yukon River which has a large dilution ratio of the sewage effluent being discharged. The following has been extracted from the water license with regards to the receiving waters:

Receiving Water Standard

The licensee shall ensure that the receiving water standards shown below are met outside the initial mixing zone. For faecal coliforms the initial mixing zone is defined as a volume of water extending seven hundred and fifty (750) meters downstream from the point of discharge from the bed to the surface of the Yukon River. For all other parameters specified, the initial mixing zone is defined as a volume of water extending three hundred (300) meters downstream from the point of discharge from the ed to the surface if the Yukon River, whose width shall not exceed twenty-five (25) per cent of the natural surface width of the river.

Parameter	**Standard**
Faecal Coliforms	not to exceed 20 counts/100 ml
Dissolved Oxygen	decrease from point upstream of discharge not to exceed 10%, and concentration not to fall below 7 mg/l as a result of sewage discharge
Oil and Grease	not to exceed 1.0 mg/l at surface
Organisms	no undesirable change in productivity
Settleable Solids	negligible increase
Floatable Solids and Scum	negligible increase
Metals	negligible increase

This water license is appended in Appendix E. The sampling to date, refer to Table 5.4 Sampling Results, has shown that the City meets all of the criteria and should continue to do so even with the increased flows for a population of 3000 persons. The projections are

based on the dilution for both winter and summer flows. The strength of the sewage increases in the summer but the flows in the river go up by a factor of 8 to 10 thereby making the mixing zones that much greater.

The receiving waters should continue to meet the current criteria as presently set with the increased population of 3000.

5.5 Sewage Treatment and Disposal

5.5.1 Existing Sewage Treatment and Disposal

The present sewage treatment is primary treatment which is achieved by the use of rotor strainers. This process eliminates the solids from the raw sewage. The solids are then disposed of in the municipal land fill.

These fine screens are estimated to remove up to 20 percent of the suspended solids and BOD_5 dependent on the incoming sewage strengths. To date, all testing of the sewage has been after screening so there is no data to compare the effectiveness of the screens, however, the testing program will be expanded to evaluate the raw wastewater characteristics. This data will be required for the upcoming water license application.

Since the sewage is very diluted the screens effectiveness for SS and BOD removal is lowered due to the low strength of the incoming sewage. However, they do provide the required primary treatment of the sewage prior to disposal to the Yukon River.

This treatment system has proven to be acceptable with the only parameter being exceeded is the Oil and Grease. The O&G will be reduced within the system by proper traps in all food serving facilities. Steps towards this has already been done by proposing a new bylaw enforcing the grease traps usage.

The primary treated effluent is discharged to the Yukon River through a 250 dia. outfall line. This line is approximately 225 meters from Front Street and is located in 5 meters of water during low water level and 13 meters of water during the summer months. The outfall line has a diffuser which was designed to produce a flume to adequately dispense the sewage effluent to meet the permits. From data to date this has been achieved to such a degree that most parameters are undetectable, refer to attached data sampling in Appendix "D".

5.5.2 Future Sewage Treatment Requirements

A. Sewage Screening Plant

It is anticipated that the strength of the sewage will not increase substantially due to the system of bleeding in both the winter and the dilute nature of the sewage in the summer.

To meet the effluent parameters for a population of 3000 the existing screening plant will require the following:

- install the second rotostrainer;
- increase the size of pumps to handle the additional flows;
- modify the piping as required;
- install a new meter for recording flows;
- update the electrical system.

The treated effluent will continue to be disposed of through the existing outfall. The outfall will require a greater head to drive the increased flows due to the size of the outfall line. To achieve this head a header tank will be constructed next to the dyke. This tank will receive the effluent from the pumps located in the screening plant and will then flow by gravity through the outfall. The flow will be driven by the increased height in the header tank.

The header tank will be 1.5 meters in diameter and be built to the same top elevation of the dyke. There will be 1.7 meters of head to drive the sewage. It will be built on the river side of the dyke, refer to Figure 5.1.

To undertake this work the capital cost estimate is shown in Table 5.4. The operating and maintenance budget would not increase significantly to what it is at present.

TABLE 5.4
Cost Estimate
Sewage Screening Plant Modifications

	Item	Cost Estimate
1.	Supply and install screen	$36,000
2.	Supply and install pumps	$58,000
3.	Outfall header tank	$18,000
4.	Contingencies and Engineering	$15,000
	Total Estimated Cost	$127,000

This upgrading could be done in two stages, first install the screen since the existing pumps can handle flows greater than that of the existing screen. Secondly increase the pump sizes once the hydraulics of the system requires it. At this time the outfall header tank should be constructed.

B. Mechanical Treatment Plant

Since the water license is up for renewal May 25, 1993 and an increase in water withdrawal will be required in the future the City wanted to compare the cost of secondary treatment in case the Water Board wanted to go that route. Therefore, an engineering analysis was undertaken.

(i) Site Location

Selection of possible sewage treatment sites is governed by the type of system: either lagoon or mechanical, and four specific criteria, namely available land area, proximity to the community, soils condition and effluent disposal area.

Lagoon systems require a large area that contains proper soils for lagoon construction and possibly lining, proper drainage, shelter belts and access. Around Dawson there are no areas unless they are located up along the Klondike River, however soils are very poor. As well, the discharge would be into the Klondike River which has not got sufficient flows and joins the Yukon River upstream of the community. For these reasons the lagoon system was abandoned.

The only treatment alternative was a mechanical plant. This plant could be located adjacent to the existing screening plant or be located to the north of the City in the old dump or on top of the waste disposal site. Since any treatment plant does give off odors and the area around the existing screening plant is prime development area the site selected for the plant would be in the north on the waste disposal area, refer to Figure 5.2;

(ii) Process Selection

There were two processes reviewed for this application since this is only a prefeasibility analysis, there are others that should be considered later if required:

- rotating biological contractors

- extended aeration plants

The treatment of municipal wastewater is classified by the level of treatment the sewage receives. The levels of treatment are primary, secondary and tertiary. Primary sewage treatment consists of screening or settling of solids, some removal of faecal coliforms,

BOD and grease and oil within the wastewater followed by disposal. The level of treatment is minimal, but often sufficient depending on site specific conditions and receiving body of water. Secondary treatment follows primary treatment and consists of improving the quality of sewage effluent to an increased level of treatment. Tertiary treatment is once again a higher level of treatment. For Dawson City the highest level of treatment which we believe the Water Board would require is secondary. Therefore, the process is based on the equivalent of secondary treatment.

When the two selected alternatives were reviewed both could do the job for this low strength sewage, however, the lowest operational costs favour the RBC system. Therefore the process selected for this analysis is the rotating biological contractors;

(iii) Rotating Biological Contactors

General

The rotating biological contactor (RBC) is essentially a fixed film type of process where micro-organisms form a thin layer (5 to 10 mm thick) on a flat surface and act to remove organic matter. The RBC typically consists of a series of closely spaced plastic disks which are mounted on a horizontal shaft. The shaft is mounted in a tank which has a contoured bottom. Each grouping of disks is referred to as a stage, and as such a single tank may contain more than one stage. The disks rotate slowly within the tank with approximately 40% of the surface area submerged. As the disks rotate, they pick up a thin layer of wastewater to adhere and grow on the disk surface. As the disks rotate, oxygen is transferred from the air to the liquid film and ultimately to the layer of micro-organisms. The biomass on the disks serves to remove both dissolved oxygen and organic matter from the wastewater. As time passes microbial growth on the disks increases until such time that excess growth is removed by shearing forces caused by rotation of the disk in the wastewater.

Operation of Rotating Biological Contactor

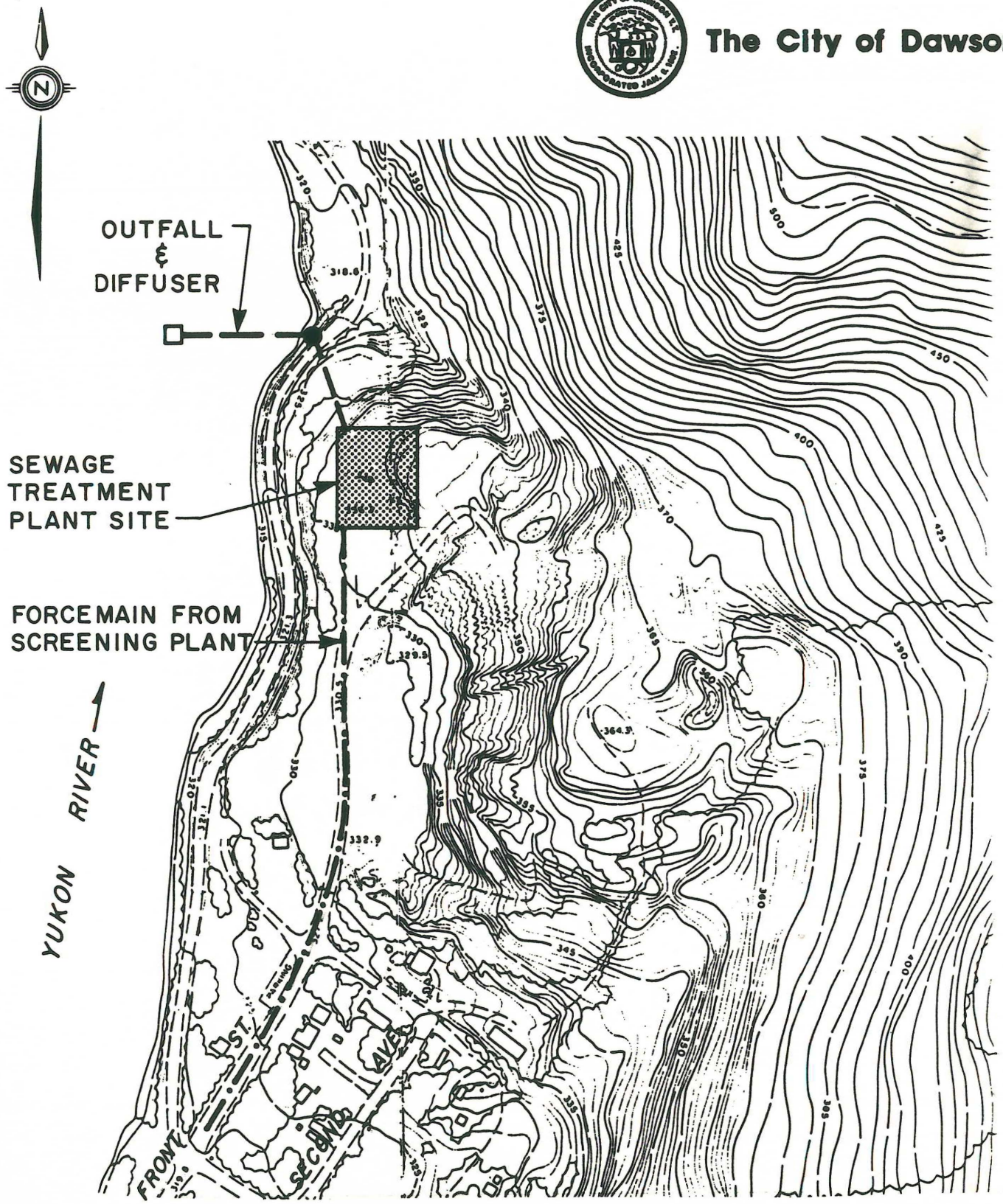
The most significant advantage associated with the use of RBC systems in small communities according to Smith (1986) and the USEPA (1977) include:

(1) low maintenance;

(2) stability under fluctuating organic and hydraulic loads.

A typical flow diagram of the rotating biological contactor system is shown in Figure 5.3. A detailed drawing of the RBC unit itself is also shown in Figure 5.3.

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Sewage Treatment Plant Proposed Site

figure 5.2

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As shown in Figure 5.3 primary treatment is an important part of the overall removal process since the flow velocity and turbulence in the RBC compartment containing the disks are not high enough to keep heavy primary wastewater solids in suspension. In this application primary treatment consists of the existing fine screens located in the screen building.

Since large surface areas of the disk are exposed to the atmosphere, the RBC serves as an efficient heat transfer device and therefore the effects of ambient temperature must be considered in the design and operation. Ross et al. (1980) suggest the two most important effects of temperature are:

1. Reduced biological activity and treatment performance; and

2. Ice formation.

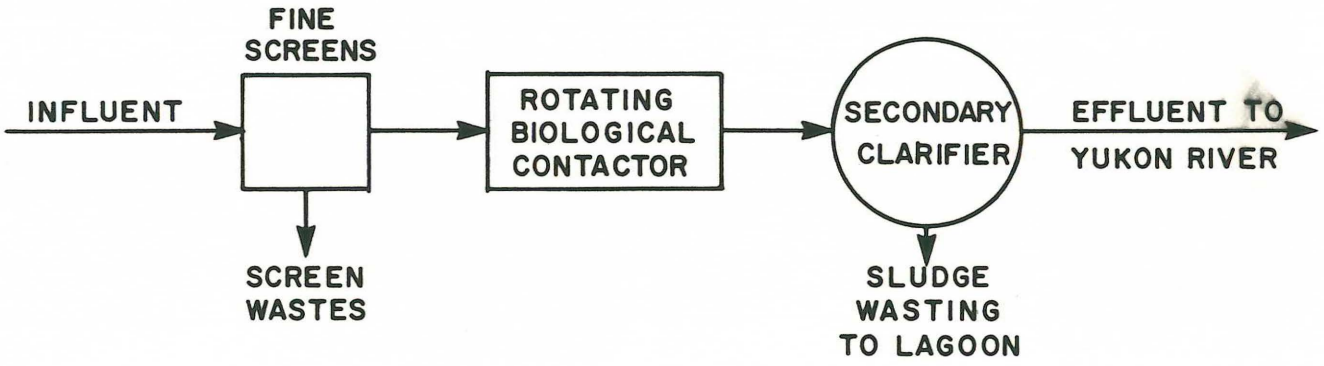
Therefore, to obtain efficient operation under cold climatic conditions it is imperative that the RBC unit be enclosed in a temperature controlled building.

A secondary clarifier is used to separate solids which form during the biological treatment process in the RBC unit. This is the final step in the treatment process and serves to provide a clarified effluent for discharge. Secondary clarifiers are typically designed based on hydraulic overflow rates. Ross et al (1980) suggests that properly designed and operated secondary clarifiers should produce a stable well-clarified effluent which is low in BOD and suspended solids. However, they stress that "good housekeeping" is essential in the operation of secondary clarifiers since it is desirable to keep the accumulation of sludge to a minimum. This clarifier also must be housed due to the low temperatures.

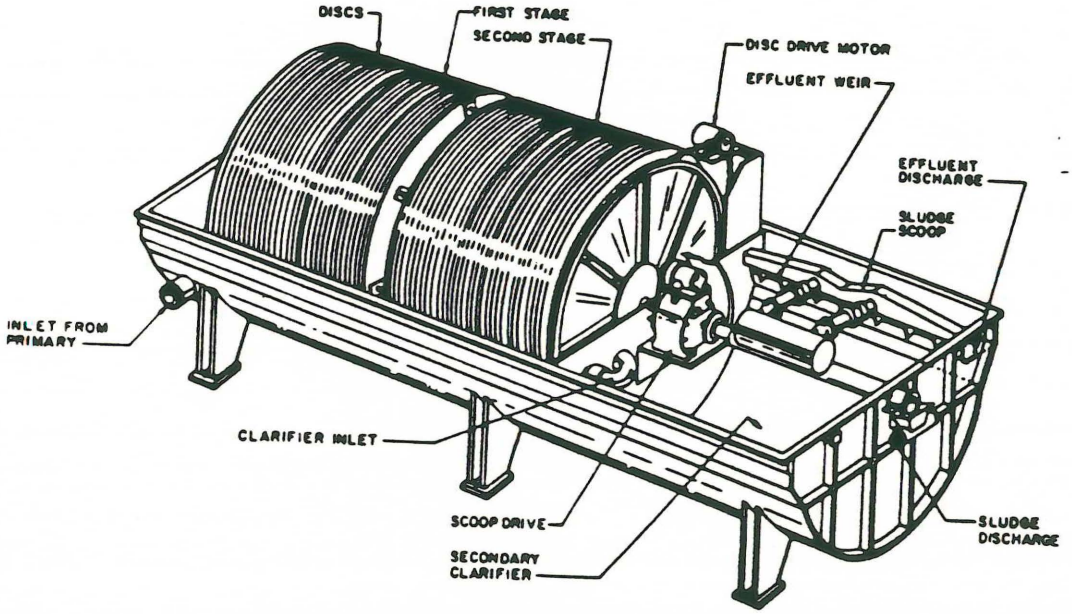
Performance Data

Smith and Given (1981) examined the effectiveness of an RBC in treating domestic wastewater which was both dilute and cold. Performance date collected at four different hydraulic loading rates is shown in Table 5.5. For cold dilute wastewater BOD removal efficiencies may range from 64 to 92% at the high and low hydraulic loading rates respectively, Table 5.6. Similarly suspended solids removal efficiencies at high and low loading values ranged from 61 to 86% respectively.

The City of Dawson



Schematic Flow Diagram of the
Rotating Biological Contactor Process
(Source: Ross et al., 1980)



Typical RBC Unit
(Source: USEPA, 1977)

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Rotating Biological Contactor - Process Schematic

figure **5.3**

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TABLE 5.5
Characteristics of Low Temperature Dilute RBC Influent and Effluent Wastewater

Operating Period	Average Q ($L/m^2.d$)	Temperature Influent (C.)	Temperature Effluent (C.)	Median BOD (Total) Influent (mg/L)	Median BOD (Total) Effluent (mg/L)	Median Suspended Solids Influent (mg/L)	Median Suspended Solids Effluent (mg/L)
1a	56	7.4	8.6	56	5	44	6
0	145	6.3	6.7	55	11	50	7
	238	8.9	8.8	70	21	78	14
	396	11.7	10.8	56	21	52	16
2a	56	7.9	10.3	39	3	33	4
	155	6.4	7.6	29	5	28	5
	248	6.2	6.7	34	10	23	6
	403	6.0	6.1	45	16	26	9

a: Operating periods and 1 and 2 refer to two consecutive years of operation. For year 1 temperature date values were measured in the morning whereas for year 2 temperature data represent the average of morning and afternoon data.

Adapted from: Smith and Given (1981)

Dawson influent temperature is approximately 2.5 C.

TABLE 5.6
RBC Unit Treatment Efficiencies

Operating Period	Average Q ($L/m^2.d$)	BOD_5 (Total) Removal (%)	Suspended Solids Removal (%)
1	56	91	86
	145	80	86
	238	70	82
	396	62	69
2	56	92	88
	155	83	82
	248	71	74
	403	64	61

a: Efficiencies determined from Table

Adapted from: Smith and Given (1981)

Based on scaled up pilot plant date Smith and Given (1981) provided an equation which relates effluent BOD's to both influent BOD's and the applied hydraulic loading.

$$BOD_e = 2.9 + 1.6 (BOD_i * Q/1000)$$

where: BOD_e = effluent BOD, mg/L

BOD_i = influence BOD, mg/L

Q = hydraulic loading expressed as L/m^2*d

Results of the Smith and Given study (1981) suggest that based upon effluent quality considerations, an RBC appears not to be significantly effected by influent wastewater strength. However, RBC percentage removal values may be greatly influenced by influent strength, much lower removal efficiencies may be expected at low wastewater strength.

Sludge Handling

According to the USEPA (1977) the amount of sludge produced will depend on individual waste characteristics and loading rates. An RBC unit designed for 80 to 95% removal of BOD would produce approximately 0.1 and 0.3 kg of sludge per kg of BOD_5 removed, respectively under typical operating conditions.

The biological sludge produced tends to be dense and settle rapidly. Solids concentrations can be maintained at 3 to 4% if continuous withdrawal is provided. Typically no sludge recycle is used in an RBC process. The sludge would be handled wet and piped to a sludge pond located by the solid waste disposal site where it would settle out.

Nitrification

RBC's can be designed to provide nitrification in addition to BOD and suspended solids removal. For this purpose temperature, pH, and the presence of toxic substances must be carefully controlled. Typically 4 to 10 step RBC units are used for this purpose. The USEPA (1977) reports that as BOD decreases the ammonia-nitrogen removal increases. At hydraulic loadings of 0.04 $m^3/m^2/d$, ammonia-nitrogen removal of more than 95% and effluent concentrations of less than 1.0 mg/L had been reported at wastewater temperatures above 13 C. Murphy and Wilson (1978) report that design loadings must be considerably reduced for load temperature applications, especially when the temperature drops below 5 C.

Operation and Maintenance

Since the operation of an RBC unit is fairly stable under conditions of fluctuating hydraulic and organic loadings, and does not require recycling of sludge, the need for great operating flexibility and instrumentation is reduced when compared to other biological processes such as extended aeration.

It is preferable that the units be placed in an enclosure such that the temperature may be maintained a few degrees above the wastewater temperature, although this will increase operating costs, it will improve operations during times of extreme cold weather.

The main mechanical components of an RBC unit are related to rotating the biological disks. These typically have separate drive units allowing each bank of disks to be shut down individually for servicing.

Summary

The RBC has been shown to be a reliable and simple process for the treatment of municipal wastewaters, even at very low temperatures and under dilute conditions. Simplicity of operation is one of the outstanding features of the RBC process. Due to the mechanical simplicity of the process only minimal maintenance is required, consisting of period sludge removal and maintenance of drive line units. These advantages make the RBC especially suitable for small plant operations. Changes in organic loadings which occur slowly can be accommodated by adjustments in the biomass. In cases where an RBC unit is operated below the design loading the units may provide treatment which is consistently better than required.

Disadvantages of RBC units include the limited residence time (typically less than 3 hours) which can seriously hamper the ability of an RBC to equalize or absorb varied or shock loadings. Additional equalization equipment should be installed where large fluctuations in flow or BOD are expected. Although the estimated man-hour requirement for the operation of an RBC is similar to that for an extended aeration unit, the lack of a defined need for a process control makes this process superior to extended aeration.

RBC Cost Estimates

The estimated cost for a RBC plant in Dawson City is shown in Table 5.7.

TABLE 5.7
RBC Cost Estimates

1.	Site Preparation and Gravelling	$180,000.00
2.	Plant Supply, Install and Commission	$1,900,000
3.	Plant Building	$850,000
4.	Miscellaneous Site Work and Fencing	$89,000
5.	Screen Plant Pumps	$75,000
6.	Lift Station Controls and Metering	$50,000
7.	Sewage Force Main	$120,000
8.	Plant Discharge Pipe and Diffuser	$110,000
9.	Sludge Lagoons	150,000
	Construction Subtotal	$3,515,000
	25% Engineering and Contingency	$880,000
	Construction Total	**$4,395,000**

The annual operating and maintenance costs for the rotating biological contactor is estimated as follows:

1.	Inspection and Maintenance Labour	$90,000
2.	Miscellaneous Maintenance Costs	$60,000
3.	Power Costs	$180,000
4.	Landfilling Sludge	$60,000
	Operating and Maintenance Subtotal	$390,000
	10% Contingency	$39,000
	Operating and Maintenance Total	**$429,000 /year**

5.6 Sewage Collection System

The sewage collection system, refer to Figure 5.4, follows the water distribution system as outlined in Section 3 complete with cost estimates. The collection system is expanded to complete the infill and northern expansion area within the study boundaries. The lift station will require some modification to handle the northern expansion area at a cost of $20,000.00.

Section 5.7 Cost Estimate Summary

Cost estimates are summarized from the previous subsections and tablized below: The future sewage treatment costs carried forward are those of the screening plant modifications. The cost of secondary treatment is very high and in light of the sewage strengths and disposal source unwarranted.

TABLE 5.8
Summary Recommended Capital Costs

A.	Modify Screen Plant and outfall line	$127,000
B.	Modify Lift Station	$20,000
	Total	$147,000

5.8 Conclusion

The following conclusions have been made from this study:

1. The sewage flows are equivalent to the water usage.

2. The present and future sewage effluent will meet the present water license requirements.

3. The existing screening plant with modifications will meet the treatment requirements for the population of 3000 for a capital expenditure of $127,000.00.

4. To provide secondary treatment will cost approximately $4.4million.

5.9 Recommendations

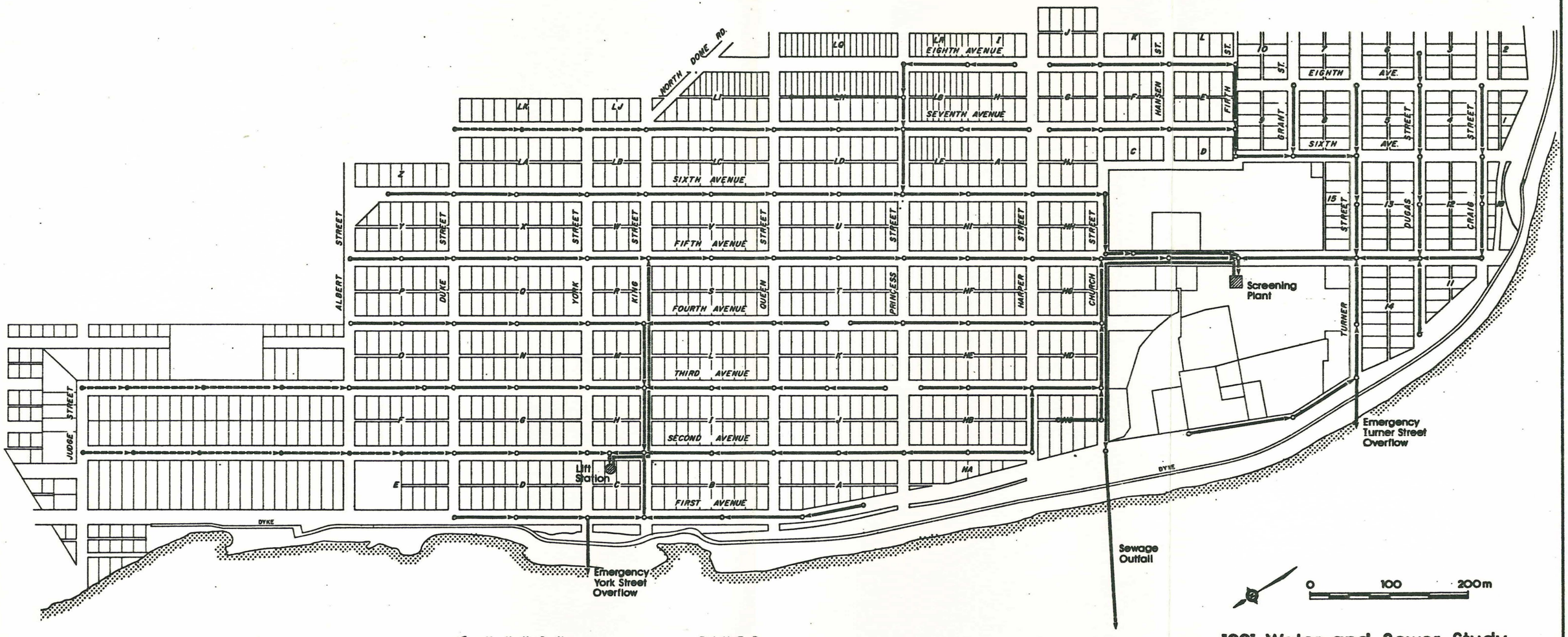
1. The screening plant be modified at an estimated cost of $127,000.00 to meet the treatment requirements of 3000 persons.

2. The water license expires on May 25, 1991 and a new application should eventually be applied for using primary treatment for the sewage effluent. In the meantime an extension to the existing permit should be applied for until such time as the water withdrawal exceeds the existing permit.

Legend

- Existing Collection System
- Existing Forcemain
- Future Collection System

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1991 Water and Sewer Study

Sewage Collection System

figure **5.4**

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SECTION 6 WATER LICENSE REVIEW

6.1 Existing License

The existing license is dated May 26, 1983 between the City of Dawson and the Yukon Territory Water Board and expires on May 25, 1993, a period of 10 years. A copy of the water license is attached in Appendix "E". To date, the City has met all portions of the license except at times, the oil and grease in the effluent discharge. The City, with their present facilities can continue to meet these requirements.

As the City population increases the water requirements will increase and exceed the water withdrawal portion of the license. Since the license expires in May 1993, the City should be preparing a request for extension until such time as the water withdrawal exceeds the present license.

6.2 New License Application

The City should prepare a new license when requested after application of an extension based on this report and contain the following:

1. Rate of use of water not to exceed: 5.6 Ml/day (1,300,000 igpd)

2. Sewage treatment of the effluent to continue to be primary treatment.

The extension and application takes some time and should begin early in 1992. An engineering budget of approximately $50,000 may be required.

SECTION 7 CAPITAL WORKS SCHEDULE

7.1 Introduction

The previous sections outlined the needed requirement to bring the water and sewage systems to a level to adequately serve 3000 persons. The level of service expansion does not have to be done at one time but can be phased in over a period of years. Numbers therefore, presented in Table 7.1 is a schedule of works with the associated capital costs for a given year. In certain cases the work for that particular year may be delayed or accelerated due to a change in growth or based on political/administration requirements.

TABLE 5.9
CITY OF DAWSON
CAPITAL WORKS SCHEDULE - WATER & SEWER
1991 WATER AND SEWER STUDY

Item	1991	1992	1993	1994	1995	1996	1997	Totals
A. Water Supply Well System								
1. Site Analysis	$6,500							$6,500
2. Aquifer Analysis and drilling	$40,000	$110,000						$150,000
3. Engineering		$50,000						$50,000
4. Construct wells, Pipelines and Pumphouses		$270,000						$270,000
B. Pumphouses Upgrading Reservoir Expansion								
1. Engineering		$35,000	$25,000					$60,000
2. Pumphouse Mod.		$80,000	$260,000					$340,000
3. Reservoir		$120,000						$120,000
C. Water and Sewer System Expansion								
1. 8th Ave. and 7th Ave. Addition-Engineering		$10,000	$7,000					$15,000
2. 8th Ave. and 7th Ave. Addition Construction		$324,000						$324,000
3. Northern Expansion Area Survey & Legal		$75,000						$75,000

TABLE 5.9 (CONTINUED)
CITY OF DAWSON
CAPITAL WORKS SCHEDULE - WATER & SEWER
1991 WATER AND SEWER STUDY

Item	1991	1992	1993	1994	1995	1996	1997	Totals
4. NEA - Engineering		$350,000	$80,000		$80,000		$80,000	$320,000
5. NEA - Block BE		$80,000						$350,000
6. NEA - Stage 1			$717,000					$717,000
7. NEA - Stage 2					$717,000			$717,000
8. NEA - Stage 3							$717,000	$717,000
9. Water Meter Program				$180,000	$180,000			$360,000
D. Water System Heating								
1. Alt #1 - Option B Engineering		$35,000						$35,000
2. Construction		$403,000						$403,000
E. Sewage Treatment								
1. Upgrade Screening Plant and Outfall	$40,000	$7,000	$80,000					$127,000
2. Prepare New Water License		$50,000						$50,000
3. Modify Lift Station			$20,000					$20,000
TOTALS - YEARLY	$86,500	$1,999,000	$1,189,000	$180,000	$977,000	$0	$797,000	$5,228,500

7.3 Financing and Grants

The City receives the majority of its capital works money through "Block Funding Payments" based partially on population. The Capital Works Water and Sewer Projected Schedule indicates several major expenditures for the water and sewer systems over the next three years. The Yukon Territorial Government should be approached for "Extraordinary Funding" for both the water supply (well development) and sewage treatment facilities.

7.4 Rate Recovery By-Laws

The By-Laws for recovery of operation and maintenance of the water and sewer systems should be reviewed for user charges. An economical analysis of the service charges to actual costs should be undertaken.

Special levies should also be considered for any new building/development that connects to the existing systems.

The waste heat subsidiary agreement alters the term date to April 1st 1993, which is a 10 year period. This period is approaching and discussions should begin to determine the future of the plant, modifications required, and the continuous use of waste heat. Portion of these costs should be reflected in the user charges.

APPENDIX "A"

FIRE UNDERWRITERS SURVEY, 1981

WATER SUPPLY FOR PUBLIC FIRE PROTECTION

A Guide to Recommended Practice

1981

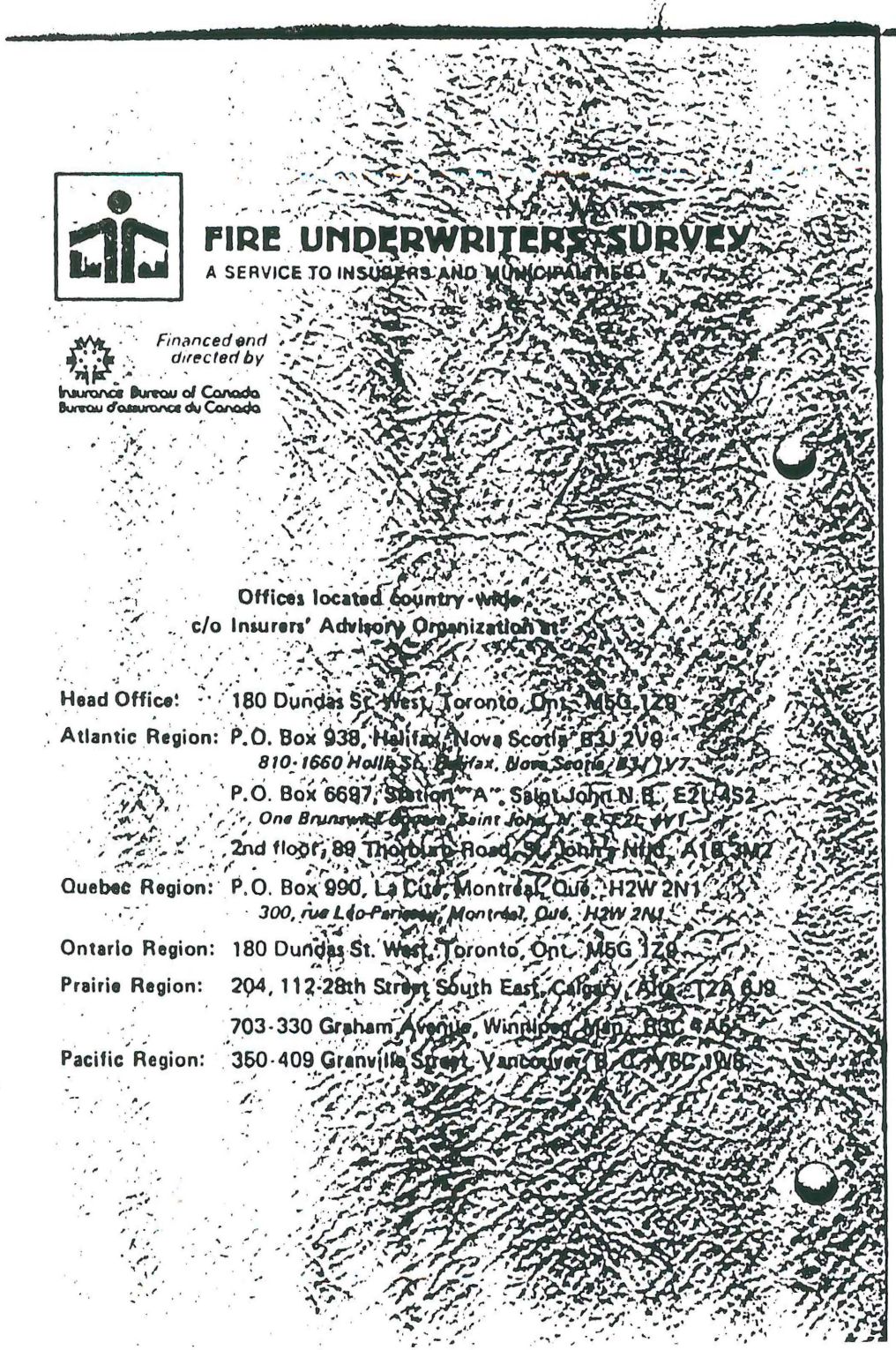
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FIRE UNDERWRITERS SURVEY

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WATER SUPPLY FOR PUBLIC FIRE PROTECTION

A GUIDE TO RECOMMENDED PRACTICE

PREFACE

This guide summarizes the more significant recommendations of Fire Underwriters Survey with respect to fire protection requirements in municipal water works system design. It reflects the manner in which the FUS surveyor assesses the water supply aspect of a municipality's fire risk potential during surveys on behalf of the Canadian property insurance industry and represents the accumulated experience of many years study of actual fires. Water supply is one of a number of components evaluated by FUS in the community fire protection system. Recommendations applying to fire departments and Code enforcement are covered in other publications of Fire Underwriters Survey. FUS local offices are prepared to assist municipal officials or their consultants with advice on specific problems, as time limits permit, in accordance with the intent of this guide. The minimum size water supply credited by FUS must be capable of delivering not less than 1000 L/min (200 gpm) for two hours or 2000 L/min (400 gpm) for one hour in addition to any domestic consumption at maximum daily rate. Static suction supplies to fire department pumpers are recognized only as a supplement to the piped system.

In the FUS assessment of a water supply system the major emphasis is placed upon its ability to deliver adequate water to control major fires throughout the community on a reliable basis via sufficient and suitable hydrants. What is ultimately available to the fire department is the critical test in this fire protection evaluation.

In this second edition, coincident with conversion to metric units, some reductions in the amounts and durations of fire flows have been introduced to reflect changing conditions in the structure of communities and in fire suppression techniques.

Rates of flow for firefighting purposes are expressed in litres per minute as this is the adopted unit for the firefighting field.

With this edition of the Guide, quantities are specified in S.I. units. Imperial equivalents or approximations are also given for convenience only.

PART I

GENERAL

ADEQUACY AND RELIABILITY. An adequate and reliable water supply for firefighting is an essential part of the fire protection system of a municipality. This is normally a piped system in common with domestic potable water service for the community.

A water supply system is considered to be fully adequate if it can deliver the necessary fire flow at any point in the distribution gridiron for the applicable time period specified in the table "Required Duration of Fire Flow" with consumption at the maximum daily rate (average rate on maximum day of a normal year). When this delivery is also possible under certain emergency or unusual conditions as herein specified, the system is considered to be reliable. In cities of population in excess of 250,000 (or smaller places with high fire incidence and severe hazard conditions) it is usually necessary to consider the possibility of two simultaneous major fires in the area served by the system.

Fire flows are amounts of water necessary to control fires. These are determined as shown in Part II. System design should contemplate meeting the required fire flows existing or probable with the possible exception of gross anomalies where there is no fire threat to the remainder of the community. In these cases, the properties should preferably be modified in hazard to reduce the required flow as part of a coordinated community fire protection system.

The protection of buildings by automatic sprinkler systems is a significant contribution to the fire protection of the community and should be encouraged, not penalized by onerous service charges or metering requirements.

In order to provide reliability, duplication of some or all parts of the system will be necessary, the need for duplication being dependent upon the extent to which the various parts may reasonably be expected to be out of service as a result of maintenance and repair work, an emergency or some unusual condition. The introduction of storage, either as part of the supply works or on the distribution system, may partially or completely offset the need for duplicating various parts of the system, the value of the storage depending upon its amount, location and availability.

STORAGE. In general, storage reduces the requirements of those parts of the system through which supply has already passed. Since storage usually fluctuates, the normal daily minimum maintained is the amount that should be considered as available for fires. Because of the decrease in pressure when water is drawn down in standpipes, only the portion of this normal daily minimum storage that can be delivered at a residual pressure of 150 kPa (20 psi) at the point of use is considered as available. As well as the quantity available, the rate of delivery of water to the system from storage for the fire flow period is critical to this consideration.

PRESSURE. The principal requirement to be considered is the ability to deliver water in sufficient quantity to permit pumpers of the fire department to obtain an adequate supply from hydrants. To overcome friction loss in the hydrant branch, hydrant and suction hose, a minimum residual water pressure of 150 kPa (20 psi) on the street main is required during flow. Under conditions of exceptionally low suction losses a lower residual may be possible. This includes the use of 100 mm (4-inch) and larger outlets for fire department pumper use and hydrants with large waterways.

Higher sustained pressure is of importance in permitting direct continuous supply to automatic sprinkler systems, to building standpipe and hose systems, and in maintaining a water plane such that no portion of the protected area is without water, such as during a fire at another point. Residual pressures that exceed 700 kPa (75 psi) during large flows are of value as they permit short hose-lines to be operated directly from hydrants without supplementary pumping. The volumes and pressures of water supply required for individual automatic sprinkler systems vary considerably, but a flow characteristic of 4500 L/min (1000 gpm) at 300 kPa (40 psi) is considered adequate for a majority of such systems protecting low hazard industrial or commercial buildings.

SUPPLY WORKS

NORMAL ADEQUACY OF SUPPLY WORKS. The source of supply, including impounding reservoirs, and each part of the supply works should normally be able to maintain the maximum daily consumption rate plus the maximum required fire flow. Each distribution service within the system should similarly support its own requirements. In large cities where fire frequency may result in simultaneous fires, additional flow must be considered in accordance with the potential. Filters may be considered as capable of operating at a resonable overload capacity based upon records and experience. In general, overload capacity will not exceed 25 per cent, but may be higher in well designed plants operating under favourable conditions.

The absolute minimum supply available under extreme dry weather conditions should not be taken as the measure of the normal ability of the source of supply such as supply from wells. The normal or average capacity of wells during the most favourable nine month period should be considered, or the normal sustained flow of surface supplies to the source.

RELIABILITY OF SOURCE OF SUPPLY. The effect on adequacy must be considered for such factors as frequency, severity and duration of droughts, physical condition of dams and intakes; danger from earthquakes, floods, forest fires, and ice dams or other ice formations; silting-up or shifting of channels; possibility of accidental contamination of the watershed or source; absence of watchmen or electronic supervision where needed; and injury by physical means. Where there is a risk of disruption, special precautions or alternate supplies should be arranged.

Where supply is from wells, some consideration should be given to the absolute minimum capacity of the wells under the most unfavorable conditions; also to the length of time that the supply from the wells would be below the maximum daily consumption rate, and the likelihood of this condition recurring every year or only at infrequent intervals. It should be recognized that some water is generally available from wells and that the most extreme conditions are not as serious as a total interruption of the supply, as would be the case in the breaking of a dam or shifting of a channel. The possibility of clogging, salinity, and the need for periodic cleaning and overhauling must be considered. Dependence upon a single well, even where records are favorable, may be considered a feature of unreliability.

equent cleaning of reservoirs and storage tanks may be considered as affectinn liability.

Continuity of and delay in implementing water supplies obtained from systems or sources not under the control of the municipality or utility should be considered also from these aspects.

GRAVITY SYSTEMS. A gravity system delivering supply from the source to distribution directly without the use of pumps is advantageous from the fire protection point of view because of its inherent reliability, but a pumping system can also be developed to a high degree of reliability.

PUMPING

RELIABILITY OF PUMPING CAPACITY. Pumping capacity, where the system or service is supplied by pumps, should be sufficient, in conjunction with storage when the two most important pumps are out of service, to maintain the maximum daily consumption rate plus the maximum required fire flow at required pressure for the required duration. For smaller municipalities (usually up to about 25,000 population) the relative infrequency of fires is assumed as largely offsetting the probability of a serious fire occurring at times when two pumps are out of service. (The most important pump is normally, but not always, the one of largest capacity, depending upon how vital is its contribution to maintaining flow to the distribution system.)

To be adequate, remaining pumps in conjunction with storage should be able to provide required fire flows for the specified durations at any time during a period of 5 days with consumption at the maximum daily rate. Effect of normal minimum capacity of elevated storage located on the distribution system and storage of treated water above lowlift pumps should be considered, for example. The rate of flow from such storage must be considered in terms of any limitation of water main capacity. The availability of spare pumps or prime movers that can quickly be installed may be credited as may pumps of compatible characteristics which may be valved from another service,to assist.

POWER SUPPLY FOR PUMPS. Electric power supply to pumps should be so arranged that a failure in any power line or the repair or replacement of a transformer, switch, control unit or other device will not prevent the delivery, in conjunction with elevated storage, of required fire flows for the required durations at any time during a period of two days with consumption at the maximum daily rate.

Power lines should be underground from the station or substation of the power utility to water plants and pumping stations and have no other consumers en route. The use of the same transmission lines by other consumers introduces unreliability because of the possibility of interruption of power or deterioration of power characteristics.

Overhead power lines are more susceptible to damage and interruption than underground lines and introduce a degree of unreliability that depends upon their location and construction. In connection with overhead lines, consideration should be given to the number and duration of lightning, wind, sleet, and snow storms in the area; the type of poles or towers and wires; the nature of the country traversed; the effect of earthquakes, forest fires, and floods, the lightning and surge protection provided; the extent to which the system is dependent upon overhead lines; and the ease of and facilities for repairs.

The possibility of power system or network failures affecting large areas should be considered. In-plant auxiliary power or internal combustion driver standby pumping are appropriate solutions to these problems in many cases, particularly in small plants where high pumping capacity is required for fire protection service. When using automatic starting, prime movers for auxiliary power supply and pumping should have controllers labelled or listed by Underwriters' Laboratories of Canada to establish their reliability.

FUEL SUPPLY. At least a 5-day supply of fuel for internal-combustion engines or boilers used for regular domestic supply should be provided; where long hauls, condition of roads, climatic conditions, or other circumstances could cause interruptions of delivery longer than five days, a greater storage should be provided. Gas supply should be from two independent sources or from duplicate gas-producer plants with gas storage sufficient for 24 hours. Unreliability of regular fuel supply may be offset in whole or in part by suitable provisions for the use of an alternate fuel or power supply.

BUILDINGS AND PLANT

BUILDINGS AND STRUCTURES. Pumping stations, treatment plants, control centers and other important structures should be located, constructed, arranged, and protected so that damage by fire, flooding, or other causes will be held to a minimum. They should contain no combustible material in their construction, and, if hazards are created by equipment or materials located within the same structure, the hazardous section should be suitably separated by fire resistive partitions or fire walls.

Buildings and structures should have no fire exposures. If exposures exist, suitable protection should be provided. Electrical wiring and equipment should be installed in accordance with the Canadian Electrical Code. All internal hazards should be properly safeguarded in accordance with good practice. Private in-plant fire protection should be provided as needed.

MISCELLANEOUS SYSTEM COMPONENTS, PIPING AND EQUIPMENT. Steam piping, boiler-feed lines, fuel-piping (gas or oil lines to boilers as well as gas, oil or gasoline lines to internal-combustion engines), and air lines to wells or control systems should be so arranged that a failure in any line or the repair or replacement of a valve, fuel pump, boiler-feed pump, injector, or other necessary device, will not prevent the delivery, in conjunction with storage, of the required fire flows for the specified duration at any time during a period of two days with consumption at the maximum daily rate.

Plants should be well arranged to provide for effective operation. Among the features to be considered are: ease of making repairs and facilities for this work, danger of flooding because of broken piping; susceptibility to damage by spray; reliability of priming and chlorination equipment; lack of semi-annual inspection of boilers or other pressure vessels; dependence upon common nonsectionalized electric bus bars; poor arrangement of piping; poor condition or lack of regular inspections of important valves; and factors affecting the operation of valves or other devices necessary for fire service such as the design, operation, and maintenance of pressure regulating valves, altitude valves, air valves, and other special valves or control devices, provision of power drives, location of controls, and susceptibility to damage.

Reliability of the treatment works is likely to be influenced by the removal from service of at least one filter or other treatment unit; the reduction of filter capacity by turbidity, freezing, or other conditions of the water; the need for cleaning basins; and the dependability of power for operating valves, wash-water pumps, mixers, and other appurtenances.

OPERATIONS. Reliability in operation of the supply system and adequate response to emergency or fire demands are essential. Instrumentation, controls and automatic features should be arranged with this in mind. Failure of an automatic system to maintain normal conditions or to meet unusual demands should sound an alarm where remedial action will be taken.

The operating force should be competent, adequate, and continuously available as may be required to maintain domestic and fire service.

EMERGENCY SERVICES. Emergency crews, provided with suitable transportation, tools, and equipment, should be continuously on duty in the larger systems and be readily available upon call in small systems. Spare pipe and fittings and construction equipment should be readily available. Alarms for fires in buildings should be received by the utility at a suitable location where someone is always on duty who can take appropriate action as required, such as placing additional equipment in operation, operating emergency or special valves, or adjusting pressures. Receipt of alarms may be by fire alarm circuit, radio, outside alerting device, or telephone, but where special operations are required, the alarm service should be equivalent to that needed for a fire station.

Response of an emergency crew should be made to major fires to assist the fire department in making the most efficient use of the water system and to ensure the best possible service in the event of a water main break or other emergency. The increase of pressures by more than 25 per cent for fires is considered to increase the possibility of breaks.

PIPING

RELIABILITY OF SUPPLY MAINS. Supply mains cut off for repair should not drastically reduce flow available to any district. This includes all pipe lines or conduits on which supply to the distribution system is dependent, including intakes, suction or gravity lines to pumping stations, flow lines from reservoirs, treatment plant piping, force mains, supply and arterial mains, etc. Consideration should be given to the greatest effect that a break, joint separation or other failure could have on the delivery of the maximum daily consumption rate plus required fire flow at required pressure over a three day period. Aqueducts, tunnels or conduits of substantial construction may be considered as less susceptible to failure and equivalent to good mains with a long history of reliability.

INSTALLATION OF PIPE. Mains should be in good condition and properly installed. Pipe should be suitable for the service intended. Asbestos-cement, cast and ductible iron, reinforced concrete and steel pipe manufactured in accordance with a appropriate Canadian Standards Association or ANSI/AWWA standards, or any pipes listed by Underwriters' Laboratories of Canada for fire service are considered satisfactory. Normally, pipe rated for a maximum working pressure of 1000 kPa (150 psi) is required. Service records, including the frequency and nature of leaks, breaks, joint separations, other failures and repairs, and general conditions should be considered as indicators of reliability. When mains are cleaned they should be lined.

Mains should be so laid as not to endanger one other, and special construction should be provided to prevent their failure at stream crossings, railroad crossings, bridges, and other points where required by physical conditions, supply mains shall be valved about once a mile and should be equipped with air valves at high points and blow offs at low points. Mains should not be buried extremely deep or be otherwise unusually difficult to repair, though depths to ten feet may be required because of frost conditions.

The general arrangement of important valves, of standard or special fittings, and of connections at cross-overs, intersections, and reservoirs, as well as at discharge and suction headers, should be considered with respect to the time required to isolate breaks. The need for check valves on supply or force mains and for other arrangements to prevent flooding of stations or emptying of reservoirs at the time of a break in a main should also be considered, as well as the need for relief valves or surge chambers. Accessibility of suitable material and equipment and ease of making repairs should be considered.

Arterial feeder mains should provide looping throughout the system for mutual support and reliability, preferably not more than 1000 metres (3000 feet) between mains. Dependence of a large area on a single main is a weakness. In general the gridiron of minor distributors supplying residential districts should consist of mains at least 150 mm (6-inch) in size arranged so that the lengths on the long sides of blocks between intersecting mains do not exceed 200 metres (600 feet). Where longer lengths of 150 mm (6-inch) pipe are necessary 200 mm (8-inch) or larger intersecting mains should be used. Where initial pressures are unusually high, a satisfactory gridiron may be obtained with longer lengths of 150 mm (6-inch) pipe between intersecting mains.

Where deadends and a poor gridiron are likely to exist for a considerable period or where the layout of the streets and the topography are not well adapted to above arrangement, 200 mm (8-inch) pipe should be used. Both ability to get the required fire flows and reliability of a reasonable supply by alternate routing must be taken into account in this consideration.

VALVES. A sufficient number of valves should be installed so that a break or other failure will not affect more than 400 metres (¼ mile) of arterial mains, 150 metres (500 feet) of mains in commercial districts, or 250 metres (800 feet) of mains in residential districts. Valves should be maintained in good operating condition. The recommended inspection frequency is once a year, or more frequently for larger valves and valves for critical applications.

A valve repair that would result in reduction of supply is a liability, but because of the probable infrequency of occurrence, it might be considered as introducing only a moderate degree of unreliability even if it resulted in total interruption. The repair of a valve normally should be accomplished in 2 days. Valves opening opposite to the majority are undesirable and when they do occur they should be clearly identified.

HYDRANTS

SIZE, TYPE, AND INSTALLATION. Hydrants should conform to American Water Works Association Standard for Dry Barrel Fire Hydrants (AWWA C502) or Underwriters Laboratories of Canada listing. Hydrants should have at least two 65 mm (2½-inch) outlets. Where required fire flows exceed 5000 L/min (1000 gpm) or pressures are low there should also be a large pumper outlet. The lateral street connection should be not less than 150 mm (6-inch) in diameter. Hose threads and operating and cap nuts on outlets should conform to Provincial Standard dimensions. A valve should be provided on lateral connections between hydrants and street mains when on major feeder mains, where fire flows exceed 5000 L/min (1000 gpm) and where grid is not close. Hydrants that open in a direction opposite to that of the majority are considered unsatisfactory. Flush hydrants are considered undesirable because of delay in getting into operation; this delay is more serious in areas subject to heavy snow storms. Cisterns are considered unsatisfactory as an alternative to pressure hydrants. The number and spacing of hydrants should be as indicated in the accompanying table "Standard Hydrant Distribution".

INSPECTION AND CONDITION. Hydrants should be inspected at least semi-annually and after use; inspection should include operation at least once a year. Where freezing temperatures occur, the semi-annual inspections should be made in the spring and fall of each year. Because of the possibility of freezing they should be checked frequently during extended periods of severe cold. Hydrants should be kept in good condition and suitable records of inspections and repairs be maintained. Hydrants should be painted in highly visible colors so that they are conspicuous and be situated with outlets at least twelve inches above grade. There should be no obstruction that could interfere with their operation. Snow should be cleared promptly after storms and ice and snow accumulations removed as necessary.

HYDRANT DISTRIBUTION. All areas should have hydrants installed in locations and at spacing convenient for fire department use along streets and in other areas, including private developments, where fire apparatus can go. General distribution density of hydrants should be in accordance with the required fire flows as indicated in the accompanying table "Standard Hydrant Distribution" to allow for convenient utilization of supplies. In addition convenient fire department use normally calls also for a maximum lineal distance between hydrants along streets in congested areas of 100 metres (300 feet) and for light residential districts, 200 metres (600 feet). Good practice calls for hydrants at intersections, in the middle of long blocks, particularly when required flows exceed 6000 L/min (1300 gpm), and rear the end of long deadend streets. Hydrants should be required by by-laws within large properties having access to fire apparatus. The planning of hydrant locations should be a cooperative effort between the water utility and the fire department.

RECORDS

PLANS AND RECORDS. Complete, up-to-date plans and records essential for the proper operation and maintenance of the system should be available in convenient form, suitably indexed and safely filed. These should include plans of the source as well as records of its yield and a reliable estimate of the safe yield; plans of the supply works including dams, intakes, wells, pipelines, treatment plants, pumping stations, storage reservoirs and tanks; and a map of the distribution system showing mains, valves, and hydrants. Plans and maps should be in duplicate and stored at two locations.

Detailed distribution system plans in a form suitable for field use should be available for maintenance crews. Records of consumption, pressures, storage levels, pipes, valves, and hydrants, and of the operations of the supply works and distribution system, including valve and hydrant inspections and repairs should be maintained.

STANDARD HYDRANT DISTRIBUTION

Fire Flow Required litres per minute	Average Area per Hydrant - m^2	Fire Flow Required Imp. gal/min	Average Area per Hydrant - ft^2 (Approx.)
2,000	16,000	400	170,000
4,000	15,000	800	160,000
6,000	14,000	1,000	155,000
8,000	13,000	1,500	144,000
10,000	12,000	2,000	132,000
12,000	11,000	2,500	120,000
14,000	10,000	3,000	108,000
16,000	9,500	3,500	100,000
18,000	9,000	4,000	97,000
20,000	8,500	4,500	90,000
22,000	8,000	5,000	85,000
24,000	7,500	5,500	78,000
26,000	7,000	6,000	72,000
28,000	6,500	6,500	66,000
30,000	6,000	7,000	63,000
32,000	5,500	7,000	60,000
34,000	5,250	8,000	57,000
36,000	5,000	8,500	53,000
38,000	4,750	9,000	51,000
40,000	4,500	9,500	48,000
42,000	4,250	10,000	45,000
44,000	4,000		
46,000	3,750		
48,000	3,500		

" refers to surface area of blocks and bounding streets. For a street without adjacent streets, a depth of one-half block is used.

REQUIRED DURATION OF FIRE FLOW

Fire Flow Required litres per minute	Duration hours	Fire Flow Required Imp. gal/min	Duration hours
2,000 or less	1.0	400	1.0
3,000	1.25	600	1.25
4,000	1.50	800	1.50
5,000	1.75	1,000	1.75
6,000 100 L/s	2.0	1,500	2.0
8,000	2.0	2,000	2.0
10,000	2.0	2,500	2.5
12,000	2.5	3,000	3.0
14,000	3.0	3,500	3.5
16,000	3.5	4,000	4.1
18,000 300L/s	4.0	4,500	4.7
20,000	4.5	5,000	5.2
22,000	5.0	5,500	5.7
24,000	5.5	6,000	6.3
26,000	6.0	6,500	6.9
28,000	6.5	7,000	7.5
30,000	7.0	7,500	8.0
32,000	7.5	8,000	8.6
34,000	8.0	8,500	9.2
36,000	8.5	9,000 and over	9.5
38,000	9.0		
40,000 and over	9.5		

Interpolate for intermediate figures.

A water supply system is considered to be adequate for fire protection when it can supply water as indicated above with consumption at the maximum daily rate. Certain types of emergency supplies may be included where reasonable conditions for their immediate use exist. Storage on the system is credited on the basis of the normal daily minimum maintained insofar as pressure permits its delivery at the rate considered.

PART II

GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOW

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N.B.: It should be recognized that this is a "guide" in the true sense of the word, and requires a certain amount of knowledge and experience in fire protection engineering for its effective application. Its primary purpose is for the use of surveyors experienced in this field, but it is made available to municipal officials, consulting engineers and others interested as an aid in estimating fire flow re-'ements for municipal fire protection. Some examples of typical fire flow uirements are shown in the Appendix.

Required Fire Flow may be described as the amount and rate of water application required in fire fighting to confine and control the fires possible in a building or group of buildings which comprise essentially the same fire area by virtue of immediate exposure. This may include as much as a city block.

1. An estimate of the fire flow required for a given fire area may be determined by the formula: $F = 220\,C\,\sqrt{A}$

   where

   F = the required fire flow in litres per minute.

   C = coefficient related to the type of construction.

   → = 1.5 for wood frame construction (structure essentially all combustible). (including dry wall)

   = 1.0 for ordinary construction (brick or other masonry walls, combustible floors and interior)

   = 0.8 for noncombustible construction (unprotected metal structural components, masonry or metal walls).

   = 0.6 for fire-resistive construction (fully protected frame, floors, roof).

   Note: For types of construction that do not fall within the categories given, coefficients shall not be greater than 1.5 nor less than 0.6 and may be determined by interpolation between consecutive construction types as listed above. Construction types are defined in the Appendix.

   A = The total floor area in square metres (including all storeys, but excluding basements at least 50 per cent below grade) in the building being considered.

   (The above formula using gallons per minute and area in square feet would be $F = 14.8\,C\,\sqrt{A}$.)

   For fire resistive buildings, consider the two largest adjoining floors plus 50 per cent of each of any floors immediately above them up to eight, when the vertical openings are inadequately protected. If the vertical openings and exterior vertical communications are properly protected (one hour rating), consider only the area of the largest floor plus 25 per cent of each of the two immediately adjoining floors.

   The fire flow as determined by the above shall not exceed

   30,000 L/min (6,700 gpm) for wood frame construction
   30,000 L/min (6,700 gpm) for ordinary construction
   23,000 L/min (5,000 gpm) for noncombustible construction
   23,000 L/min (5,000 gpm) fire-resistive construction

   except that for a normal 1-storey building of any type of construction the fire flow shall not exceed 20,000 L/min (5,000 gpm).

   The fire flow determined shall not be less than 2,000 L/min (400 gom).

   For 1-family and small 2-family dwellings not exceeding 2-stories in height, see Note J.

2. The value obtained in No. 1 may be reduced by as much as 25% for occupancies having a low contents fire hazard or may be increased by up to a 25% surcharge for occupancies having a high fire hazard. Those may be classified as to contents as follows:

Non-Combustible	- 25%	Free Burning	+ 15%
Limited Combustible	- 15%	Rapid Burning	+ 25%
Combustible	No charge		

   As a guide for determining low or high fire hazard occupancies, see the lists in the Appendix.

   The fire flow determined shall not be less than 2,000 L/min (400 gpm).

3. The value obtained in Number 2 above may be reduced by up to 50% for complete automatic sprinkler protection depending upon adequacy of the system. Where buildings are either fire resistive or non-combustible construction, and have a very low fire hazard, the reduction may be up to 75%. The percentage reduction made for an automatic sprinkler system will depend upon the extent to which the system is judged to reduce the possibility of fires spreading within and beyond the fire area. Normally this reduction will not be the maximum allowed without proper system supervision including water flow and control valve alarm service.

4. To the value obtained in No. 2 above ~~(after allowing any reduction under No. 3)~~ a percentage should be added for structures exposed within 45 metres (150 feet) by the fire area under consideration. This percentage shall depend upon the height, area, and construction of the building(s) being exposed, the separation, openings in the exposed building(s), the length and height of exposure, the provision of automatic sprinklers and/or outside sprinklers in the building(s) exposed, the occupancy of the exposed building(s), and the effect of hillside locations on the possible spread of fire.

   The charge for any one side generally should not exceed the following limits for the separations shown:

Separation	Charge	Separation	Charge
0 to 3 m (0 - 10 ft.)	25%	20.1 to 30 m (61 - 100 ft.)	10%
3.1 to 10 m (11 - 30 ft.)	20%	30.1 to 45 m (101 - 150 ft.)	5%
10.1 to 20 m (31 - 60 ft.)	15%		

   The total percentage shall be the sum of the percentages for all sides, but shall not exceed 75%

The fire flow shall not exceed 45,000 L/min (10,000 gpm) nor be less than 2,000 L/min (400 gpm).

Note A: The guide is not expected to necessarily provide an adequate value for lumber yards, petroleum storage, refineries, grain elevators, and large chemical plants but may indicate a minimum value for these hazards.

Note B: Judgement must be used for business, industrial, and other occupancies not specifically mentioned.

Note C: Consideration should be given to the configuration of the building(s) being considered and accessibility by the fire department.

Note D: Wood frame structures separated by less than 3 metres (10 feet) shall be considered as one fire area.

E: Fire Walls: – In determining floor areas, a fire wall that meets or exceeds the requirements of the current edition of the National Building Code of Canada (provided this necessitates a fire resistance rating of 2 or more hours) may be deemed to subdivide the building into more than one area or may, as a party wall, separate the building from an adjoining building.

Normally any unpierced party wall considered to form a boundary when determining floor areas may warrant up to a 10% exposure charge.

Note F: High one-storey buildings: – When a building is stated as 1 = 2, or more storeys, the number of storeys to be used in the formula depends upon the use being made of the building. For example consider a 1 = 3 storeys building. If the building is being used for high-piled stock, or for rack storage, the building would probably be considered as 3 stories and, in addition, an occupancy percentage increase may be warranted. However, if the building is being used for steel fabrication and the extra height is provided only to facilitate movement of objects by a crane, the building would probably be considered as a 1-storey building and an occupancy credit percentage may be warranted.

Note G: If a building is exposed within 45 metres (150 feet), normally some surcharge for exposure will be made.

Note H: Where wood shingle or shake roofs could contribute to spreading fires, add 2,000 L/min (400 gpm) to 4,000 L/min (800 gpm) in accordance with extent and condition.

Note I: Any non-combustible building is considered to warrant an 0.8 coefficient.

Note J: Dwellings: – For groupings of detached 1-family and small 2-family dwellings not exceeding 2 stories in height, the following short method may be used. (For other residential buildings, the regular method should be used.)

Exposure distances	Suggested required fire flow	
	Wood Frame	Masonry or Brick
Less than 3 m (10 ft.)	See Note "D"	6,000 L/min (1,200 gpm)
3 to 10 m (30 ft.)	3,600 L/min (800 gpm)	3,600 L/min (800 gpm)
10.1 to 30 m (100 ft.)	2,700 L/min (600 gpm)	2,700 L/min (600 gpm)
Over 30 m (100 ft.)	2,000 L/min (400 gpm)	2,000 L/min (400 gpm)

If the buildings are contiguous, use a minimum of 8,000 L/min (1,800 gpm).

Also consider Note H.

OUTLINE OF PROCEDURE

A. Determine the type of construction.

B. Determine the ground floor area.

C. Determine the height in stories.

D. Using the fire flow formula, determine the required fire flow to the nearest 1,000 L/min (200 gpm).

E. Determine the increase or decrease for occupancy and apply to the value obtained in D above. Do not round off the answer.

F. Determine the decrease, if any, for automatic sprinkler protection. Do not round off the value.

G. Determine the total increase for exposures. Do not round off the value.

H. To the answer obtained in E, subtract the value obtained in F and add the value obtained in G.

The final figure is customarily rounded off to the nearest 1,000 L/min (200 gpm) if less than 10,000 L/min (2,000 gpm) and to the nearest 2,000 L/min (400 gpm) if 10,000 L/min (2,000 gpm) or greater.

APPENDIX

TYPES OF CONSTRUCTION

For the specific purpose of using the Guide, the following definitions may be used:

Fire-Resistive Construction – Any structure that is considered fully protected, having at least 3-hour rated structural members and floors. For example, reinforced concrete or protected steel.

Non-combustible Construction – Any structure having all structural members including walls, columns, piers, beams, girders, trusses, floors, and roofs of non-combustible material and not qualifying as fire-resisitive construction. For example, unprotected metal buildings.

nary Construction – Any structure having exterior walls of masonry or such non-combustible material, in which the other structural members, including but not limited to columns, floors, roofs, beams, girders, and joists, are wholly or partly of wood or other combustible material.

Wood Frame Construction – Any structure in which the structural members are wholly or partly of wood or other combustible material and the construction does not qualify as ordinary construction.

OCCUPANCIES

Examples of Low Hazard Occupancies:

- Apartments
- Asylums
- Churches
- Clubs
- Colleges & Universities
- Dormitories
- Dwellings
- Hospitals
- Hotels
- Institutions
- Libraries, except Large Stack Room Areas
- Museums
- Nursing, Convalescent and Care Homes
- Office Buildings
- Prisons
- Public Buildings
- Rooming Houses
- Schools
- Tenements

Generally, occupancies falling in National Building Code Groups A, B, C and D are of this class.

Examples of High Hazard Occupancies:

- Aircraft Hangers
- Cereal, Feed, Flour and Grist Mills
- Chemical Works – High Hazard
- Cotton Picker and Opening Operations
- Explosives and Pyrotechnics Manufacturing
- Foamed Plastics, Storage or use in Manufacturing
- High Piled Combustibles Storage in Excess of 6.5 metres high
- Linoleum and Oilcloth Manufacturing
- Linseed Oil Mills
- Match Manufacturing
- Oil Refineries
- Paint Shops
- Pyroxylin Plastic Manufacturing and Processing
- Shade Cloth Manufacturing
- Solvent Extracting
- Varnish and Paint Works
- Wood Working with Flammable Finishing

Other occupancies involving processing, mixing, storage and dispensing flammable and/or combustible liquids.

Generally, occupancies falling in National Building Code Group F, Divisions 1 and 2 would be in this class.

Experience has shown that the following credits should normally be applied for the occupancies listed:

Dwellings*, apartments, and dormitories	–	25 %
Hospitals	–	20 %
Elementary Schools	–	20 %
Junior and Senior high schools	–	15 %
Open parking garages	–	25 %

*When applying the standard method.

For other occupancies, good judgment should be used, and the percentage increase will not necessarily be the same for all buildings that are in the same general category – for example "Colleges and Universities": this could range from a 25% decrease for buildings used only as dormitories to an increase for a chemical laboratory. Even when considering high schools, the decrease should be less if they have extensive shops.

It is expected that in commercial buildings no percentage increase or decrease for occupancy will be applied in most of the fire flow determinations. In general, percentage increase or decrease will not be at the limits of plus or minus 25%.

EXPOSURES

When determining exposures it is necessary to understand that the exposure percentage increase for a fire in a building (x) exposing another building (y) does not necessarily equal the percentage increase when the fire is in building (y) exposing building (x). The Guide gives the maximum possible percentage for exposure at specified distances. However, these maximum percentages should not be used for all exposures at those distances. In each case the percentage applied should reflect the actual conditions but should not exceed the percentage listed.

The maximum percentage for the separations listed generally should be used if the exposed building meets all of the following conditions:

a. Same type or a poorer type of construction than the fire building.
b. Same or greater height than the fire building.
c. Contains unprotected exposed openings.
d. Unsprinklered.

- Resid. – 100 L/s = 6000 L/min
- Other – 300 L/s = 18,000 L/min

FUS WATER SUPPLY FOR PUBLIC FIRE PROTECTION 1981

EXAMPLES OF REQUIRED FIRE FLOWS (REVISED)

For convenience in making general estimates some examples of required fire flows in typical buildings are provided below. In establishing fire flows for areas of a Municipality as yet undeveloped, but where a broad range of commercial, institutional, residential and industrial occupancies may be expected to be created under modern building code requirements, an outside design figure of 15,000 L/min appears likely to be suitable. When very large or high fire load buildings are probable, 25,000 L/min is more appropriate. It should be noted particulary that the tendency to install automatic sprinkler protection in large area and high hazard industrial and commercial buildings is a key factor in keeping required fire flows within economically acceptable limits in many cases.

The following examples suppose no significant exposures to other buildings nor sprinkler protection unless specified. Where areas are given they are ground areas unless specified.

DETACHED DWELLINGS (TOTAL FLOOR AREAS)

- Under 100 m² (1,200 ft.²) = 2,000 L/min (400 gpm)
  101 m² – 200 m² (1,201 – 2,400 ft.²) = 3,000 L/min (600 gpm)
  Over 200 m² (2,400 ft.²) = 4,000 L/min (800 gpm)
- Add for exposures to similar buildings on both sides:
  Over 30 m (100 ft.) – nil
  30 – 10 m (100 – 30 ft.) add 1,000 L/min (200 gpm)
  10 – 3 m (30 – 10 ft.) add 2,000 L/min (400 gpm)
  Less than 3 m (10 ft.) see Note "D", if Frame. Brick, add 3,000 L/min (600 gpm).
- If wood shingle or shake roofs are prevalent, add 2,000 to 4,000 L/min (400 to 800 gpm).
- Modern residential subdivisions of 1 and 2 storey single family homes detached 3 to 6 m (10 to 20 ft.) require usually 4,000 to 5,000 L/min (800 to 1,000 gpm). 83 L/s
- Old congested two and three family tenements detached less than 3 m (10 ft.) and running the length of the block may require 14,000 to 23,000 L/min (3,000 to 5,000 gpm) and should be calculated according to Note "D".
- Modern Row or Town House groups may require 6,000 to 9,000 L/min (1,400 to 2,000 gpm) including adjoining exposures, providing required fire separations are adequate.

APARTMENT BUILDINGS

- 3 storeys, frame, 300 m² (3,300 ft.²) = 7,000 L/min (1,600 gpm) and exposure coverage.
- 4 storeys, brick, 1,900 m² (20,000 ft.²) = 15,000 L/min (3,200 gpm) and exposure coverage.
- 3 or more storeys, fire resistive, 5,600 m² (60,000 ft.²) with cut off shafts and stairs = 9,000 L/min (2,000 gpm) and exposure coverage.

INSTITUTIONAL BUILDINGS

- 1 storey, fire resistive school of 2,300 m² (25,000 ft.²) = 5,000 L/min (1,200 gpm)
- 3 storey, brick ordinary school of 2,300 m² (25,000 ft.²) = 15,000 L/min (3,200 gpm)
- 3 or more storey, fire resistive hospital with adequate floor separations 1,000 m² (10,000 ft.²), no exposures – 4,000 L/min (800 gpm).

INDUSTRIAL BUILDINGS

- Typical industrial park, 1 storey ordinary, area 3,700 m² (40,000 ft.²) with average combustible contents fire load 14,000 L/min (3,000 gpm).
- Frame warehouse 1 storey, Moderate contents fire load 3,700 m² (40,000 ft.²) = 20,000 L/min (4,400 gpm).
- Warehouse high fire load contents, brick non-combustible, 1 storey, 14,000 m² (150,000 ft.²) = 25,000 L/min (5,600 gpm). With full, adequate automatic sprinkler protection (item 3, P. 17) 13,000 L/min (2,800 gpm).
- Traditional 3 storey brick, ordinary, factory with high fire load. 9,300 m² (100,000 ft.²) = 36,000 L/min (8,000 gpm).

COMMERCIAL BUILDINGS

- Old business district city blocks with largely contiguous brick ordinary construction, 2 to 4 storey with no exposures 14,000 to 23,000 L/min (3,000 to 5,000 gpm).
- Large Mall Shopping Centre, no exposure, in one area of 16,000 m² (170,000 ft.²).
  Non-combustible – 22,000 L/min (4,800 gpm)
  Fire Resistive – 17,000 L/min (3,600 gpm)
- Moderately large shopping centre, no exposure, in one area of 9,300 m² (100,000 ft.²).
  Non-combustible – 17,000 L/min (3,600 gpm)
  Ordinary – 22,000 L/min (4,800 gpm)
- Small open shopping centre, or part of large one, 5,000 m² (54,000 ft.²).
  Non-combustible – 12,000 L/min (2,800 gpm)
  Ordinary – 16,000 L/min (3,600 gpm)
  Frame – 23,000 L/min (5,000 gpm)
- Individual department store 4,600 m² (50,000 ft.²), 3 storeys.
  Fire Resistive – 16,000 L/min (3,600 gpm)
  Brick ordinary – 26,000 L/min (5,800 gpm)
- High-Rise, fire-resistive office building more than 9 storeys, 2,500 m² (27,000 ft.²).
  Floors cut-off – 8,000 L/min (1,800 gpm)
  Not cut-off – 16,000 L/min (3,600 gpm)

AUTOMATIC SPRINKLERS

The required flows shown above may be reduced by from 25 to 50% for buildings having full approved automatic sprinkler protection with satisfactory alarm supervisory service and to 75% where conditions of very low fire load and non-combustible or fire resistive construction are also present, as noted in Item 3 on page 17.

EXPOSURES

In addition, if not included in the description in the above, water for hosestreams covering any exposures is needed. There are many variables in this consideration. In general for significant expc ures in the area of 3 to 20 metres (10 to 60 feet) distant, 15 to 25 percent of the required flow may be added per exposing side.

WATER SUPPLY

FOR

PUBLIC FIRE PROTECTION

A Guide to Recommended Practice

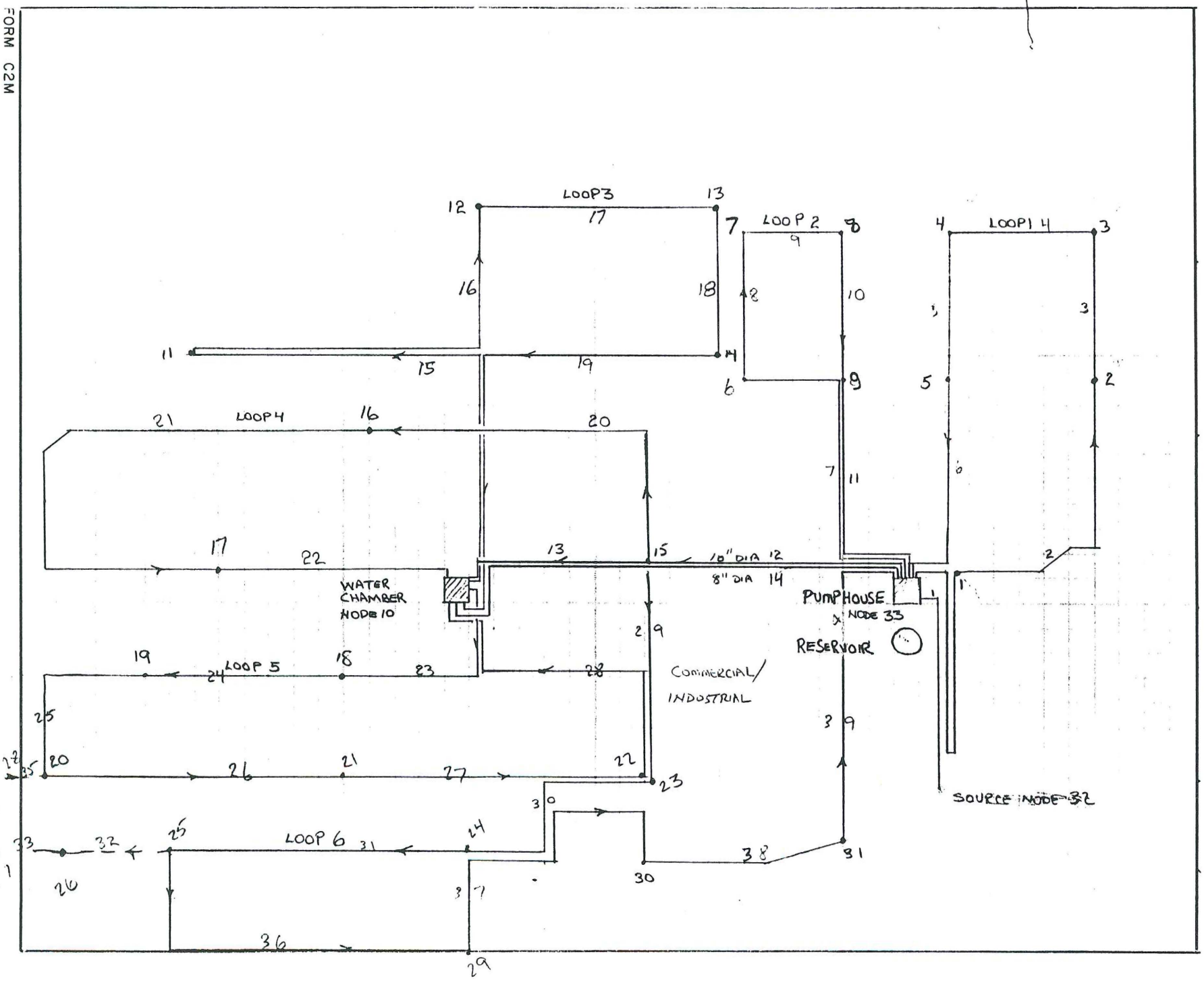
1981

APPENDIX "B"

WATER SYSTEMS COMPUTER ANALYSIS

FORM C2M

STC


LOOP 3
LOOP 2
LOOP 1
LOOP 4
LOOP 5
LOOP 6
WATER CHAMBER NODE 10
10" DIA
8" DIA
PUMP HOUSE
NODE 33
RESERVOIR
COMMERCIAL/ INDUSTRIAL
SOURCE NODE 32

SYNOPSIS OF ANALYSIS #5

This analysis considered the following components in the water distribution networks:

1. New Development;

2. Existing Network;

3. Installation of a Fire Pump capable of 212 l/s @ 67m TDH (2800 imp. gal/min @ 95 PSI).

The result of this pump operating at this point when a fire flow demand did not exist resulted in pressures ranging from 490 - 655 KPa and velocities ranging from 0.03 - 0.74 m/s.

Recommendations: This analysis of the network shows no signs of high pressures and velocities, therefore this pump works well at this point with the existing network. However, as shown in the fourth analysis this pump does not meet the fire demand criteria.

STC

2e5.647c66F2S

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+------------------------------------------------------------------------+
|        Waterworks All-in-one   -   Water System Analysis Report        |
+------------------------------------------------------------------------+
|                                                                        |
| DATA   : DAWSON.WK4                                                    |
|                                                                        |
| FIRST  : Dawson City                                                   |
| SECOND : Water Supply System, June 1991                                |
| THIRD  : New Development, No Fire, Fire Pump 212l/s @ 67.00m TDH       |
| FOURTH : File Name : Dawson.wk5                                        |
|                                                                        |
+---------------------------- Long Report ----------------------------+
|                                                                        |
| The analysis use Hazen-Williams's formula                              |
| Iteration termination threshold:  0.01000                              |
| Maximum number of iterations:   40                                     |
|                                                                        |
| There are:   39 Pipes(s)                                               |
|              32 nodes(s)                                               |
|               1 sources(s)                                             |
|               0 booster pump(s)                                        |
|               0 pressure reducing valve(s)                             |
|               0 check valve(s)                                         |
|               0 pressure sustaining valve(s)                           |
|                                                                        |
+------------------------------------------------------------------------+
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STC

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+-----------------------------------------------------------+
|                                                           |
| The program terminated after  4 iterations.               |
|                                                           |
| The maximum unbalanced head is:    0.00000 m              |
|                                                           |
+-----------------------------------------------------------+
```

STC

PIPE TABLE

Pipe	UpNode	DnNode	Length	Diameter	Roughness	Flow	Velocity	HeadLoss	Status
			m	mm		l/s	m/s	m	Open
1	1	33	230.00	150.00	140.00	-2.26	-0.13	0.03	
2	2	1	195.00	150.00	140.00	-1.47	-0.08	0.01	
3	3	2	95.00	150.00	140.00	-0.47	-0.03	0.00	
4	4	3	72.00	150.00	140.00	0.81	0.05	0.00	
5	5	4	90.00	150.00	140.00	1.67	0.09	0.01	
6	33	5	160.00	150.00	140.00	2.95	0.17	0.04	
7	6	33	280.00	150.00	140.00	-1.96	-0.11	0.03	
8	7	6	90.00	150.00	140.00	-0.53	-0.03	0.00	
9	8	7	80.00	150.00	140.00	0.47	0.03	0.00	
10	9	8	90.00	150.00	140.00	1.32	0.07	0.00	
11	33	9	210.00	150.00	140.00	2.11	0.12	0.03	
12	15	33	400.00	250.00	140.00	-36.02	-0.73	0.84	
13	10	15	280.00	250.00	140.00	-18.11	-0.37	0.16	
14	33	10	690.00	200.00	140.00	16.43	0.52	1.00	
15	11	10	520.00	150.00	140.00	-5.89	-0.33	0.46	
16	12	11	410.00	150.00	140.00	-3.89	-0.22	0.17	
17	13	12	430.00	150.00	140.00	-2.03	-0.11	0.05	
18	14	13	80.00	150.00	140.00	2.25	0.13	0.01	
19	10	14	650.00	150.00	140.00	6.39	0.36	0.66	
20	16	15	510.00	150.00	140.00	-5.82	-0.33	0.44	
21	17	16	920.00	150.00	140.00	-0.68	-0.04	0.02	
22	10	17	400.00	150.00	140.00	5.31	0.30	0.29	
23	18	10	410.00	150.00	140.00	-8.39	-0.47	0.69	
24	19	18	270.00	150.00	140.00	-4.26	-0.24	0.13	
25	20	19	230.00	150.00	140.00	-3.26	-0.18	0.07	
26	21	20	400.00	150.00	140.00	-1.98	-0.11	0.05	
27	22	21	610.00	150.00	140.00	3.59	0.20	0.21	
28	10	22	410.00	150.00	140.00	8.58	0.49	0.72	
29	23	15	170.00	150.00	140.00	-9.22	-0.52	0.34	
30	24	23	350.00	150.00	140.00	-7.00	-0.40	0.42	
31	25	24	613.00	150.00	140.00	-4.14	-0.23	0.28	
32	26	25	105.00	200.00	140.00	-3.00	-0.10	0.01	
33	27	26	10.00	200.00	140.00	-3.00	-0.10	0.00	
34	28	27	20.00	200.00	140.00	-1.43	-0.05	0.00	
35	20	28	80.00	200.00	140.00	0.14	0.00	0.00	
36	29	25	670.00	150.00	140.00	3.71	0.21	0.25	
37	30	29	400.00	150.00	140.00	6.13	0.35	0.38	
38	31	30	350.00	150.00	140.00	7.20	0.41	0.45	
39	33	31	210.00	150.00	140.00	13.07	0.74	0.81	

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NODE TABLE

Node	Elevation	Demand	Pressure	HGL	XCoord	YCoord	Status
	m	l/s	kPa	m			ON
1	320.00	0.79	655.63	386.97			
2	320.00	1.00	655.50	386.95			
3	320.00	1.28	655.49	386.95			
4	323.00	0.86	626.13	386.95			
5	320.00	1.28	655.58	386.96			
33	320.00	0.00	655.97	387.00			
6	320.00	1.43	655.65	386.97			
7	326.00	1.00	596.88	386.97			
8	323.00	0.86	626.27	386.97			
9	320.00	0.78	655.70	386.97			
10	320.00	0.00	646.18	386.00			
11	332.00	2.00	524.19	385.54			
12	332.00	1.86	522.56	385.38			
13	328.00	4.28	561.22	385.33			
14	325.00	4.14	590.72	385.34			
15	320.00	2.86	647.79	386.16			
16	320.00	5.14	643.49	385.73			
17	320.00	5.99	643.34	385.71			
18	320.00	4.13	639.39	385.31			
19	323.00	1.00	608.74	385.18			
20	323.00	1.14	608.08	385.11			
21	320.00	5.57	637.00	385.06			
22	320.00	4.99	639.10	385.28			
23	320.00	2.22	644.43	385.82			
24	320.00	2.86	640.28	385.40			
25	320.00	4.85	637.53	385.12			
26	332.00	0.00	519.95	385.11			
27	332.00	1.57	519.94	385.11			
28	335.00	1.57	490.56	385.11			
29	320.00	2.42	639.98	385.37			
30	320.00	1.07	643.69	385.75			
31	320.00	5.87	648.06	386.19			

STC

INFLOW TABLE

Node	Pumps	OpCurve	%Estimate	%Actual	Inflow	Status
					l/s	ON
33	1	pump1	1	1.00	-74.79	

BOOST TABLE

Pipe	Pumps	OpCurve	Boost	Status
			NA	ON

<< Booster data not available >>

REDUCING (PRV) TABLE

Pipe	Source	Pressure	OpenK	CKV	PRVLoss	CKVState
		NA			NA	

<< PRV data not available >>

SUSTAINING (PSV) TABLE

Node	UpNode	DnNode	Pressure	Options	DnDemand	Pressure
			NA		NA	NA

<< PSV data not available >>

CHECK (CKV) TABLE

Pipe	State

<< CKV data not available >>

STC

PUMP1	
<------- Input ------>	
Flow	Head
l/s	m
212.00	67.00

APPENDIX "C"

WASTE HEAT AGREEMENTS

MASTER

AGREEMENT BETWEEN

NORTHERN CANADA POWER COMMISSION

AND

GOVERNMENT OF YUKON TERRITORY

COVERING PROVISION OF RESIDUAL HEAT

FROM COMMISSION POWER FACILITIES

IN YUKON TERRITORY

THIS AGREEMENT made in duplicate this 1st of April, 1983 A.D.

BETWEEN:

NORTHERN CANADA POWER COMMISSION,
a Corporation established by an Act
of Parliament of Canada, hereinafter
referred to as "the Commission"

OF THE FIRST PART

- and -

GOVERNMENT OF YUKON TERRITORY
hereinafter referred to as
"Yukon" and represented by the
Minister of Municipal and Community
Affairs

OF THE SECOND PART

WHEREAS the Commission operates diesel-electric power plants at a number of locations in the Yukon Territory;

AND WHEREAS residual heat energy is available from the jacket water and/or exhaust system of these power plants during their normal operation;

AND WHEREAS Yukon wishes to utilize the available residual heat energy for various heating purposes;

AND WHEREAS the utilization of the available residual heat energy will contribute to energy conservation and reduced heating costs for various locations in the Yukon;

AND WHEREAS withdrawal of residual heat from the power plant may be of benefit to the Commission;

NOW THEREFOR THIS AGREEMENT WITNESSES that, in consideration of the premises and the terms and conditions hereinafter set forth, the parties covenant and agree as follows:

1. RESIDUAL HEAT

1.1 In this Agreement, the term "residual heat" shall mean the heat contained in the jacket water coolant and/or exhaust system of the Commission's diesel-electric power plants in various locations in the Yukon.

2. TERM

2.1 The Commission agrees to supply, and Yukon agrees to withdraw, residual heat to be used for various heating purposes for varying periods of time, as identified in each specific subsidiary Agreement which may from time to time be made.

3. RESPONSIBILITY FOR EQUIPMENT AND MAINTENANCE

3.1 The Commission will make available residual heat at no charge for the heat energy supplied to Yukon. The Commission's responsibility for provision of the residual heat terminates at the places within the Commission's Power Plant where Yukon's heat recovery piping and related equipment is connected to the Commission's piping and related equipment for the dissipation of residual heat.

3.2 In each subsidiary agreement, Yukon shall assume the capital installation, maintenance and operating costs incurred after the subsidiary agreement is made for the heat recovery equipment, including all heat exchangers and piping required to transmit the residual heat to the connected heating load.

3.3 The Commission shall permit Yukon full access, under supervision of its representative, to Yukon's heat recovery equipment and all heat exchangers and piping located on the Commission Power Plant property for the purpose of maintenance and repair of the equipment and pipelines.

3.4 Electrical energy consumed in each heat recovery process shall be metered and assessed to Yukon at the applicable power rate in each specific location, as amended from time to time.

4. INDEMNITY

4.1 Yukon shall agree to indemnify and save harmless the Commission from and against all claims, demands, loss, costs, damages, actions, suits, claims or other proceedings by whomsoever made, brought or procesuted in any manner based upon, occasioned to, by or attributable to the execution of each specific subsidiary Agreement, or any action taken or things done or maintained by virtue thereof, or the exercise in any manner or rights arising hereunder, except claims for damage resulting from the negligence of any officer or servant of the Commission.

5. WAIVER

5.1 No waiver on behalf of the Commission, or Yukon, of any breach shall take place or be binding unless it is written over the signature of duly authorized officers of the Commission or of Yukon, as the case may be, and any waiver so expressed shall extend only to the particular breach to which such waiver will specifically relate, and shall not be deemed a general waiver with respect to any other breach.

6. HOUSE OF COMMONS

6.1 No member of the House of Commons shall be admitted to any share or part of this Agreement, or to any benefit to arise therefrom.

7. SUSPENSION OR TERMINATION OF SUPPLY

7.1 The Commission shall not be liable to Yukon for any loss or damage which Yukon may sustain by reason of any suspension, interruption or termination, in whole or in part, whether temporary or permanent, from whatever cause, other than a negligent intentional act of an officer or servant of the Commission, arising in the supply of residual heat pursuant to this Agreement or a specific subsidiary agreement.

8. DEFAULT

8.1 If the Commission or Yukon fails to perform any of the covenants, conditions or agreements herein contained, and shall allow such default to continue for fifteen (15) days after notice thereof, then each specific subsidiary Agreement may, at the option of the party who is not in default, be terminated effective immediately upon giving notice.

9 TERMINATION

9.1 Either party may terminate each specific subsidiary Agreement on one hundred and eighty (180) days written notice to the other party.

10. NOTICES

10.1 Notices required under this Agreement shall be mailed to the following addresses:

In the case of the Commission, to:

Northern Canada Power Commission
7909 - 51 Ave.
P.O. Box 5700, Station "L"
Edmonton, Alberta T6C 4J8

In the case of Yukon to:

Government of Yukon Territory
Municipal and Community Affairs
P.O. Box 2703
Whitehorse, Yukon
Y1A 2B6

Notices shall be deemed to have been received immediately upon personal service or seven (7) days after mailing by regular mail.

11. GOVERNING LAW

11.1 The provisions of this Agreement shall be construed in accordance with the laws in force in the Yukon Territory.

12. MARGINAL CAPTIONS

12.1 The marginal captions in this Agreement are for the convenience of reference only, and shall not affect the scope, intent or interpretation of any provision.

13. TRANSFER

13.1 The Government of Yukon may assign any specific subsidiary Agreement to a municipal body or some other government department or agency.

IN WITNESS WHEREOF the parties hereto have executed this Agreement under the hands of their officers, duly authorized in that behalf, as of the day and year first above written.

SIGNED, SEALED AND DELIVERED

in the presence of:

NORTHERN CANADA POWER COMMISSION

Witness

Assistant General Manager

GOVERNMENT OF YUKON

Witness

Minister of Municipal and Community Affairs

SUBSIDIARY

AGREEMENT BETWEEN

NORTHERN CANADA POWER COMMISSION

AND

GOVERNMENT OF YUKON

RE: SUPPLY AND WITHDRAWAL OF RESIDUAL HEAT

AT

CITY OF DAWSON, YUKON TERRITORY

THIS AGREEMENT made in duplicate this lst of April, 1983 A.D.

BETWEEN:

NORTHERN CANADA POWER COMMISSION,
a Corporation established by an Act
of Parliament of Canada, hereinafter
referred to as "the Commission"

OF THE FIRST PART

- and -

Government of Yukon, hereinafter referred to as
"Yukon" and represented by the Minister of
Municipal and Community Affairs

OF THE SECOND PART

WHEREAS the Commission operates a diesel-electric power plant at City of Dawson, Yukon;

AND WHEREAS residual heat energy is available from the jacket water and/or exhaust system of the power plant during its operation;

AND WHEREAS Yukon wishes to withdraw the available residual heat energy for the purpose of heating of the City of Dawson water system and related buildings;

AND WHEREAS the utilization of the available residual heat energy will contribute to energy conservation and reduced heating costs for water supply system operations;

AND WHEREAS withdrawal of residual heat from the power plant may be of benefit to the Commission;

NOW THEREFOR THIS AGREEMENT WITNESSES that, in consideration of the premises and the terms and conditions hereinafter set forth, the parties covenant and agree as follows:

1. RESIDUAL HEAT

1.1 In this Agreement, the term "residual heat" shall mean the heat contained in the jacket water coolant and/or exhaust system of the Commission's diesel-electric Power Plant in the City of Dawson, Yukon.

2. TERM

2.1 The Commission agrees to supply, and Yukon agrees to withdraw the residual heat it requires to heat its water system and related buildings for a ten year period, commencing on the 1st day of April, 1983 A.D.

3. RESPONSIBILITY FOR EQUIPMENT AND MAINTENANCE

3.1 In consideration of payment by Yukon of $1.00, receipt of which is acknowledged by the Commission, the Commission will make available residual heat at no charge for the heat energy supplied to Yukon. The Commission's responsibility for provision of the residual heat terminates at the places within the Commission's Power Plant where Yukon's heat recovery piping and related equipment is connected to the Commission's piping and related equipment for the dissipation of residual heat.

3.2 Yukon shall assume the capital installation, maintenance and operating costs incurred after the date this agreement is made and associated with the heat recovery equipment, including all heat exchangers and piping required to transmit the residual heat to the connected heating load.

3.3 The Commission shall permit Yukon full access, under the supervision of a representative of the Commission, to Yukon's heat recovery equipment and all heat exchangers and piping located on the Commission Power Plant property for the purpose of maintenance and repair of the equipment and pipelines.

3.4 Electrical energy consumed in the heat recovery process shall be metered and assessed to Yukon at the applicable power rate in the City of Dawson, as amended from time to time.

4. INDEMNITY

4.1 Yukon agrees to indemnify and save harmless the Commission from and against all claims, demands, loss, costs, damages, actions, suits, claims or other proceedings by whomsoever made, brought or procesuted in any manner based upon, occasioned to, by or attributable to the execution of this Agreement, or any action taken or things done or maintained by virtue thereof, or the exercise in any manner or rights arising hereunder, except claims for damage resulting from the negligence of any officer or servant of the Commission.

5. WAIVER

5.1 No waiver on behalf of the Commission, or Yukon, of any breach shall take place or be binding unless it is written over the signature of duly authorized officers of the Commission or of Yukon, as the case may be, and any waiver so expressed shall extend only to the particular breach to

which such waiver will specifically relate, and shall not be deemed a general waiver with respect to any other breach.

6. HOUSE OF COMMONS

6.1 No member of the House of Commons shall be admitted to any share or part of this Agreement, or to any benefit to arise therefrom.

7. SUSPENSION OR TERMINATION OF SUPPLY

7.1 The Commission shall not be liable to Yukon for any loss or damage which Yukon may sustain by reason of any suspension, interruption or termination, in whole or in part, whether temporary or permanent, from whatever cause, other than a negligent or intentional act of an officer or servant of the Commission, arising in the supply of residual heat pursuant to this Agreement.

8. DEFAULT

8.1 If the Commission or Yukon fails to perform any of the covenants, conditions or agreements herein contained, and shall allow such default to continue for fifteen (15) days after notice thereof, then this Agreement may, at the option of the party who is not in default, be terminated effective immediately immediately upon giving notice.

9 TERMINATION

9.1 Either party may terminate this Agreement on one hundred and eighty (180) days written notice to the other party.

10. NOTICES

10.1 Notices required under this Agreement shall be mailed to the following addresses:

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7909 - 51 Ave.
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In the case of Yukon, to:

Government of Yukon
Municipal and Community Affairs
P.O. Box 2703
Whitehorse, Yukon, Y1A 2C6

Notices shall be deemed to have been received immediately upon personal service or seven (7) days after mailing by regular mail.

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11.1 The provisions of this Agreement shall be construed in accordance with the laws in force in the Yukon Territory.

12. MARGINAL CAPTIONS

12.1 The marginal captions in this Agreement are for the convenience of reference only, and shall not affect the scope, intent or interpretation of any provision.

13. TRANSFER

13.1 The Government of Yukon may assign this Agreement to the City of Dawson or some other government department or agency.

IN WITNESS WHEREOF the parties hereto have executed this Agreement under the hands of their officers, duly authorized in that behalf, as of the day and year first above written.

SIGNED, SEALED AND DELIVERED

in the presence of:

NORTHERN CANADA POWER COMMISSION

Assistant General Manager

GOVERNMENT OF YUKON

Minister of Municipal and Community Affairs

APPENDIX "D"

TESTS OF WATER SUPPLIES

Quanta Trace Laboratories 09-

QUALITY CONTROL REPORT
SAMPLE # 15741-1

Cations

Calcium	36.8	Magnesium	10
Sodium	2.41	Potassium	.6

Anions

Phenolthalein Alkalinity	0	Total Alkalinity	86
Sulphate(SO4)	52.2	Chloride(Cl)	.9
Fluoride(F)	0	Nitrate Nitrogen(NO3)	.3

Results For Sample #15741-1

		STATUS	LIMITS
Cation-Anion Bal.:		PASSED	
Cation Sum	= 2.78114		
Anion Sum	= 2.85241		
Difference	= .712693E-01		<= .150712

quanta trace laboratories inc.
#401-3700 Gilmore Way, Burnaby, B.C., V5G 4M Tel:(604)438-5226 Fax:436

To: City of Dawson, W/O: 15741-1 P:

Sample type			water
Identification			DC-1 Raw Supply 09:30 hrs
Lab Reference #			15741-001
Analyzed by Ultrasonic Nebulization - ICP			
Method used			extractable 1% HNO3
Total Hardness as CaCO3	mg/l		134.
Aluminum	Al		0.059
Antimony	Sb	<	0.05
Arsenic	As	<	0.05
Barium	Ba		0.069
Beryllium	Be	<	0.0005
Bismuth	Bi	<	0.01
Cadmium	Cd		0.0014
Calcium	Ca		36.8
Chromium	Cr	<	0.001
Cobalt	Co	<	0.001
Copper	Cu	<	0.001
Iron	Fe		0.015
Lead	Pb	<	0.004
Lithium	Li	<	0.05
Magnesium	Mg		10.0
Manganese	Mn		0.002
Molybdenum	Mo	<	0.005
Nickel	Ni	<	0.001
Phosphorus	P		0.09
Potassium	K		0.68
Selenium	Se	<	0.01
Silicon	Si		3.5
Sodium	Na		2.41
Strontium	Sr		0.198
Thorium	Th	<	0.02
Titanium	Ti	<	0.001
Uranium	U	<	0.02
Vanadium	V	<	0.0005
Zinc	Zn		0.008
Zirconium	Zr	<	0.001
Results in			mg/l

Test results are for internal use only. Quanta Trace liability is limited to the testing fee paid. Analyst: _____

...5700 Balkore Ave., Burnaby, B.C., V5G 4H1 Tel:(604)438-5226 Fax:436-

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: City of Dawson,
Box 308
Dawson City, Yukon
Y0B 1G0

Attn: Norm Carlson

Re: Water Samples 11-Mar-91

Workorder: 15741
Received : 13-Mar
Completed: 08-Apr

Sample type		water
Identification		DC-1 Raw Supply 09:30 hrs
Lab Reference #		15741-001
Alkalinity-CaCO3		
Bicarbonate		86.
Results in		mg/l
Physical Tests		
pH		7.2
Turbidity	FTU	1.
Colour	TCU	< 5.
Conduct.	uS/cm	250.
Wtr Sol Ions IEC		
Fluoride	F	< 1.
Chloride	Cl	0.90
Nitrate	NO3-N	0.30
Sulfate	SO4	52.2
Results in		mg/l
Colorimetric		
Nitrite	NO2-N	< 0.003
Total	PO4-P	0.084
Results in		mg/l
Cold Vapour - UV		
Mercury	Hg	< 0.0002
Results in		mg/l

/2..

Quanta Trace Laboratories Inc.
#401-3700 Gilmore Way, Burnaby, B.C., V5G 4M1 Tel:(604)438-5226 Fax:436-0

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: City of Dawson,
Box 308
Dawson City, Yukon
Y0B 1G0

Attn: Norm Carlson

Re: Water Samples 11-Mar-91

Workorder: 15741
Received : 13-Mar
Completed: 08-Apr

Sample type	water	water	water
Identification	DC - 4 Receiving 14:10 hrs	DC - 5 Receiving 16:10 hrs	DC - 6 Receiving 16:45 hrs
Lab Reference #	15741-003	15741-004	15741-005
Physical Tests			
pH	7.5	7.8	7.8
Conduct. uS/cm	245.	230.	240.
Sus. Solids mg/l	< 5.	140.	174.
Colorimetric			
Total PO4-P	< 0.005	0.098	0.118
Results in	mg/l	mg/l	mg/l
Ions By SIE			
Ammonia NH3-N	0.09	0.07	0.06
Results in	mg/l	mg/l	mg/l
Bacteria			
Coliform - Total	23.	8.	2.
Coliform - Fecal	13.	2.	2.
Results in	MPN/100ml	MPN/100ml	MPN/100ml
BOD 5	< 6.	< 6.	< 6.
Results in	mg/l	mg/l	mg/l
Gravimetric			
Oil & Grease-TOT	< 5.	< 5.	< 5.
Results in	mg/l	mg/l	mg/l

Test results are for internal use only. Quanta Trace liability is limited to the testing fee paid.

Analyst: _____

Laboratories Inc.
#401-8700 Gilmore Way, Burnaby, B.C., V5G 4M1 Tel:(604)436-5226 Fax:436-

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: City of Dawson,
Box 308
Dawson City, Yukon
Y0B 1G0

Attn: Norm Carlson

Re: Water Samples 11-Mar-91

Workorder: 1574
Received : 13-Mar
Completed: 08-Apr

Sample type		water
Identification		DC - 3
		Effluent
		10:15 hrs
Lab Reference #		15741-002
Physical Tests		
pH		7.1
Conduct.	uS/cm	300.
Sus. Solids	mg/l	58.
Colorimetric		
Total	PO4-P	1.0
Results in		mg/l
Ions By SIE		
Ammonia	NH3-N	2.50
Results in		mg/l
Bacteria		
Coliform - Total		3500
Coliform - Fecal		3500
Results in		MPN/100ml
BOD 5		37.
Results in		mg/l
Gravimetric		
Oil & Grease-TOT		19
Results in		mg/l

Test results are for internal use only. Quanta Trace liability is limited to the testing fee paid.

Analyst: _____

quanta trace laboratories inc.
#401-3700 Gilmore Way, Burnaby, B.C., V5G 4M1 Tel:(604)438-5226

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: CITY OF DAWSON
Box 308
Dawson City, Yukon
Y0B 1G0

Attn: Norm Carlson

Re: Water Samples

Workorder: 16231
Received : 24-May
Completed: 31-May

Sample type	water	water	water	water	water
Identification	DC-1	DC-1A	DC-3	DC-3A	DC-3B
	30-Apr-91	22-May-91	22-May-91	22-May-91	22-May-91
	11:00 am	11:15 am	11:30 am	11:30 am	11:30 am
Lab Reference #	16231-001	16231-002	16231-003	16231-004	16231-005
Gravimetric - Solids					
Suspended	-	-	62.	-	-
Results in			mg/l		
Physical Tests					
Conduct. uS/cm	-	-	423.	-	-
Turbidity FTU	< 1.	< 1.	-	-	-
pH	-	-	7.0	-	-
SIE - Water Soluble Ions					
Ammonia NH3-N	-	-	1.60	-	-
Results in			mg/l		
Oxygen Demand					
BOD 5	-	-	-	54.0	-
Results in				mg/l	
Bacteria - Coliform					
Coliform - Total	-	-	-	-	> 240,000
Coliform - Fecal	-	-	-	-	> 240,000
Results in					MPN/100ml

Test results are for internal use only. Quanta Trace liability is limited to the testing fee paid.

Analyst:

quanta trace laboratories inc.
#401-3700 Gilmore Way, Burnaby, B.C., V5G 4M1 Tel:(604)438-5226 Fax:436-05

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: CITY OF DAWSON
Box 308
Dawson City, Yukon
YOB 1G0

Workorder: 16380
Received : 13-Jun-9
Completed: 25-Jun-9

Attn: Colm Cairns / Norm Carlson Re: Water Samples 12-Jun-91

Sample type	well water	sewage	river water	river water	river water	
Identification	DC-1	DC-3	DC-4	DC-5	DC-6	
Lab Reference #	16380-001	16380-002	16380-003	16380-004	16380-005	
Gravimetric - Solids						
Suspended	-	51.	335.	327.	310.	
Results in		mg/l	mg/l	mg/l	mg/l	
Physical Tests						
Conduct. uS/cm	-	380.	153.	147.	151.	
Turbidity FTU	1.	-	-	-	-	
pH	-	7.8	8.4	8.4	8.4	
SIE - Water Soluble Ions						
Ammonia NH3-N	-	5.60	< 0.05	0.14	0.19	
Results in		mg/l	mg/l	mg/l	mg/l	
Colorimetric						
Ortho PO4-P	-	50.	0.16	0.15	0.14	
Results in		mg/l	mg/l	mg/l	mg/l	
Oxygen Demand						
BOD 5	-	30.	< 5.	< 5.	< 5.	
Results in		mg/l	mg/l	mg/l	mg/l	
Extraction - Gravimetric						
Oil & Grease-TOT	-	12.	< 5.	< 5.	< 5.	
Results in		mg/l	mg/l	mg/l	mg/l	
Bacteria - Coliform						
Coliform - Total	-	920,000	49.	79.	110.	
Coliform - Fecal	-	920,000	33.	11.	26.	
Results in		MPN/100ml	MPN/100ml	MPN/100ml	MPN/100ml	

st results are for internal use only. Quanta Trace liability is limited to the testing fee paid. Analysti

quanta trace laboratories inc.
#401-3700 Gilmore Way, Burnaby, B.C., V5G 4M1 Tel:(604)438-5226 Fax:436-0

ANALYSIS OF ENVIRONMENTAL SAMPLES

To: CITY OF DAWSON
Box 308
Dawson City, Yukon
YOB 1G0

Attn: Norm Carlson

Workorder: 16961
Received : 29-Aug
Completed: 05-Sep

Sample type	liquid
Identification	DC-3
	28-Aug-91
	11:30 am
Lab Reference #	16961-000
Gravimetric - Solids	
Suspended	119.
Results in	mg/l
Physical Tests	
Conduct. uS/cm	570.
pH	7.3
SIE - Water Soluble Ions	
Ammonia NH3-N	15.0
Results in	mg/l
Bacteria - Coliform	
Coliform - Fecal	130,000
Results in	MPN/100ml
Oxygen Demand	
BOD 5	75.0
Results in	mg/l

Test results are for internal use only. Quanta Trace liability is limited to the testing fee paid.

Analyst:

NORTHERN TESTING LABORATORIES, INC.

3330 INDUSTRIAL AVENUE FAIRBANKS, ALASKA 99701 907-456-3116
2505 FAIRBANKS ST. ANCHORAGE, ALASKA 99503 907-277-8378

City of Dawson
PO Box 308
Dawson City YT YOB IGO

Attn: Colm Cairns

Report Date: 10/24/91

Date Arrived: 10/17/91
Date Sampled: 10/16/90
Time Sampled: 1900
Collected By: CC

Definitions
MDL = Method Detection Limit
H = Above Regulatory Max.
B = Below Regulatory Min.

Our Lab #: F111014
Location/Project: Quarterly Yukon River Sam
Your Sample ID: DC-6
Sample Matrix: Water
Comments:

Method	Parameter	Units	Results	Flag	MDL	Date Analyzed
EPA 120.1	Conductance	umhos	250		1	10/23/91
EPA 150.1	pH at 25 C	Unit	8.1			10/19/91
EPA 160.2	Total Suspended Solids	mg/l	26.0		1.0	10/18/91
EPA 350.2	Ammonia-N	mg/l	<MDL		1	10/19/91
EPA 365.2	Total Phosphate-P	mg/l	<MDL		0.10	10/19/91
EPA 405.1	Biochemical Oxygen Demand	mg/l	<MDL		6.0	10/23/91
EPA 413.2	Grease & Oil	mg/l	<MDL		0.44	10/23/91
SM 909C	Fecal Coliform	#/100	<10		2	10/18/91

Reported By: James H. Johnson
Chemistry Supervisor

NORTHERN TESTING LABORATORIES, I.

3330 INDUSTRIAL AVENUE FAIRBANKS, ALASKA 99701 907-4
2505 FAIRBANKS ST. ANCHORAGE, ALASKA 99503 907-277-

City of Dawson
PO Box 308
Dawson City YT YOB IGO

Attn: Colm Cairns

Report Date: 10/24/91

Date Arrived: 10/17/91
Date Sampled: 10/16/90
Time Sampled: 1830
Collected By: CC

Definitions
MDL = Method Detection Limit
H = Above Regulatory Max.
B = Below Regulatory Min.

Our Lab #: F111012
Location/Project: Quarterly Yukon River Sam
Your Sample ID: DC-4
Sample Matrix: Water
Comments:

Method	Parameter	Units	Results	Flag	MDL	Date Analyzed
EPA 120.1	Conductance	umhos	255		1	10/23/91
EPA 150.1	pH at 25 C	Unit	8.0			10/19/91
EPA 160.2	Total Suspended Solids	mg/l	27.0		1.0	10/18/91
EPA 350.2	Ammonia-N	mg/l	<MDL		1	10/19/91
EPA 365.2	Total Phosphate-P	mg/l	<MDL		0.10	10/19/91
EPA 405.1	Biochemical Oxygen Demand	mg/l	<MDL		6.0	10/23/91
EPA 413.2	Grease & Oil	mg/l	<MDL		0.44	10/23/91
SM 909C	Fecal Coliform	#/100	10		2	10/18/91

Reported By: James H. Johnson
Chemistry Supervisor

NORTHERN TESTING LABORATORIES, INC.

3330 INDUSTRIAL AVENUE, FAIRBANKS, ALASKA 99701, 907-456-3116
2505 FAIRBANKS ST., ANCHORAGE, ALASKA 99503, 907-277-8378

City of Dawson
PO Box 308
Dawson City YT YOBIGO

Attn: Colm Cairns

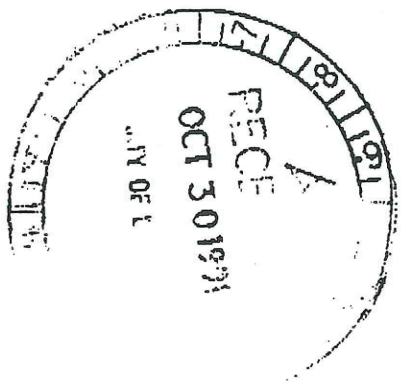
Report Date: 10/24/91

Date Arrived: 10/17/91
Date Sampled: 10/17/91
Time Sampled: 0730
Collected By: CC

Definitions
MDL = Method Detection Limit
H = Above Regulatory Max.
B = Below Regulatory Min.

Our Lab #: F111011
Location/Project: STP Effluent Mthly/Qtrly
Your Sample ID: DC-3
Sample Matrix: Water
Comments:

Method	Parameter	Units	Results	Flag	MDL	Date Analyzed
EPA 120.1	Conductance	umhos	415		1	10/23/91
EPA 150.1	pH at 25 C	Unit	7.2			10/19/91
EPA 160.2	Total Suspended Solids	mg/l	23.0		1.0	10/18/91
EPA 350.2	Ammonia-N	mg/l	3		1	10/19/91
EPA 365.2	Total Phosphate-P	mg/l	1.18		0.10	10/19/91
EPA 405.1	Biochemical Oxygen Demand	mg/l	18.0		6.0	10/23/91
EPA 413.2	Grease & Oil	mg/l	5.10		0.44	10/23/91
SM 909C	Fecal Coliform	#/100	>6000		2	10/18/91



Reported By: James H. Johnson
Chemistry Supervisor

NORTHERN TESTING LABORATORIES, INC.

3330 INDUSTRIAL AVENUE FAIRBANKS, ALASKA 99701 907-456-3116
2505 FAIRBANKS ST. ANCHORAGE, ALASKA 99503 907-277-8378

City of Dawson
PO Box 308
Dawson City YT YOB IGO

Attn: Colm Cairns

Report Date: 10/24/91

Date Arrived: 10/17/91
Date Sampled: 10/16/90
Time Sampled: 1845
Collected By: CC

Definitions
MDL = Method Detection Limit
H = Above Regulatory Max.
B = Below Regulatory Min.

Our Lab #: F111013
Location/Project: Quarterly Yukon River Sam
Your Sample ID: DC-5
Sample Matrix: Water
Comments:

Method	Parameter	Units	Results	Flag	MDL	Date Analyzed
EPA 120.1	Conductance	umhos	255		1	10/23/91
EPA 150.1	pH at 25 C	Unit	8.1			10/19/91
EPA 160.2	Total Suspended Solids	mg/l	27.0		1.0	10/18/91
EPA 350.2	Ammonia-N	mg/l	<MDL		1	10/19/91
EPA 365.2	Total Phosphate-P	mg/l	<MDL		0.10	10/19/91
EPA 405.1	Biochemical Oxygen Demand	mg/l	<MDL		6.0	10/23/91
EPA 413.2	Grease & Oil	mg/l	<MDL		0.44	10/23/91
SM 909C	Fecal Coliform	#/100	<10		2	10/18/91

Reported By: James H. Johnson
Chemistry-Supervisor

APPENDIX "E"

PRESENT WATER LICENSE

01-204-05

Indian and Northern Affairs Affaires indiennes et du Nord

WATER LICENCE

issued pursuant to
Northern Inland Waters Act and Regulations

CITY OF DAWSON
(Licensee)

Licence Number Y2L3-2814 issued on May 26, 1983 19--

Location YUKON AND KLONDIKE RIVERS AT DAWSON CITY

Indian and Northern Affairs Affaires indiennes et du Nord

YUKON TERRITORY WATER BOARD

Pursuant to the Northern Inland Waters Act and Regulations the Yukon Territory Water Board, hereinafter referred to as the Board, hereby grants to

CITY OF DAWSON
(Licensee)

of Box 308, Dawson City, Yukon Territory
(Mailing address)

hereinafter called the Licensee, the right to alter, divert or otherwise use water subject to the restrictions and conditions contained in the Northern Inland Waters Act and Regulations made thereunder and subject to and in accordance with the conditions specified in this licence:

Licence Number Y2L3-2814

Water Management Area 02 - Yukon

Location Yukon and Klondike Rivers at Dawson City

Purpose To obtain, store, and return a flow of water.

Description Municipal water supply and waste disposal.

Quantity of Water Not to be Exceeded $16.6 \times 10^5 m^3/y$ (365,000,000 igpy)

Rate of Use of Water Not to be Exceeded $4.54 \times 10^3 m^3/d$ (1,000,000 igpd)

Effective Date of Licence May 26, 1983

Expiry Date of Licence May 25, 1993

This Licence issued and recorded at Whitehorse includes and is subject to the annexed conditions.

Dated this 4 day of , 1983.

Witness

Yukon Territory Water Board

Chairman

Dated this 25 day of , 1983.

Witness

Approved by

Minister of Indian Affairs and Northern Development

General Conditions

Part A

1. Definitions

(a) "Act" means Northern Inland Waters Act, R.S.C. 1970 (first supplement) Chapter 28 and any amendments thereto;

(b) "Regulations" means the Regulations made under the Act;

(c) "Board" means the Yukon Territory Water Board;

(d) "Minister" means the Minister of Indian Affairs and Northern Development;

(e) "Controller" means the Controller of Water Rights for Yukon, of the Department of Indian Affairs and Northern Development;

(f) all terms and definitions in this licence, including the above, unless otherwise expressly stated shall be defined in the same manner as in the Act and Regulations.

2. Compensation

The Licensee shall provide appropriate compensation to any person whose rights are adversely affected as a result of the granting of this water use licence.

3. Waste Water Discharge

This licence is issued to the Licensee, subject to the conditions contained herein, with respect to the use or return of water, or the depositing or permitting the deposit of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposit of such waste may enter any waters. However, it is also a condition of the granting of this licence to the Licensee that, whenever future Regulations are made by the Governor in Council under the Northern Inland Waters Act, or any other statute imposing conditions relating to the quantity and types of waste that may be so deposited, or under which any such waste may be so deposited that are more stringent than conditions included in this licence, this licence shall be deemed, upon prescription of such Regulations, to be automatically amended to conform with such Regulations.

4. Non-compliance

In the event the Licensee fails to comply with any provision or condition of this licence, the Board may, subject to the Act, cancel the Licence, and without limiting its rights to cancellation of the licence, if the Licensee has failed to perform the works as specified in the licence, or has performed works contrary to the licence, the Board may apply to the Courts for a mandatory injunction compelling the Licensee to perform the works, or for an injunction to restrain the Licensee from performing the works, as the case may be.

5. Correspondence

Where any direction, notice or order under this licence is required to be in writing, it shall be given:

(a) to the Licensee, if left at or mailed by registered mail to:

City of Dawson
P.O. Box 308
Dawson City
Yukon Territory

and shall be deemed to have been given to the Licensee on the day it was left, or seven (7) days after the day it was mailed, as the case may be.

(b) to the Board, if left at or sent by registered mail to the following address:

Yukon Territory Water Board
Suite 200, 4114 - 4th Avenue
Whitehorse, Yukon
Y1A 4N7

and shall be deemed to have been given to the Board on the day it was left or seven (7) days after the day it was mailed, as the case may be.

6. Appeals

An appeal may be filed with the Board within ten (10) days from any action taken by the Controller under this licence.

7. Annual Report

The Licensee shall submit to the Board reports pursuant to Section 15 of the Regulations not later than March 1st of the year next following the year reported. In addition to the information required by the Regulations, these reports shall contain:

(a) tabular and graphical summaries of water quality and quantity data as collected under Schedule "A" to this licence, including an analysis and interpretation of the data by a qualified individual, and a discussion of any variance from upstream stations and from previous years.

(b) a detailed record of the operation of water supply and sewage treatment works, including operational difficulties, maintenance work, and modifications.

(c) the monthly quantity of water withdrawn and quantity of effluent discharged.

(d) any other details on water use and waste disposal requested by the Board.

8. Deposit of Waste

The Licensee shall advise by telex (No. 036-8-342) or telephone (No. 668-5151 or 667-7244 - a 24-hour spill report number) the Controller immediately should a deposit of waste occur or seem likely to occur. A detailed written report on any such event including, but not limited to dates, quantities, parameters, causes and other relevant details and explanations, shall be submitted to the Controller not later than fifteen (15) days after its occurrence.

9. Term of Licence

The term of this licence is for a period of ten (10) years from the effective date of this licence.

CONDITIONS APPLYING TO CONSTRUCTION

PART B

1. The Licensee shall submit to the Board all final design data, engineering reports, construction drawings and specifications for any new, extended, improved or altered works in connection with the City of Dawson water supply and waste treatment works, or associated works at least sixty (60) days prior to the start of any construction or work, or such other period of time as approved by the Board, and receive a letter of approval from the Board prior to the start of any construction or work.

2. The Licensee shall construct each structure or work in accordance with the plans filed with and approved by the Board.

3. The Licensee shall submit to the Board within sixty (60) days of completion of any new water supply wells, or other such period of time as approved by the Board, copies of well logs, pump test data and other related performance data.

4. The Licensee shall provide "as-constructed" plans, drawings and specifications for all works referred to in Part B, Section(1),(2)and (3), of this licence, within ninety (90) days of completion of the construction.

5. Within one year of the effective date of this licence, the Licensee shall ensure that "as-constructed" plans, drawings, and specifications for all existing water supply and sewage treatment works have been submitted to the Board.

OPERATION OF MUNICIPAL WATER AND WASTE DISPOSAL SYSTEM

PART C

1. Water Supply

   (a) The Licensee shall obtain water from the Klondike River via adjacent infiltration wells or groundwater sources for municipal purposes at a rate not exceeding 4.545×10^3 cubic metres per day (1,000,000 gallons per day).

   (b) The water supplied by the Licensee shall conform to the most recent Guidelines for Canadian Drinking Water Quality, as published by authority of the Minister of Health and Welfare, Canada, and any conditions as provided by applicable Ordinances.

   (c) The water supplied by the Licensee shall be disinfected. The equipment and controls used to effect disinfection shall at all times be effectively maintained and operated, and such spare parts as may be necessary to maintain the equipment shall be kept on hand at all times. When chlorine, or any of its compounds, is used as the disinfecting agent, the free chlorine residual shall be tested and recorded at least once each day. There shall be maintained a "free chlorine" residual of not less than 0.1 milligrams per litre in all parts of the water distribution system.

   (d) The Licensee shall submit for approval to the Controller details of the methods and procedures used for the measurement of rates of water use and water quality.

   (e) The Licensee shall operate and maintain the water supply system in a manner satisfactory to the Controller.

2. Wastewater (sewage systems)

   (a) The Licensee shall ensure that all wastewater from the collector systems is directed to the sewage treatment facilities located within the City of Dawson and thence through the outfall to the Yukon River.

   (b) The Licensee shall operate and maintain the sewage treatment facilities in a manner satisfactory to the Controller.

   (c) The Licensee shall ensure that all effluent from the sewage treatment facilities shall meet the following standards:

Parameter	Maximum Concentration For Any Grab Sample
BOD_5	150 mg/L
Suspended Solids	150 mg/L
pH	6 - 9 units
Oil and Grease	5 mg/L
Phosphorus	5 mg/L
Faecal Coliforms	16.0×10^5 counts/100 mL
Toxic Organic Substances	Nil

No effluent shall be toxic to fish as per static LC_{50} bioassay.

(d) Receiving Water Standard

The Licensee shall ensure that the receiving water standards shown below are met outside the initial mixing zone. For faecal coliforms the initial mixing zone is defined as a volume of water extending seven hundred and fifty (750) metres downstream from the point of discharge from the bed to the surface of the Yukon River. For all other parameters specified, the initial mixing zone is defined as a volume of water extending three hundred (300) metres downstream from the point of discharge from the bed to the surface of the Yukon River, whose width shall not exceed twenty-five (25) per cent of the natural surface width of the river.

Parameter	Standard
Faecal Coliforms	Not to exceed 200 counts/100 mL
Dissolved Oxygen	decrease from point upstream of discharge not to exceed 10%, and concentration not to fall below 7 mg/L as a result of sewage discharge.
Oil and Grease	not to exceed 1.0 mg/L at surface
Organisms	no undesirable change in productivity
Settleable Solids	negligible increase
Floatable Solids & Scum	negligible increase
Metals	negligible increase

(e) The licensee shall notify the Controller of the name of the Chief Treatment Plant Operator, along with his address and qualifications and shall also notify the Controller when and if a replacement in the position of Chief Plant Operator occurs.

(f) The Licensee shall advise the office of the Controller immediately when a failure of the waste treatment works occurs, which results in, or may result in, an unauthorized discharge of waste.

(g) Should effluent from the sewage treatment facilities prove at any time to be toxic as per static LC_{50} bioassay, the Licensee shall, within two years of discovery of such toxic effluent, submit to the Board detailed plans for the elimination of such toxic effluent, and shall receive from the Board a letter of approval for those plans.

(h) Within five years of discovery of a toxic effluent the licensee shall implement the plans referred to in Part C, Section 2(g) of this licence to the satisfaction of the Board.

(i) Within six months of the effective date of this licence, the licensee shall submit to the Board, and receive approval for, a plan for the safe removal and disposal of solids from the sewage treatment facilities.

(j) Upon approval by the Board, of the plan referred to in Part C, Section 2 (i) of this licence, the licensee shall implement the plan to the satisfaction of the Board.

3. Solid Waste and Refuse Disposal Sites

(a) The Licensee shall not operate refuse-disposal sites within 100 metres of the highwater mark of any water course or within 1.5 metres of the groundwater table and shall ensure that refuse does not enter any watercourse as a result of any such operation(s) carried out by the Licensee.

(b) The Licensee shall dispose of all solid waste and refuse at the site located in the south-east portion of Lot 329 and the north-west portion of lot 23 in group 1052 West near Dawson City.

(c) No liquid waste shall be deposited in any refuse disposal site.

(d) The Licensee shall submit to the Board, and obtain approval for, a plan for any new refuse disposal sites prior to the use of any such sites.

4. Surveillance Network Program

(a) The Licensee shall comply with the Surveillance Network Program attached as Schedule "A" hereto, and with any variations made by the Controller, and shall comply with all provisions for sampling, sample preservation and analysis specified by the Controller.

(b) Unless otherwise specified or approved by the Controller, all analyses shall be conducted in accordance with the most recent edition of "Standard Methods for the Examination of Water and Wastewater", prepared and published jointly by the American Water Works Association and the Water Pollution Control Federation.

(c) All analyses shall be performed in a facility approved by the Controller.

(d) All sampling and sample preservation shall be done according to methods approved by the Controller.

(e) The results of all monitoring and analyses shall be presented in the Licensee's annual report and shall be available at any time at the request of the Controller.

SCHEDULE "A"

YUKON TERRITORY WATER BOARD

SURVEILLANCE NETWORK PROGRAM

LICENSEE: City of Dawson
LICENCE NUMBER: Y2L3-2814
EFFECTIVE DATE OF LICENCE: May 26, 1983
EXPIRY DATE OF LICENCE: May 25, 1993

A. LOCATION OF SAMPLING STATIONS

Sampling Station	Description
2EB-DC-1	Combined raw water supply from the two wells
2EB-DC-2	Treated water supply before entry into distribution system
2EB-DC-3	Effluent from sewage treatment facility (at screening plant outlet)
2EB-DC-4	Yukon River immediately upstream of outfall from sewage treatment facility (mid-channel)
2EB-DC-5	Yukon River 300 metres downstream of outfall from sewage treatment facility (mid-channel)
2EB-DC-6	Yukon River 750 metres downstream of outfall from sewage treatment facility (mid-channel)

B. SAMPLING AND ANALYSIS REQUIREMENTS

1. The raw water supply shall be monitored daily for flow and sampled once every six (6) months at sampling station 2EB-DC-1 and analyzed for the following parameters:

pH	Total Phosphorus
Turbidity	Potassium
Colour	Calcium
Chloride	Sulphate
Specific Conductance	Sodium
Total Alkalinity	Iron (total)
Total Hardness	Manganese (total)
Nitrate	
Nitrite	
Temperature	Zinc (total)
Flouride	Mercury (total)

2. The raw water supply at sampling station 2Eb-DC-1 shall be sampled every two (2) weeks for the following:
   Turbidity
   Total Coliforms
   Faecal Coliforms

3. The treated water at sampling station 2EB-DC-2 shall be sampled every two (2) weeks for the following:

   Total Coliforms
   Faecal Coliforms

4. The treated water supply at sampling station 2EB-DC-2 shall be monitored and recorded daily for the following:

   Free Residual Chlorine
   Temperature

DAILY WITH SEND IN.

look into cost and suppliers

WATER RESOURCES 667-317

5. Effluent from the sewage treatment facility at sampling station 2EB-DC-3 shall be sampled daily for flow and monthly for the following parameters:

DIANO 200 RANGE R.

Ammonia	Faecal Coliforms	Dissolved Oxygen
Suspended Solids	Conductivity	Temperature
pH	BOD_5	

send sample monthy from screened section faecal coliforms

6. Effluent from the sewage treatment facility at sampling station 2EB-DC-3 shall be subjected to a detailed chemical analysis each year during summer, and at the same time shall be sampled for a static LC_{50} bioassay which shall be conducted according to methods set out in GUIDELINES FOR MUNICIPAL WASTE-WATER DISCHARGES IN THE YUKON TERRITORY, or any other methods approved by the Controller.

contact water board -> KEN NORDIN 668-4884

7. Effluent from the sewage treatment facility at sampling station 2EB-DC-3 shall be sampled quarterly for the following parameters:

ask Ken if TONY'S BIOASSAY IS 6000 ENOUGH.

Phosphorus
Oil & Grease

8. Receiving waters at sampling stations 2EB-DC-4, 2EB-DC-5 and 2EB-DC-6 shall be sampled quarterly for the following parameters:

Ammonia

BOD_5

pH

Suspended Solids

Oil and Grease

Phosphorus

Faecal Coliforms

Dissolved Oxygen

Temperature

Conductivity

Check with water board.

YUKON TERR, W.B.
1-668-4884

JACK NICKEL

MONITORING SCHEDULE - DAWSON CITY LICENCE

STATION / ANALYSIS	DC1	DC2	DC3	DC4	DC5	DC6
Total Chemical Analysis - as per Section B(1) of Schedule "A".	6M					
Total Coliforms	2w	2w				
Faceal Coliforms	2w	2w	M	Q	Q	Q
Free Residual Chlorine		D				
Temperature		D	M	Q	Q	Q
BOD_5			M	Q	Q	Q
Suspended Solids			M	Q	Q	Q
pH			M	Q	Q	Q
Oil and Grease			Q	Q	Q	Q
Phosphorus			Q	Q	Q	Q
Dissolved Oxygen			M	Q	Q	Q
Conductivity			M	Q	Q	Q
Detailed Chemistry			A			
$Bioassay_{LC50}$			A			
Flow	D		D			
Ammonia			M	Q	Q	Q
Turbidity	2w					

LEGEND: D = Daily
W = Weekly
2w = Every two weeks
M = Monthly
6M = Every 6 Months
Q = Quarterly
A = Annually

SAMPLING RESULT

DC-3 SAMPLING CONDUCTED

Parameter	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
BOD5 MG/L	37	108	54.0	30.	66	75.0	N/A	18.0	18.0	18.0	22
Suspended Solids MG/L	58	28.	62.	51.0	114	119.	N/A	23.0	15.0	23.4	30.0
pH	7.1	7.5	7	7.8	7	7.3	N/A	7.2	6.6	7.2	7
Oil & Grease MG/L	19			12.0				5.10		5.09	
Phosporus MG/L	1.0			5.0				1.18		.70	
Faecal Coliforms 100 ML	8500	2000	>240,000	920,000	130,000	130,000	N/A	<500,000	<500,000	<500,000	<500,000
Ammonia MG/L	2.5	1.30	1.60	5.60	17	15.0	N/A	3	3	L.D.	2
US/CM Conductance	300	300	H25	380	490	570	N/A	415	340	340	350
Dissolved O2%				12.2	11.8	13.7	14.2	13.9	15.2	16.3	17.7

SAMPLING RESULT

YUKON RIVER SAMPLING CONDUCTED

	DC-4				DC-5				DC-6			
Parameter	Mar	Jun	Oct	Dec	Mar	Jun	Oct	Dec	Mar	Jun	Oct	Dec
BOD5 MG/L	<6.	<5.	<L.D.	<6.0	<6.	<5.	<L.D.	<6.0	<6.	<5.	<L.D.	<6.0
Suspended Solids MG/L	<5.	335.	27.0	<L.D.	140.	327.	27.0	37.4	174	310.	26.0	4.8
pH	7.5	8.4	8	7.5	7.8	8.4	8.1	7.8	7.8	8.4	8.1	7.8
Oil & Grease MG/L	<5.	<5.	<L.D.	<L.D.	<5.	<5.	<L.D.	<L.D.	<5.	<5.	<L.D.	<L.D.
Phosporus MG/L	<0.005	0.16	<L.D.	<L.D.	0.098	0.098	0.15	<L.D.	0.118	0.14	<L.D.	<L.D.
Faecal Coliforms 100 ML	13	33	10	<10	2	11	<10	<10	2	*26	<10	<10
Ammonia MG/L	0.09	0.05	<L.D.	<L.D.	0.07	0.14	<L.D.	<L.D.	0.06	0.19	<L.D.	<L.D.
Conductivity	245.	153.	255	300	230.	147.	255	300	240.	151	250	300

* Sampling procedure to be checked