PRETREATMENT STUDY

FOR THE

NORTH END WATER POLLUTION CONTROL CENTRE

Winnipeg, Manitoba, 1988

By

JEROME E. COMEAU, P. Eng.

A Practicum

in partial fulfillment of the
requirements for the degree of

Master in Engineering

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SUMMARY

The purpose of this study was to investigate the problems associated with the pretreatment process of the North End Water Pollution Control Centre (NEWPCC). The pretreatment process consists of screening, grit removal and pre-aeration.

This study contains recommendations that will make the pretreatment process more efficient with increased capacity and reduced maintenance. More maintenance is required for the pretreatment process relative to other processes at the NEWPCC.

This study has several major areas of concern, they are; the mechanical bar screens, the grit removal system, and the ventilation system.
The major recommendations made in this report are that:

1. Climber screens be installed in place of all four existing bar screens to reduce maintenance requirements and increase screening capacity.

2. A continuous conveyor system be installed to reduce maintenance requirements.

3. The chain-and-flight grit removal system be installed in all four grit tanks.

4. Both the grit and pre-aeration portions of the tanks should be covered to contain and exhaust gases and aerosols from the pretreatment building.

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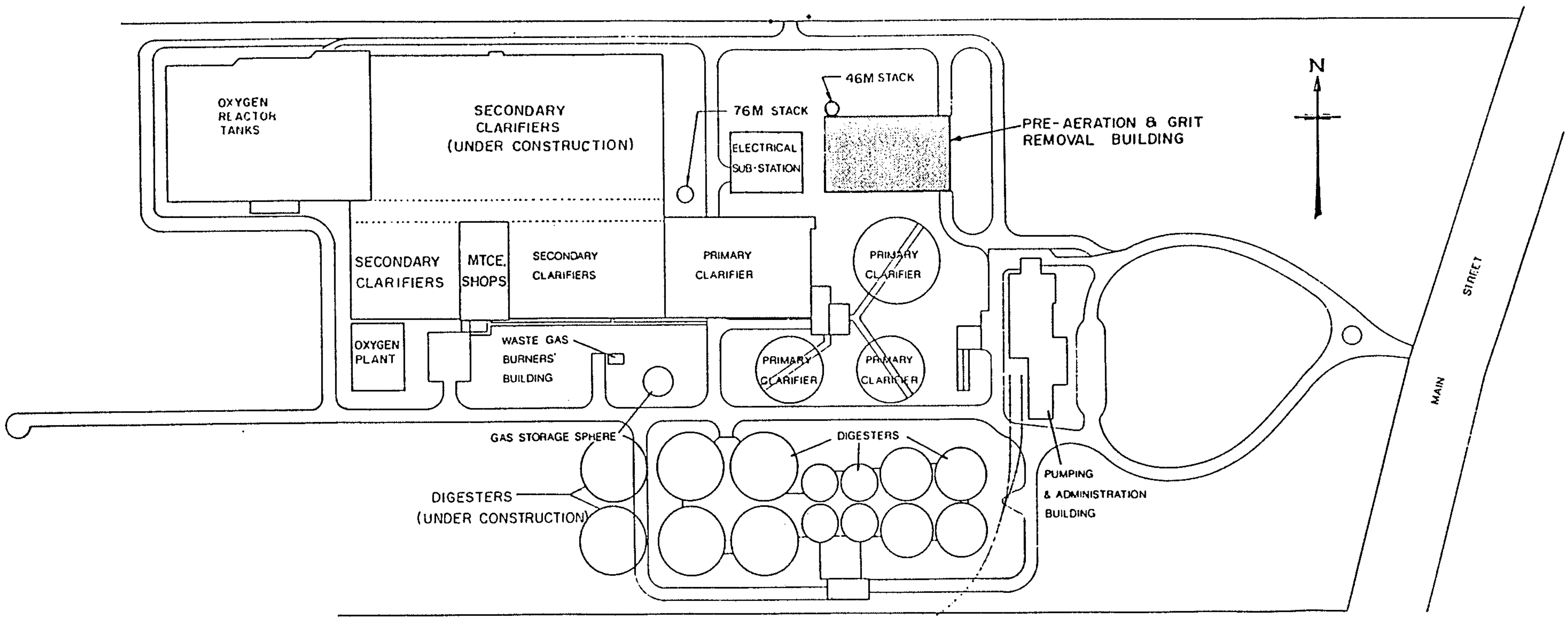
1.0 INTRODUCTION

Pretreatment or preliminary treatment at the North End Water Pollution Control Centre (NEWPCC) is the first step in the wastewater treatment process (see Figure 1.1). Efficient pretreatment is important for subsequent wastewater treatment processes.

Bar screens are used in Pretreatment to remove large floating or suspended debris. Such debris consists of pieces of wood, cloth, paper, plastics, aluminum cans and other such items that may find their way into the collection system. These items, if not removed will plug and/or severely damage pumps and other mechanical components of the plant. Additionally, this debris must be removed from sludge digesters should it find its way that far into the system.

Grit tanks remove heavy inorganic solids such as sand, gravel, metal, glass, and some heavy organic solids such as coffee grounds.

The NEWPCC pretreatment process also makes use of pre-aeration to improve the wastewater's overall treatability. Pre-aeration strips harmful gases, such as hydrogen sulfide and promotes uniform distribution of suspended solids to provide greater removal in the primary clarifier.



NORTH END WATER POLLUTION
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SITE PLAN

Figure 1.1

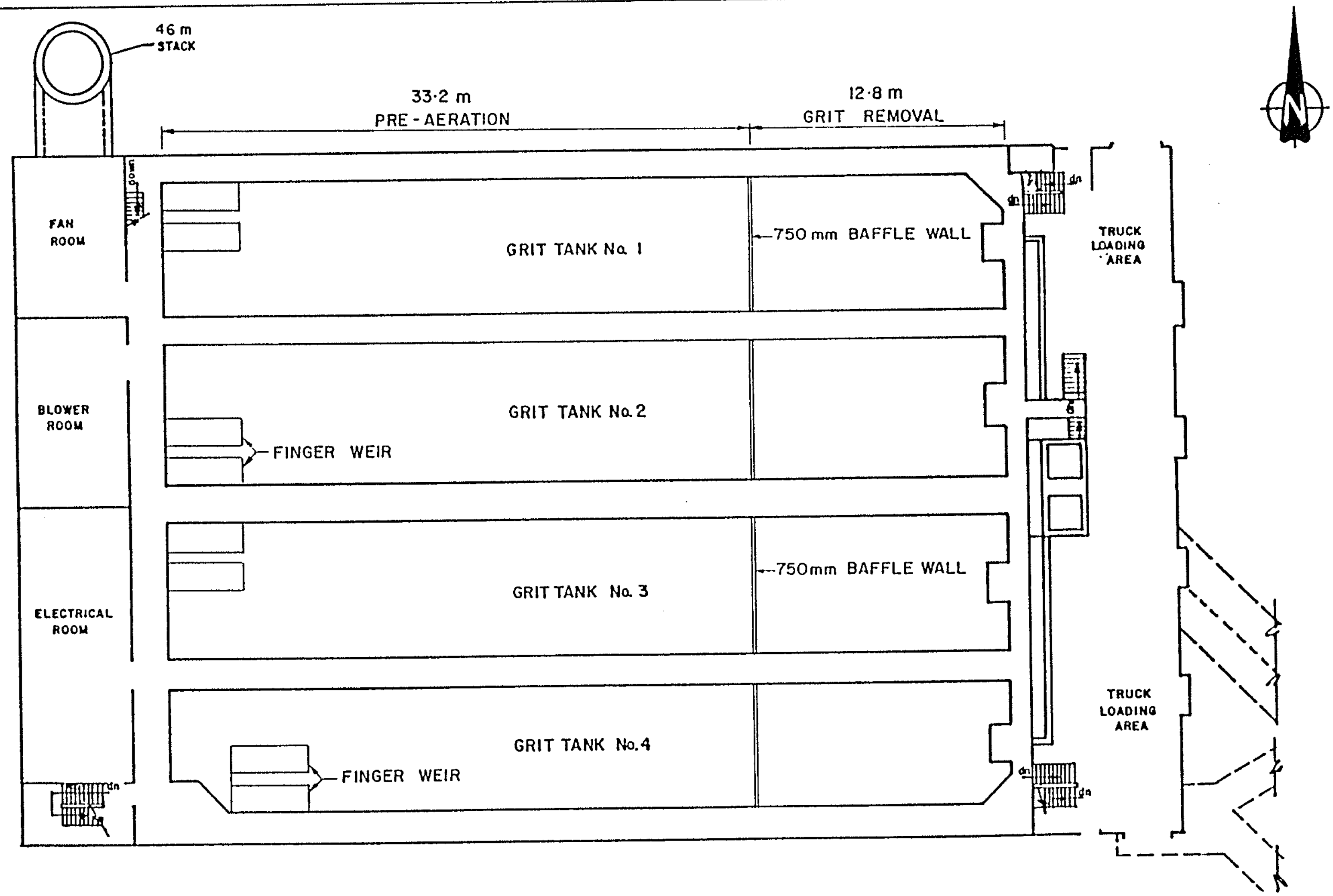
1.1 Existing System Description

Wastewater to the NEWPCC is supplied by three main interceptor sewers. The raw sewage enters the surge well, is pumped to a discharge chamber, and flows by gravity from the discharge chamber to the pretreatment facilities and the rest of the plant.

The pretreatment section of the plant consists of screening, grit removal, and pre-aeration. The wastewater passes through the bar screens, into the grit and pre-aeration tanks, then over the weirs to conduits leading to the primary clarifiers.

The NEWPCC has a mechanical bar screen preceding each of the four grit tanks. The bar screens consist of 51mm x 9mm bars, with 19mm bar spacings. Each screen is mounted on the tank inlet channel, which measures 2.03m deep x 2.56m wide x 2.24m long. Bypass openings, for use during high flows, are located on each side of the bar screens to prevent flooding. The bypass weirs are 0.33 metres above normal water level.

There are four pretreatment tanks each with a grit removal and pre-aeration section. Tanks are divided into two portions with a dividing wall separating the treatment processes. The first 12.8 metres is the grit removal portion and the next 33.2 metres is the pre-aeration portion (see Figure 1.2).



NORTH END WATER POLLUTION CONTROL CENTRE

GRIT AND PRE-AERATION TANKS

Figure 1.2

2.0 Plant Hydraulics

The original peak design of the grit removal and pre-aeration system in 1963-64 was 827 ML/d, but the addition of the screening system has reduced the capacity. Flows exceeding the bar screen cross-sectional area capacity will bypass the screens.

Hydraulic tests were performed March 12, 1985 to determine the capacity and the point at which the wastewater bypasses the bar screens (see Appendix A). These are discussed in Section 2.2.

2.1 Finger Weirs

One possible hydraulic problem was thought to be the effluent weirs causing rise in hydraulic grade line, flooding out the bar screens thereby producing bypassing. However, calculations shown in Appendix C reveal that the finger weirs have little or no effect on the bar screen operation. The bar screens themselves are the problem, as will be discussed in Sections 2.2 and 3 of this report.

2.2 Bar Screens

The bar screens at the NEWPCC are not adequate to meet the required peak capacity of 827 ML/d. This is discussed in detail below.

A plugged or partially plugged bar screen will cause the sewage level to rise upstream of the screens. If the level upstream of the bar screens becomes too high, the sewage will bypass the screens. The unscreened sewage spills over an overflow weir into the grit tank (Wardrop.1985). This unscreened sewage may interfere with downstream equipment such as pumps, valves, mechanical aerators, and digester mixing equipment.

From the hydraulic tests conducted in March, 1985 it was determined that sewage flows of 680 ML/d would be above the overflow level. Also concluded from the tests was that wave motion of the sewage influent will cause bypassing at flows lower than 680 ML/d. It was estimated that such bypassing begins at about 500 ML/d.

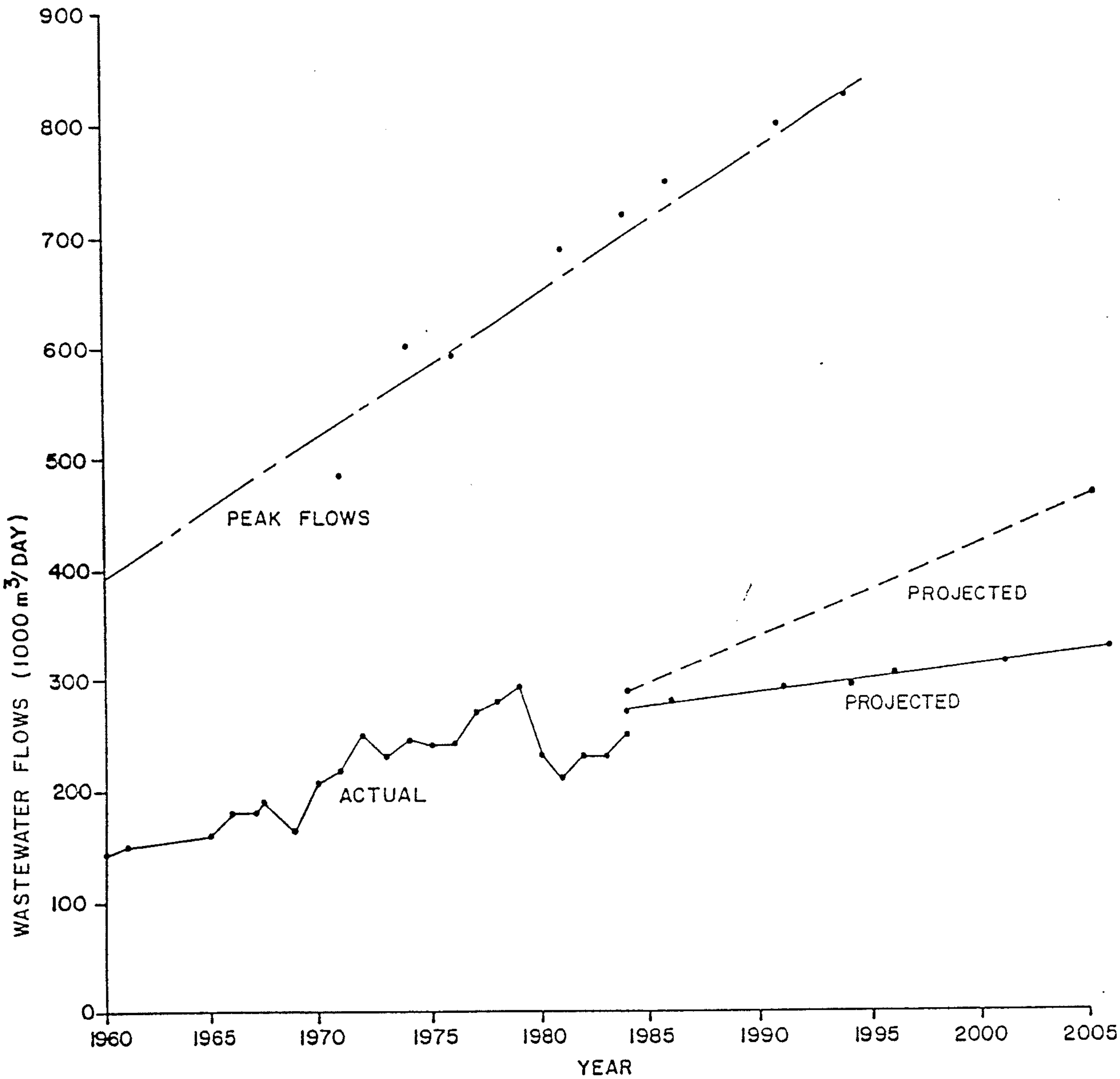
Based on the Operations Division's daily flow data, it can be seen that wastewater bypasses the bar screens during spring runoff and rainstorm events. Assuming all four tanks were in operation it is estimated that flow bypassed the bar screens approximately 13 times in 1983, 29 times in 1984, and 31 times in 1985. Peak raw sewage inflow to the plant was not recorded prior to 1983. Any bypassing is unacceptable because the unscreened wastewater creates downstream treatment and maintenance problems.

2.3 Required Capacity

Average annual flow projections are shown in Figure 2.1. These are based on the Plan Winnipeg Projections and recent population projections obtained from the City of Winnipeg Environmental Planning Department. The lower flows which are calculated from recent Environmental Planning Department population projections are considered to be the best estimates to date. Detailed information on population projections can be found in the Environmental Planning Department report "A Cohort Survival Projections of Winnipeg's Population 1981-2006".

Because it is the Waterworks, Waste and Disposal Department policy that all flows pumped will receive preliminary and primary treatment, the capacity of the pretreatment system must equal the firm pumping capacity of 827 ML/d. A flow of 827 ML/d will be equivalent to 2.75 x average annual flow (AAF) in 1996 or 2.5 x AAF in 2005. Therefore, recommendations contained herein are based on a peak flow of 827 ML/d. Additionally, because the hydraulic capacity of the civil works (grit and preaeration tankage) is about 827 ML/d, it is not practical to size related equipment beyond this flow capacity.

An overall plant capacity study is proposed for the early 1990's. Terms of reference for this study should include future requirements and planning for grit removal and preaeration at the NEWPCC.



LEGEND

FLOW BASED ON PLAN WINNIPEG POPULATION FORECAST (1981) — — — — — —

FLOW BASED ON ENVIRONMENTAL PLANNING POPULATION FORECAST (1985) ————

PEAK FLOWS (2.75 x ANNUAL DRY WEATHER FLOW) ——— – ——— – ———

NORTH END WATER POLLUTION CONTROL CENTRE

FLOW PROJECTIONS

Figure 2.1

3.0 Mechanical Bar Screens

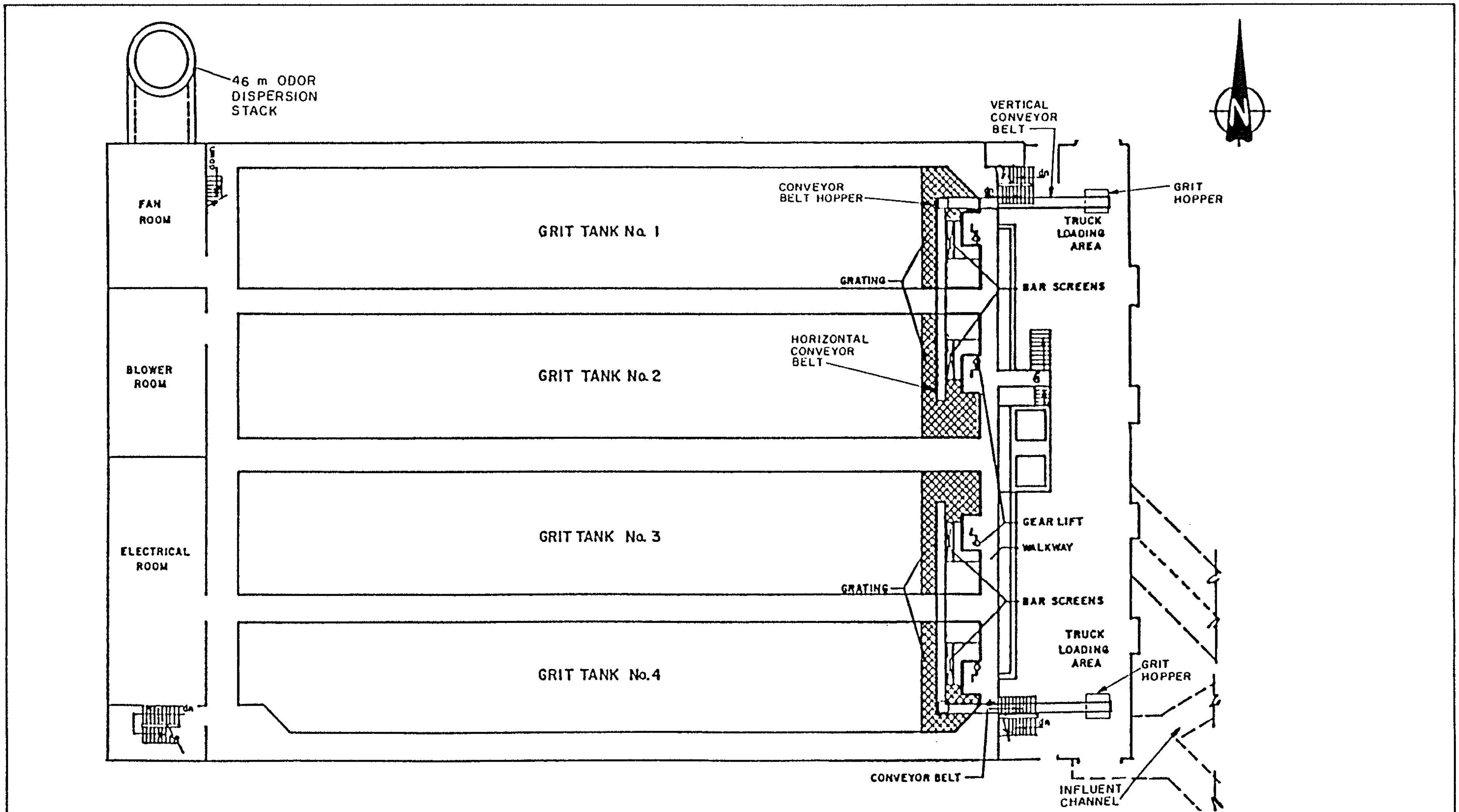
There are four mechanical bar screens at the headend of the treatment plant. The bar screens are cleaned of debris by automatic rakes that discard that debris on a conveyor belt system. (See Figures 3.1, 3.2 and 3.3).

3.1 Current Operating Experience

The bar screens frequently plug causing wastewater bypassing around the screens during the high flow periods and it is necessary to supplement mechanical cleaning of screens with manual cleaning. The bar screens are known to plug within eight hours after manual cleaning (Cassiram. 1985). This plugging reduces the screening capacity.

When the screen openings are 100 percent clear the velocity of wastewater through the bar screens is within the upper limit of the design range (see Table 3.1). However, if the openings in the screen are plugged, the velocity through the screens can be up to 25 percent greater than the design range. A high velocity will produce a very low screenings capture ratio (Borowiec, et al. 1984). Therefore, it is important that the NEWPCC rake cleaning mechanism operates efficiently.

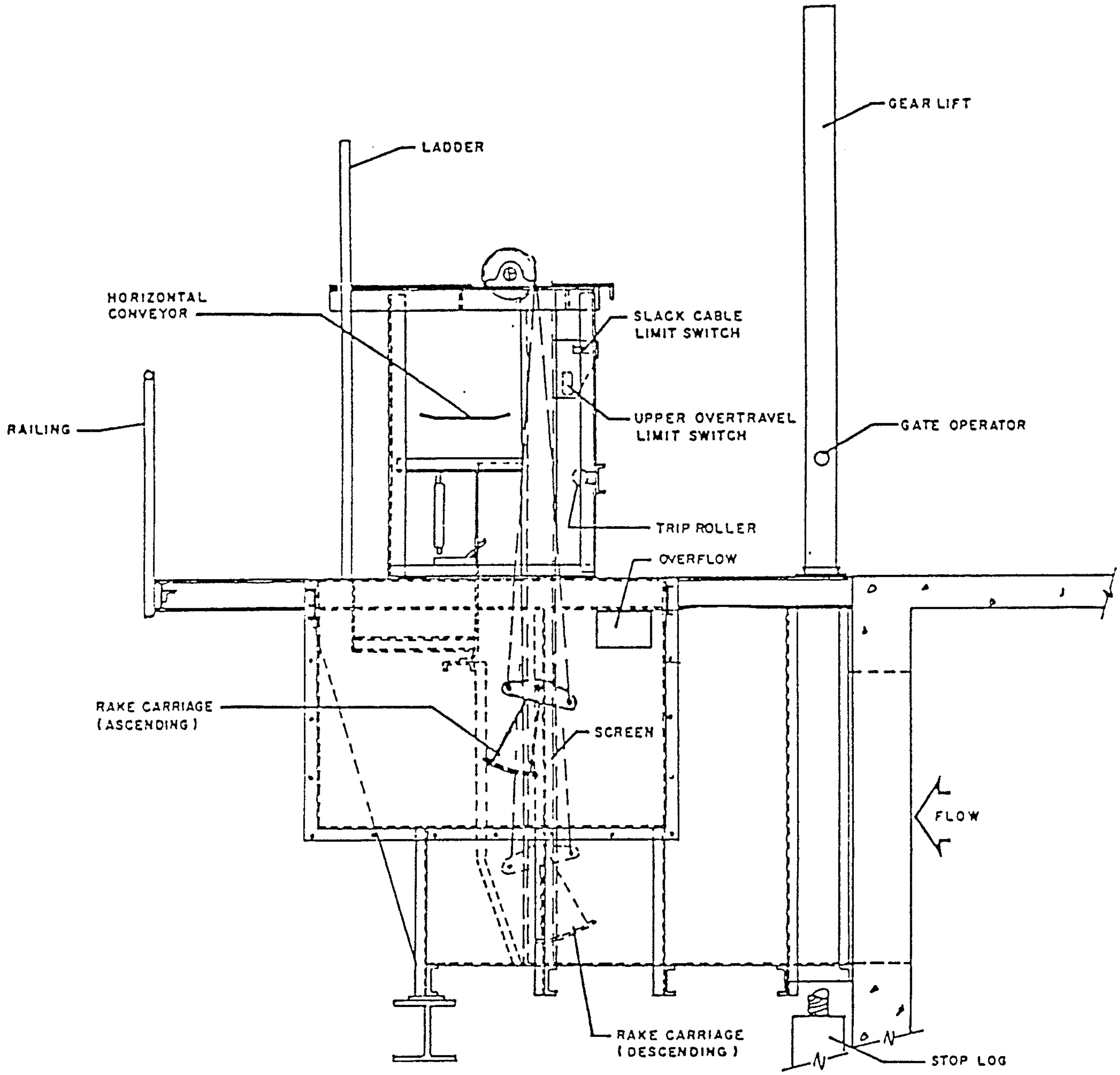
The bar screen rake mechanisms are cable driven. The cables stretch over a period of time and finally break. The frequency of cables failing this way is approximately twice a year for each screen (Paterson. 1985).



NORTH END WATER POLLUTION CONTROL CENTRE

BAR SCREENS PLAN VIEW

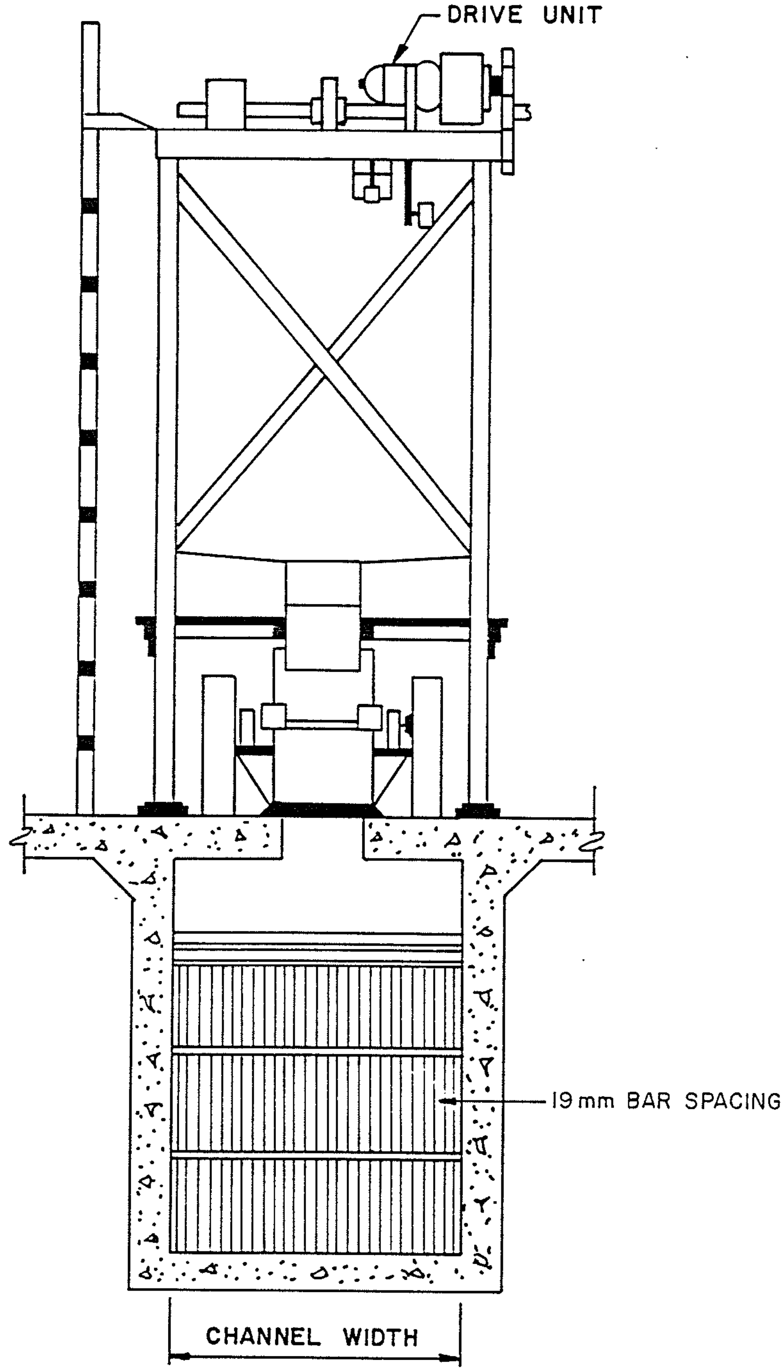
Figure 3.1



NORTH END WATER POLLUTION CONTROL CENTRE

TYPICAL BAR SCREEN (SECTION)

Figure 3.2



NORTH END WATER POLLUTION CONTROL CENTRE

TYPICAL BAR SCREEN (FRONT VIEW)

Figure 3.3

The Operations Division has observed that some debris is still getting past the bar screen to cause plugging of piping and pumps. The amount of debris that gets through can be reduced by decreasing the width between the bars from 19mm to 13mm. Thirteen millimetre spacing has been effective at moving debris from the wastewater at the South End Water Pollution Control Centre . Given the current screen design this would further reduce an already restricted hydraulic capacity. A more efficient rake mechanism discussed in the following sections would be necessary if the width between the bars were decreased.

The present mechanical bar screen system produces continued maintenance problems, which are consumptive of both time and money (Russell. 1985). More information on the maintenance requirements of this area is found in Section 5.0.

MECHANICAL BAR SCREEN DESIGN PARAMETERS

Table 3.1

Parameter	NEWPCC Actual Value	Published Values: Metcalf & Eddy	EPA	GLUMRB	NYSDEC
Bar Size					
Width,mm	9	5-15	-	-	-
Depth,mm	51	25-75	-	-	-
Clear spacing between bars,mm	19	15-75	19-50	16-44	19-50
Slope from vertical, deg	0	0-30	-	-	0-45
Approach Velocity m/s	0.97[1]	0.6-1.0	0.6-1.2	0.38-0.9	
Head Loss mm	100[2]	0-150	-	-	-

1. Assuming an unplugged screen
2. Measured on Tank 2 under a controlled flow condition (Approximate Flow = 740 ML/d)

3.2 Alternative Screen Designs

Screens in sewage treatment plants or in pumping stations may be divided into three classifications: first are the Trash racks which have a clear opening between bars of from 40mm to 100mm. The second is the standard mechanically cleaned bar screen which has clear openings between bars of from 13mm to 40mm. The last classification is the fine screen which has screen openings 13mm wide or smaller.

Trash racks or coarse bar racks are often installed for protection of comminutors. Coarse racks are also used to safeguard fine screens from damage. The NEWPCC does not lend itself to the installation of trash racks as too many coarse solids would still pass through, unless the racks were installed in conjunction with finer screens downstream.

The 19mm spacing between the bars at the NEWPCC, would put these screens in the classification of mechanically cleaned bar screens.

Fine screens can remove up to 25 percent of the suspended solids of the raw sewage. They are most often used in low capacity plants instead of primary treatment. Because the NEWPCC has adequate primary treatment, fine screens are an unnecessary costly addition. Therefore, the balance of this report will focus on mechanically cleaned bar screens.

3.2.1. Mechanically Cleaned Bar Screens

There are many different designs for mechanically cleaned bar screens but they all fall within the following general three groups: cable drive, chain drive, and rack and pinion drive. Each group name describes how the cleaning rake is operated. The cable and chain drive systems are the oldest systems and are still used throughout the world. The rack and pinion drive is the newest in bar screen technology and is rapidly becoming a favorite in the industry (Crawford, Jr. 1985).

3.2.1.1. Cable Drive

The cable operated bar screen is used basically for light-duty screening applications, such as secondary screens (Borowiec, et al. 1984). Secondary screening facilities are defined as screening operations not situated at the headend of the plant, but rather downstream either before primary settling tanks or thickeners (Borowiec, et al. 1984).

The cycle begins when the rake carriage at the bottom of the screen moves toward the bar rack, the rake engages the bar rack and begins the cleaning of the screens. The bar screen at the bottom is angled to enable the rake to engage the screens at the lowest possible point. The carriage then proceeds upward cleaning the bar rack, dumping the screenings at the top of the rack (see Figure 3.2) (Design Notes, PWS-78).

The cable drive system at the NEWPCC does not prevent the bar screens from plugging. The plugging of the screens is due to the inability of the rake mechanisms to adequately remove debris from between the bars. Cycle time of the rake mechanism has been shortened so that debris is removed more often but the rake mechanism is still ineffective. Plugging of these screens creates persistent maintenance problems. These are discussed in Section 5.2.

3.2.1.2. Chain Drive

The chain-operated mechanical bar screen has been used in wastewater treatment plants for years (Borowiec, et al. 1984), and is often used for heavy-duty conditions under the most severe flow conditions.

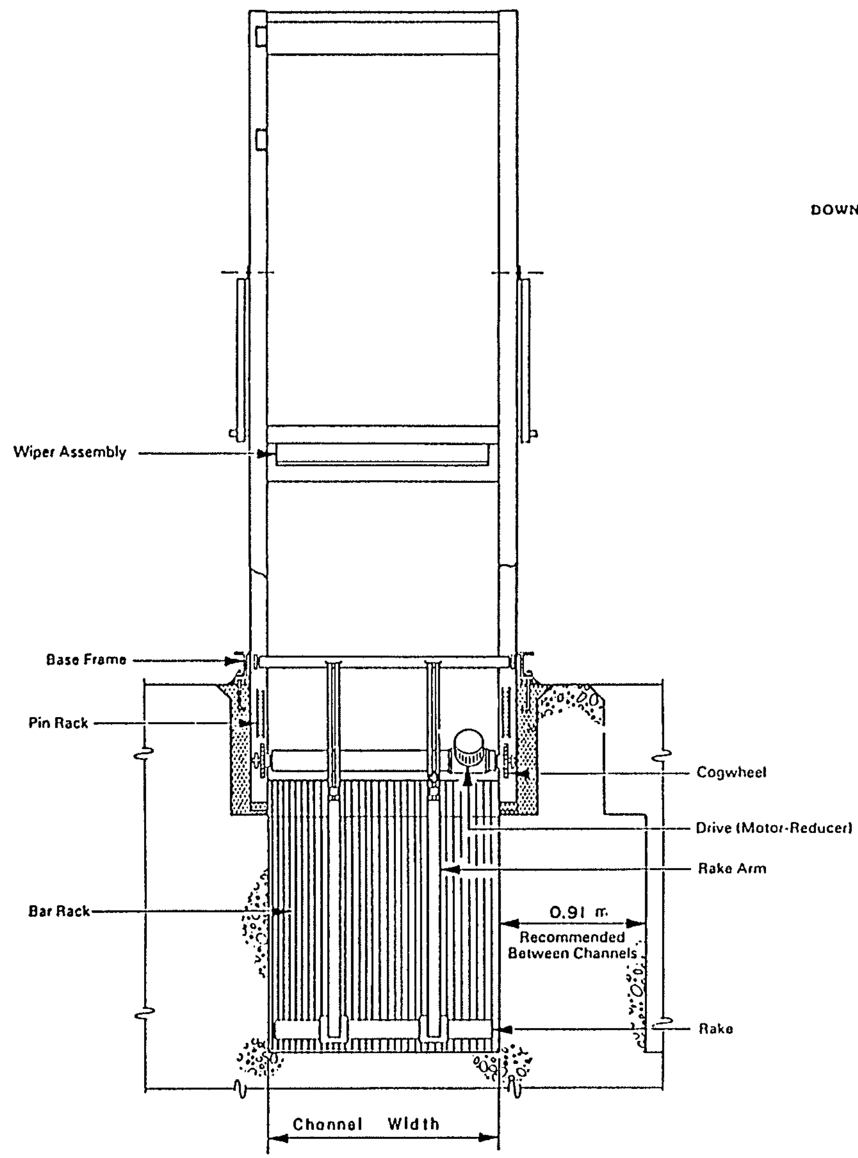
The design is similar to the cable drive except a chain is used in place of the cable. The chains are rugged and stronger than cables but still susceptible to breaking. These systems wear rapidly and require extensive labour for repairs and maintenance (Borowiec, et al. 1984.).

3.2.1.3. Rack and Pinion Drive

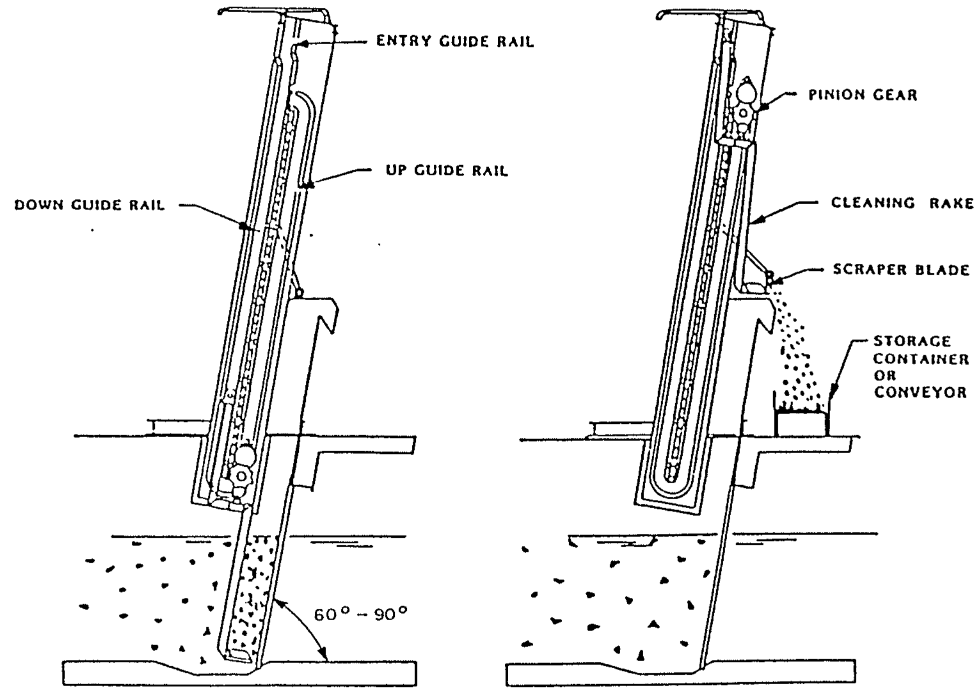
The rack and pinion drive uses a rake system that employs a pinion gear which travels up and down a toothed rack. All moving parts are kept out of the wastewater (see Figure 3.4), thus eliminating many of the problems common to other bar screen designs. These include corrosion and abrasion caused by grit.

The rack and pinion system has an overload device that permits the rake to climb over obstructions which are too large to remove, in which case an overload switch is activated, the motor stops, and an alarm sounds. This reduces the amount of damage and necessary maintenance done to the rake mechanism.

One modification of the rack and pinion system is a reciprocating rake known as a climber screen. This system is so superior to all other rake mechanisms, that many Sanitary Engineers will settle for nothing less for a heavy duty bar screen application (Crawford, Jr. 1985).



FRONT VIEW



SECTION

REFERENCE INFILCO DEGREMONT INC.

NORTH END WATER POLLUTION CONTROL CENTRE

RACK AND PINION BAR SCREENS
CLIMBER SCREENS
(PROPOSED)

Figure 3.4

In 1984, a report titled "New York City's Experiences with Mechanically Cleaned Bar Screens" was written by the New York City Department of Environmental Protection and the environmental consultant Metcalf and Eddy. The report was written because of New York City's wastewater treatment plants' inefficient screening facilities. The report recommended climber screens manufactured by Infilco Degremont Inc.. Infilco Degremont have been making climber screens for 20 years and these screens have been operating with little or no maintenance required. Although there are several new climber screen manufacturers, the Infilco Degremont screen is the most popular because of positive results relative to other designs (Crawford, Jr. 1984). In New York City, an Infilco test unit was installed. Following the successful operation of that screen, additional screens were specified and purchased for treatment plants throughout the city. There are over 2000 climber screens installed in Europe and North America, many of which serve combined sewer systems (Borowiec, et al. 1984).

The only limiting factor of the climber screen is the headroom requirement (screen frame height above the floor). These screens require clearance above the bar rack equal to at least twice the depth of the influent channel. The overhead space can be reduced by putting the bar screens on an incline. This slanted-bar screen design will also increase the cross-sectional area of the screens, thereby increasing screening capacity. There is sufficient headroom at NEWPCC, and the suppliers advise they can do the modifications required, therefore headroom would not be an installation problem at the NEWPCC.

3.3 Pretreatment - Conveyor System

Both the grit from the tanks and the screenings from the bar screens are transported by a system of conveyors to a storage hopper. This system is a major maintenance problem which is further discussed in Section 5.3.

The conveyor belts, for the most part, are wet and grimy because of the moisture in the screenings and grit. This wet sticky material accumulates on the conveyor rollers, resulting in belt slipping and uneven wear on belts and rollers.

The horizontal conveyor transports the debris to a vertical conveyor, which dumps the debris into a storage hopper. The debris is transferred from the horizontal conveyor belt to the vertical conveyor belt via a conveyor hopper (see Figure 3.1). During the transfer of material, debris is lost because of the spilling of material from the conveyor hopper and because of debris remaining in the hopper (Paterson.1985).

When installing the new bar screens a new conveyor system should also be installed. The existing conveyor system is maintenance intensive. This is discussed in detail in Section 5.3. Installing the bar screens and the conveyor system together would make for a more compatible removal system than is presently employed.

The conveyor system for material handling has greatly improved over the years. One system which has reduced maintenance requirements is the continuous path conveyor. In February, 1986, Denver, Colorado "Metro One" Wastewater Treatment Plant installed a continuous path conveyor system that was manufactured by Serpentix Conveyor Corporation. The conveyor system has operated since that time virtually maintenance free (Holst. 1986). A continuous path conveyor has the ability to incline and decline steeply and to make continuous horizontal, helical, and vertical curves. The flexibility of the continuous path conveyor system permits a single conveyor to replace multiple conventional conveyors thereby eliminating troublesome transfer points and reducing energy and maintenance costs (see Figure 3.5).

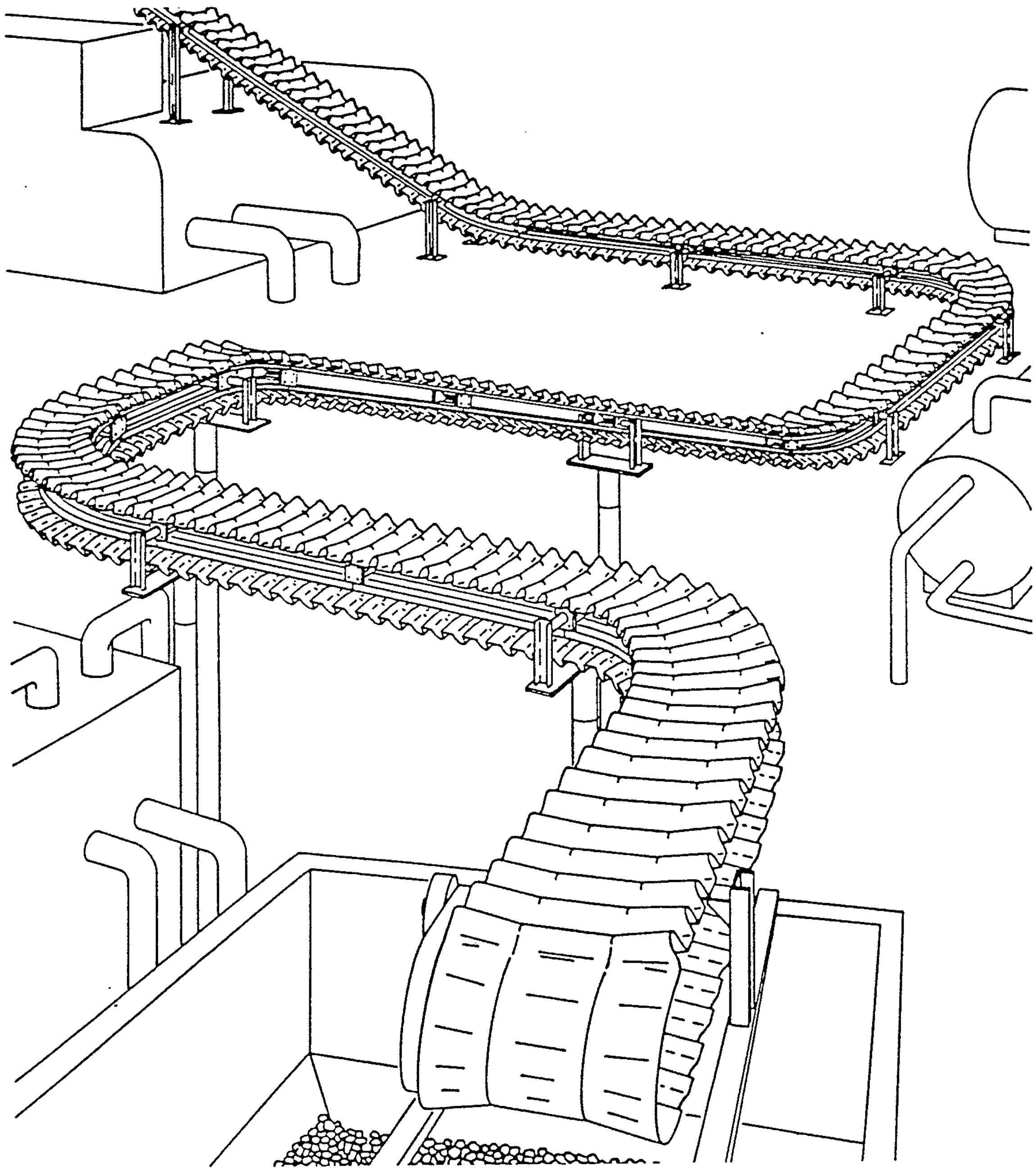


ILLUSTRATION COURTESY SERPENTIX INC.

NORTH END WATER POLLUTION CONTROL CENTRE

CONTINUOUS PATH CONVEYOR (PROPOSED)

Figure 3.5

3.4 Separate Bar Screen Building

The concept of separating the screening facilities from the grit removal and pre-aeration facilities has been raised several times over the years.

A separate bar screen building would enable additional screens to be installed when plant flow surpasses the currently proposed design flow. Once the proposed four replacement screens are installed, screening will be possible for sewage flows of up to 827 ML/d. When plant flows surpass 827 ML/d, additional treatment facilities will be necessary for all treatment processes including screening, grit removal, pre-aeration, primary, and secondary treatment, in short a new supplementary treatment complex would be necessary (Wardrop/MacLaren, 1981). Since the cost of the entire screen process building and the necessary hydraulic renovations would exceed the cost of replacing the present screens, construction of a separate screening building is not justified at this time.

One benefit of a separate screening facility is that the bar screens would be more accessible for maintenance and repair than they are under the present system. Because lower maintenance screens are proposed and because future expansions are likely to preclude the usefulness of a separate screening building, this has not been proposed.

4.0 Grit and Pre-Aeration Chamber

Grit has long been recognized as a problem component in wastewater treatment (Meunier. 1983). Because of grit's abrasive qualities, it has a significant negative effect on the lifespan of pumps, valves and other equipment. If grit is not settled properly it will accumulate in aeration tanks, clarifiers and digesters and will result in loss of useable volume (EPA. 1978).

Pre-aeration improves treatability of wastewater by increasing the dissolved oxygen in the sewage and stripping off gases such as hydrogen sulfide. The mixing motion of pre-aeration provides for a more homogeneous sewage, which provides better solids distribution in the primary clarifiers.

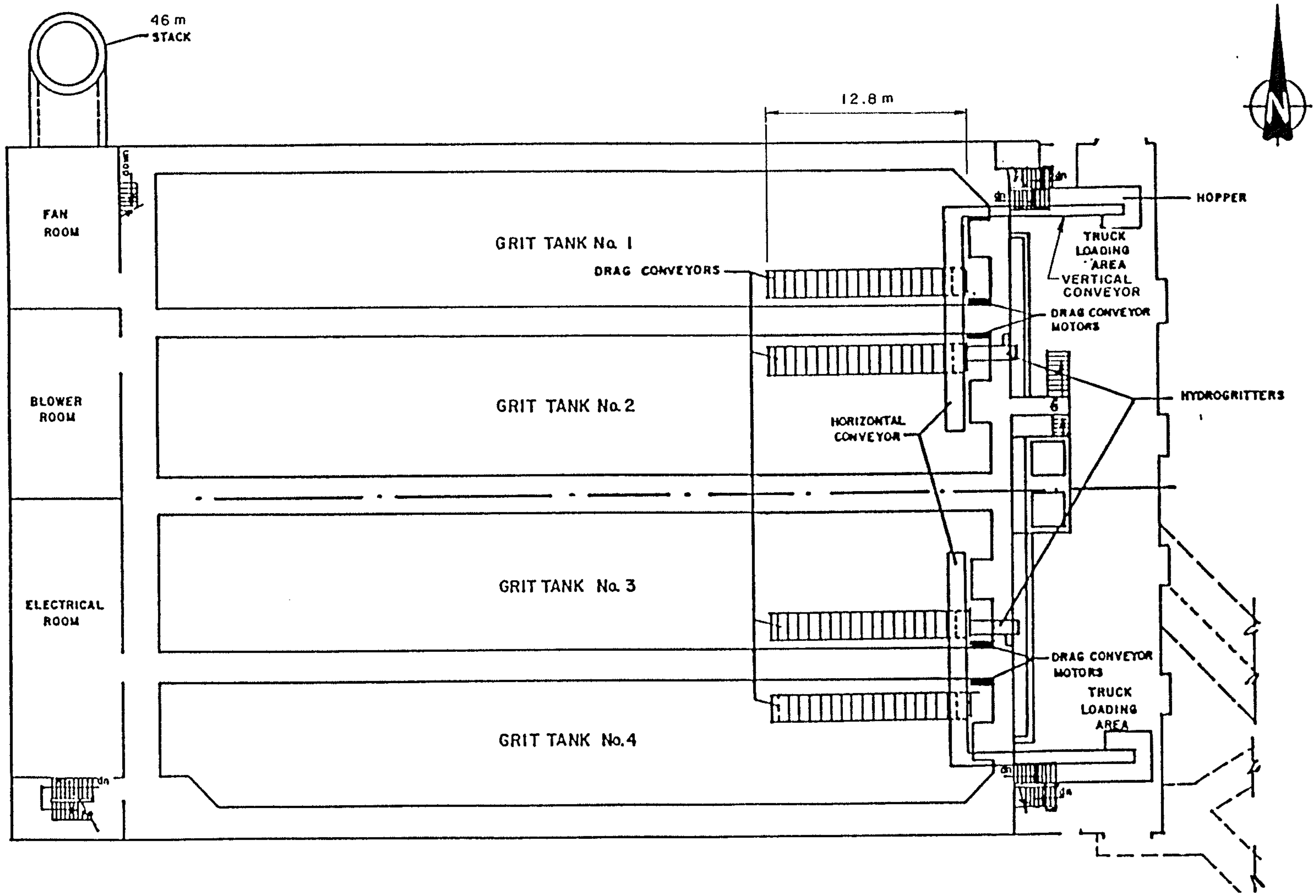
4.1 Grit Removal Experience

Grit can be removed automatically or manually from the NEWPCC grit tanks. There are two different automatic grit removal systems. These are discussed below.

The present automatic system uses a drag conveyor to convey the grit along the bottom of the grit collection trough to a drain. The grit slurry is then pumped through a hydrogritter, consisting of a hydrocyclone and a grit classifier. The hydrocylone removes the grit from the slurry and discharges the de-gritted water back ahead of the bar screens into the influent channel. The grit from the hydrocyclone is discharged into the grit classifier. The classifier uses flushing water to wash off organic matter remaining on the grit. The grit classifier then deposits the grit via a conveyor belt into a hopper. From the hopper, trucks are used to dispose of the grit (Wardrop/MacLaren. 1985). (See Figure 4.1 and 4.2)

In 1984, a new removal system was installed in tank number four because of the continued maintenance problems of the hydrogritter as explained in Section 5.1. This chain-and-flight system is a modification of the drag conveyor. It was developed by City forces so that the hydrogritter system could be abandoned, thus eliminating a maintenance-intensive component of the process. The chain-and-flight scraper deposits directly onto a conveyor belt (see Figure 4.3).

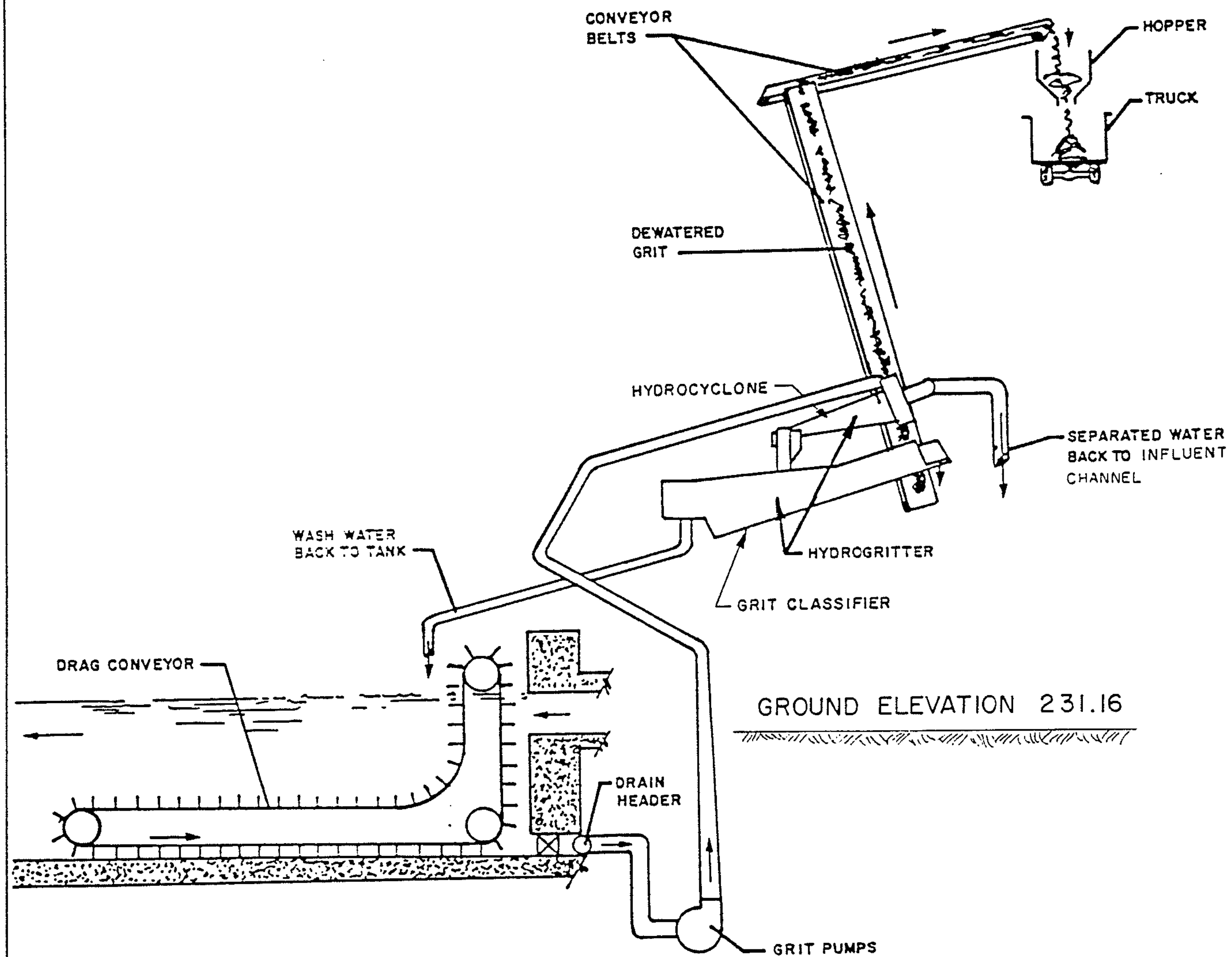
The chain-and-flight grit removal system has proved to be less labour intensive than the hydrogritter system (Cassiram. 1985). Another chain-and-flight system on a second tank was installed during the winter of 1985-86 because the reduced maintenance of the original chain-and-flight system compared to the hydrogritter system. By the end of the winter of 1986-87, all four grit tanks will use a chain-and-flight system for grit removal. With the new chain-and-flight system a certain amount of maintenance will still be required because grit removal equipment wears out faster than other wastewater treatment plant equipment due to the abrasive characteristic of grit (EPA. 1978).



NORTH END WATER POLLUTION CONTROL CENTRE

LOCATION OF GRIT REMOVAL EQUIPMENT

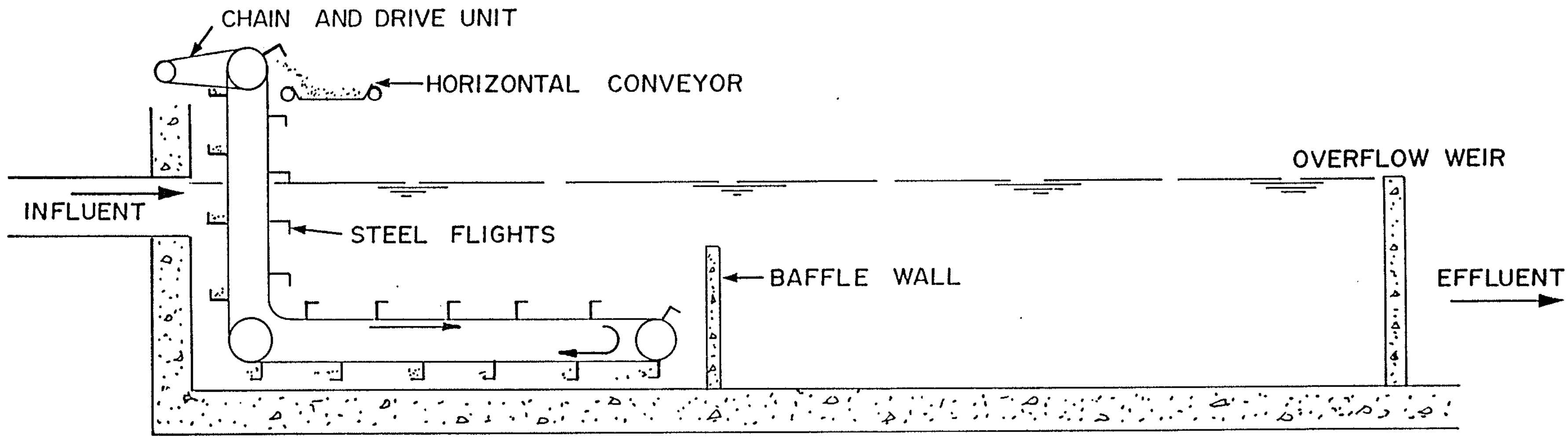
Figure 4.1



NORTH END WATER POLLUTION CONTROL CENTRE

HYDROGRITTER GRIT REMOVAL SYSTEM SCHEMATIC

Figure 4.2



NORTH END WATER POLLUTION CONTROL CENTRE

TYPICAL CHAIN AND FLIGHT SYSTEM MODIFICATION SCHEMATIC

Figure 4.3

Grit from the hydrogritter is often full of paper products because the bar screens allow paper to pass through them. This paper clogs the hydrogritter, which results in grit being passed through the system. Eliminating bypass and improving screen capture efficiency will reduce this problem.

4.1.1. Auger Grit Removal System

Another method of removing grit from the bottom of the grit tank is to use a screw or auger conveyor. The motor driven screw or auger spins on its axis, displacing the grit toward a drain as it turns. After the grit slurry is drained from the grit tank the wastewater is separated from the grit by a dewatering device such as a hydrogritter. If an auger system is installed with the present hydrogritter system the maintenance needed for the hydrogritter would still be necessary. Therefore, the benefit of installing an auger system with a hydrogritter would be minimal compared to the present removal system.

A local supplier of screw conveyors inspected the grit removal system November 29, 1985 and recommended that an auger system should not be installed at the NEWPCC. He said that an auger system may not decrease the maintenance problems, it could even increase them. The mechanical seals and bearings needed for an auger system would wear quickly in a grit tank (Walker. 1985).

4.2 Aeration

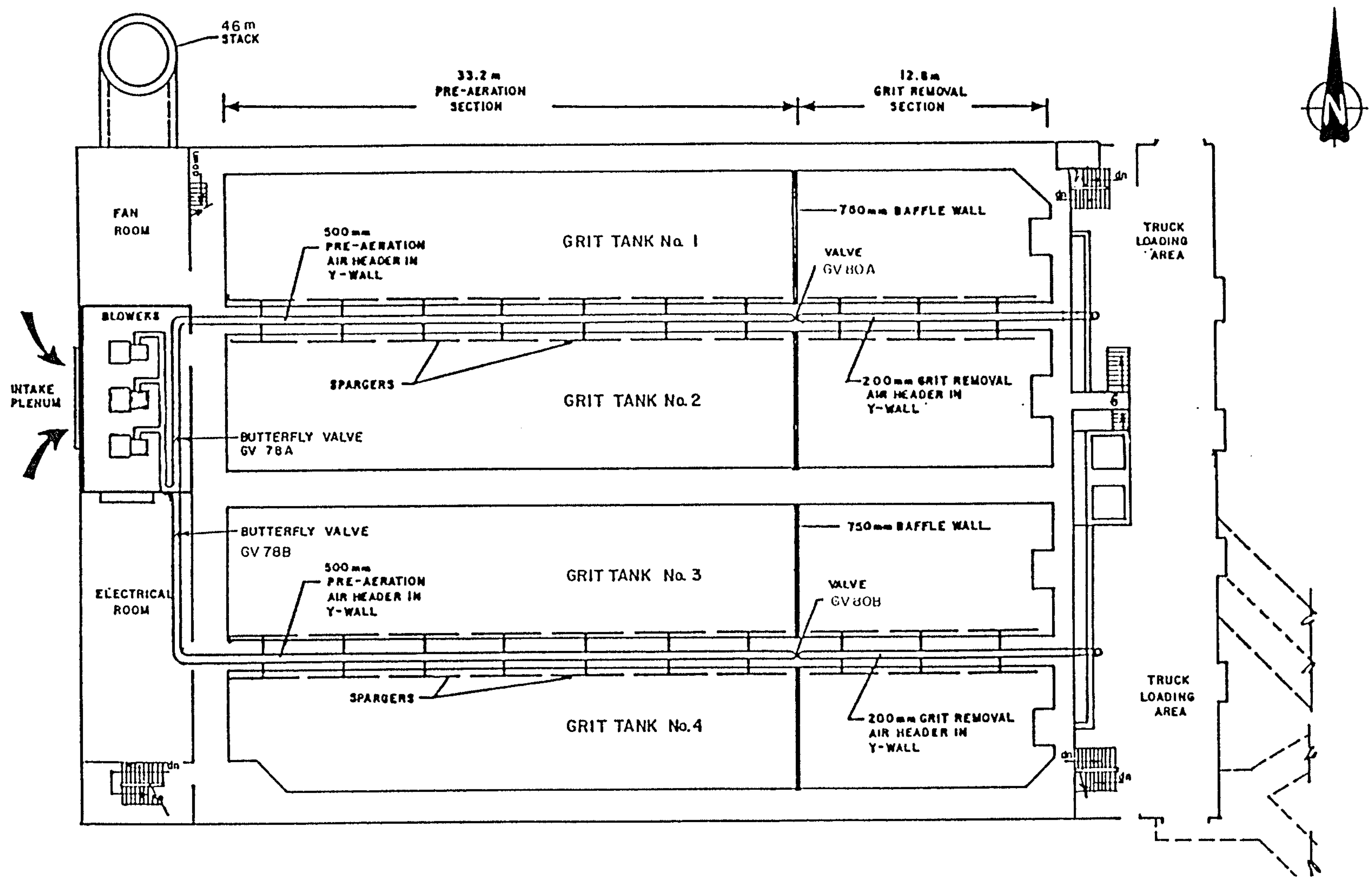
Air is supplied to both the grit and pre-aeration sections of the tanks. The air is gently ($17m^3$/hr-m) supplied to the grit portion, to allow the grit to settle. The heavier particles with their corresponding higher settling velocities drop to the bottom, whereas the lighter organic particles are suspended and are eventually carried out of the tank (WPCF. 1977). If the velocity is too low, organic material will settle with the grit. High concentrations of organics in the grit will cause objectionable odors. Also, organics should be carried over into primary treatment so these solids can be properly treated. Air is vigorously (32 m^3/hr-m) supplied to the pre-aeration portion to increase the dissolved oxygen of the sewage and to release odorous, toxic and corrosive gases (Wardrop/MacLaren. 1985).

Air is drawn from the intake plenum into the blower room and then supplied to each tank through swing arm spargers. The airflow rate is controlled by operating the sparger valves or butterfly valves GV80A, GV80B, GV78A and GV78B (See Figure 4.4).

The sparger valves for the grit section are partially closed because less air is required than in the pre-aeration section. One common problem occurs when a tank is drained for repair and the sparger valves are closed. When the tank is filled, often all the spargers valves are completely opened or it is unsure how "much open" they should be. This could be prevented by permanently setting Y-wall valves GV80A and B (see Figure 4.4) to the partially closed position. This would reduce the confusion of the sparger valve setting.

4.2.1. Optimization

The amount of air supplied to the Grit Removal system is critical because the velocity of roll governs the particle size of a given specific gravity that will be removed (Metcalf and Eddy. 1979). If air is supplied at too high a rate, grit will not settle. The grit will be carried into the pre-aeration section of the tank, primary clarifiers, and subsequently into the digesters. Also, if the air rate is too low, then organic matter will settle along with the grit (Wardrop/MacLaren. 1985). Therefore, it is important to treatment that air supply rates be optimized.



NORTH END WATER POLLUTION CONTROL CENTRE

AERATION SYSTEM

Figure 4.4

Air optimization tests were performed for four weeks during the period of March 18 to July 12, 1985. The objective of the tests was to determine the optimum air valve setting with respect to grit removal efficiency. Butterfly valves GV-78A and GV-78B were adjusted to change airflow in tanks three and four while airflow in tanks one and two were kept constant. This was done to establish base data against which to compare the test data. Airflow to each tank was measured by differential pressure gauges located in the blower room. The Laboratory Services Division sampled tank wastewater influent and effluent, and grit removed from the tank. The lab analyzed the performance of the grit removal system for each air setting.

The velocity of the air-roll was determined by measuring the time a floating object took to cross the grit tank (See Appendix B.). Air-roll velocity increases with the volume of air supplied.

The tests did not determine the airflow and air-roll velocity that would give optimum grit removal. The major problems with the tests included lack of; "grit removal efficiency" criteria, control over air-roll velocity and control over wastewater flow.

The literature is not consistent or even clear as to what constitutes grit. Therefore some grit criteria should be formulated and a testing program should be developed (Topnik. 1986). This testing program should be established by the Engineering Division in conjunction with the Laboratory Services and Operations Divisions.

Table 4.1 Grit Removal and Pre-aeration Design Parameters

Parameter	NEWPCC Actual Value	Published Values				
		Metcalf & Eddy	EPA	WPCF	GLUMRB	NYSDEC
Width-depth ratio	2:1	1:1-5:1	1.5:1-2:1	-	-	-
Detention Times:						
Grit tank (mins.)	5*	2-5	3-5	3-5	-	0.4-1
Pre-aeration tank (mins.)	40*	10-45	-	30-45	-	45
Volume per tank:						
Grit Tank (m^3)	535	37.5-700	-	-	14<--	-
Pre-aeration Tank (m^3)	1390	-	-	-	-	-
Air Supply:						
Grit Tank (m^3/hr-m)	17*	9-27	16.7-27.9	16.6-44.6	--<58.7	-
Pre-aeration (m^3/hr-m)	32*	24.9 -99.6	-	22.3-45	-	6-22.3
Grit Quantities ($m^3/10^3m^3$)	0.0009 [1]	0.004-0.20 [2]	.0075-.075	.002-.09	-	.0075-.03
Transverse Velocity (m/s)	0.6	-	0.6-0.76	0.3	0.3	-

* Approximate values in the operating range
1. Average day grit removal
2. Includes scum quantities

The grit analysis varied as much with quantity of sewage flow and quantities of grit in the raw sewage as by the airflow setting. The lack of control over air flow was because of the inaccuracy of the butterfly valve as a control valve. Although the butterfly valve can regulate the air flow, a better control valve would be a ball valve.

A future testing program should keep the wastewater flow constant in one or two test tanks by a control weir or flume, while the other tanks fluctuate with the change in daily flows. Also a longer testing period would provide for better base data and better comparison data for the different seasonal sewage flows.

5.0 Pretreatment-Maintenance

Virtually all wastewater treatment plants and most sewage collection systems will expend more fiscal resources for operation, maintenance, and repair over the lifetime of a given facility than will be invested in initial capital costs (EPA. 1978). The pretreatment section of the NEWPCC is a high maintenance area because of the corrosive and abrasive environment. Usually three men, each putting in an eight hour day, are required daily to satisfy the pretreatment maintenance requirements (Russell. 1985). This labor cost is estimated to be approximately $340 per day in 1986 dollars. This is not uncommon as other treatment plants world-wide are also subject to heavy maintenance in the pretreatment portion of the plant (WPCF. 1980).

5.1 Grit Removal Maintenance

One of the greatest problems of pretreatment is coping with grit removal maintenance (EPA. 1978). This also holds true at the NEWPCC. Hydrogritters plug with screenings that get through the bar screens (paper, string, etc) or bypass the screens. Hydrogritters have proven to be less efficient than the newly installed chain-and-flight system compared with the hydrogritter (Cassiram. 1985). Also, the chain-and-flight system reduces the operational equipment that is subject to frequent breakdown.

Chain breakages have been a chronic problem with the drag conveyor. Drag conveyor chains break at a frequency of one per tank per year (Paterson, 1985). Notwithstanding cost, a major implication of a chain breaking is that the entire tank must be taken out of service for a period of at least two weeks until the repair is completed. The drag conveyor and the conveyor guides wear out because of grit abrasion. Metal debris that has by-passed the bar screens may jam between the drag conveyor and its guide, also causing the chain to break. Regular inspection of chain links and scraper blades is important at all times but it is especially important during runoff and storm periods because all tanks are required to treat peak flows.

Several operational modifications and procedures have been used to reduce pretreatment maintenance. One method that was devised to reduce the wear on drag conveyor chains was connecting sacrificial wear plates to the chains. The plates wear preferentially and thereby protect the chain links from abrasion wear. It is also important that lubrication is sprayed on the chains and other moving parts to reduce frictional wear (Scouten, et al. 1982). The NEWPCC maintenance staff lubricate the chains once every two weeks (Russell. 1985).

5.2 Bar Screen Maintenance

The mechanical bar screens require more maintenance to keep them operational than most other mechanisms in the treatment plant (Russell. 1985). Approximately one quarter of the time spent on pretreatment maintenance is on the mechanical bar screens (Russell. 1985). The cost of this is estimated to be $85 per day.

Each bar screen has rake return cables that need to be replaced approximately three times per year (Paterson. 1985). It is also necessary to unplug the bar racks several times a year. Other bar screen maintenance problems include drive coupling repairs, brake adjustments, and rake assembly adjustments. As was stated in Section 3, many of the maintenance problems are directly related to the mechanical bar screens.

5.3 Conveyor Maintenance

As was previously discussed in Section 3.3, the pretreatment conveyor system has some operational problems and requires continued maintenance to keep it operating.

The following is a list of the operational maintenance required for the conveyor system: repair or replace conveyor belts, replace worn belt rollers, repair belt drives, replace belt scrapers, adjust belts, replace belt connectors, and remove debris from the conveyor hopper.

A possible safety hazard results from disposal hoppers leaking, leaving puddles on the floor of the truck loading area. When designing the replacement conveyor system, one consideration is to design a one hopper system for both conveyors, which would enable the water to drain into the truck except for periods when the truck is hauling grit to the landfill. Additionally, the design phase should consider a watertight hopper.

5.4 Maintenance Procedure

A routine inspection and maintenance program is necessary to prevent equipment breakdowns that would permit objectionable solids to enter downstream treatment processes (WPCF. 1980). Some preventative maintenance is done for the NEWPCC pretreatment such as lubrication and inspections, but the majority of the work appears to be breakdown maintenance (Russell. 1985). The equipment proposed will reduce breakdown maintenance to allow more time for a preventative maintenance program.

There is a further problem of a turnover of operating staff which produces the necessity of continuous retraining of work crews. Many of the staff on these crews are Assistant Operators and they have additional duties other than maintenance (Russell. 1985). It is recommended that the Operations Division evaluate this situation.

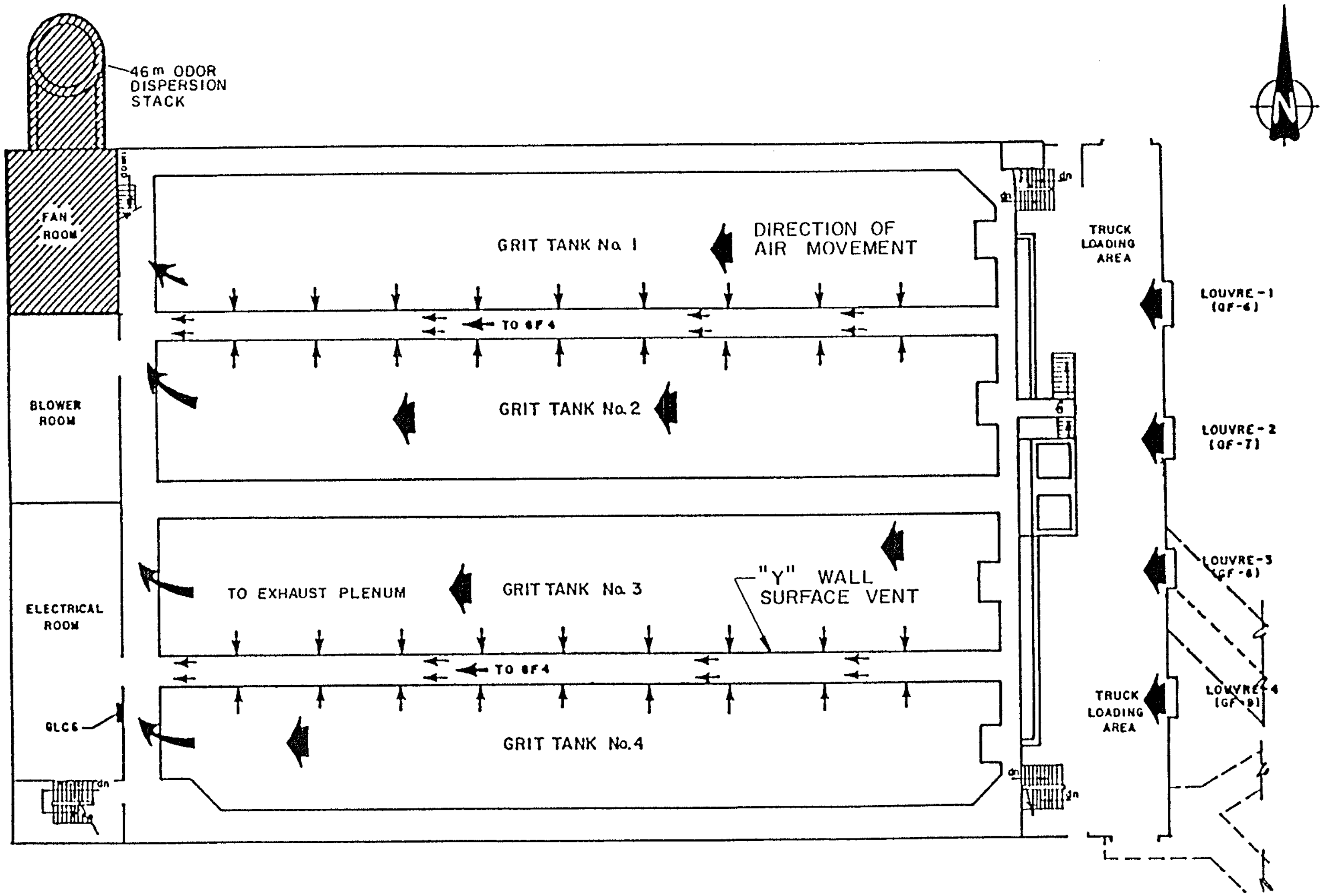
6.0 Ventilation

There are general heating, ventilation, and exhaust systems for the Grit Building that operate in conjunction with one another continuously. Exhaust fans provide positive air changes which vents the hydrogen sulfide gas (H_2S) up the 46 metre stack (see Figure 6.1) (Wardrop/MacLaren. 1985). The air exhausted from the stack is dispersed into the atmosphere and odorous gases are diluted to minimize odor nuisance.

Hydrogen sulfide is corrosive to metals, concrete, and machinery and is also toxic to humans. Therefore, the presence of H_2S in the grit building contributes to high maintenance needs relative to other areas in the plant. The Grit Building has a hydrogen sulfide analyzer and an alarm that activates when the H_2S concentration is 10 ppm or greater. The threshold value for an eight hour working period is 10 ppm (Workplace Safety and Health Division. 1978). When the alarm is activated, workers are instructed to leave the building as soon as possible. Therefore, the presence of high levels of H_2S restricts the amount of time that maintenance can be performed in the grit building.

There are four exhaust fans which work in conjunction with the opening of fresh air intake louvres along the east wall of the building. These louvres are opened to dilute H_2S and assist in ventilation. This is necessary when the H_2S alarm is activated, to clear the alarm before a maintenance crew can work in the building. These louvres cannot be left open in the winter because of the risk of freezing of flushing pipes or of the grit in the removal truck. An analysis of the H_2S in the grit building was performed. This was discussed in March, 1985 Wardrop/MacLaren report, "Odor Control at the North End Water Pollution Control Centre". From the analysis it was determined that the H_2S level is below 10 ppm for 88 percent of the time. The H_2S level peaks above 10 ppm between 1100 and 1500 hours and this peak can last from one to three hours. This is critical because these peaks occur in the middle of the working day, making maintenance unsafe during these periods without the use of cumbersome air packs. The hydrogen sulfide concentration during these peaks is usually around 20 ppm and may reach as high as 50 ppm (Wardrop/MacLaren. 1985). The hydrogen sulifide concentrations should not peak as high since August, 1985, when Dominion Tanners reduced sulphide levels in their plant effluent (Duchominsky. 1986).

The two overhead doors for the truck loading area, are often opened when a maintenance crew is working in the grit building to provide a greater supply of fresh air and more favourable working conditions. However, this practice reduces the effectiveness of the odor control stack, reduces ventilation efficiency in the building and contributes to odors in residential areas surrounding the NEWPCC.



NORTH END WATER POLLUTION CONTROL CENTRE

VENTILATION SYSTEM

Figure 6.1

Also discussed in the Wardrop/MacLaren (1985) report were methods of reducing the hydrogen sulfide concentration. One method is to cover the tanks and to exhaust the H_2S up the stack. Another method of reducing H_2S concentration is to add chlorine to the raw sewage in the surge well (Wardrop/MacLaren. 1985). Of these two methods, covering the tanks is preferred because it would reduce the risk of other contaminants in addition to H_2S from entering the grit building atmosphere. Some other contaminants are aerosols including solvents, and pathogenic bacteria and viruses (Sekla, et al. 1979).

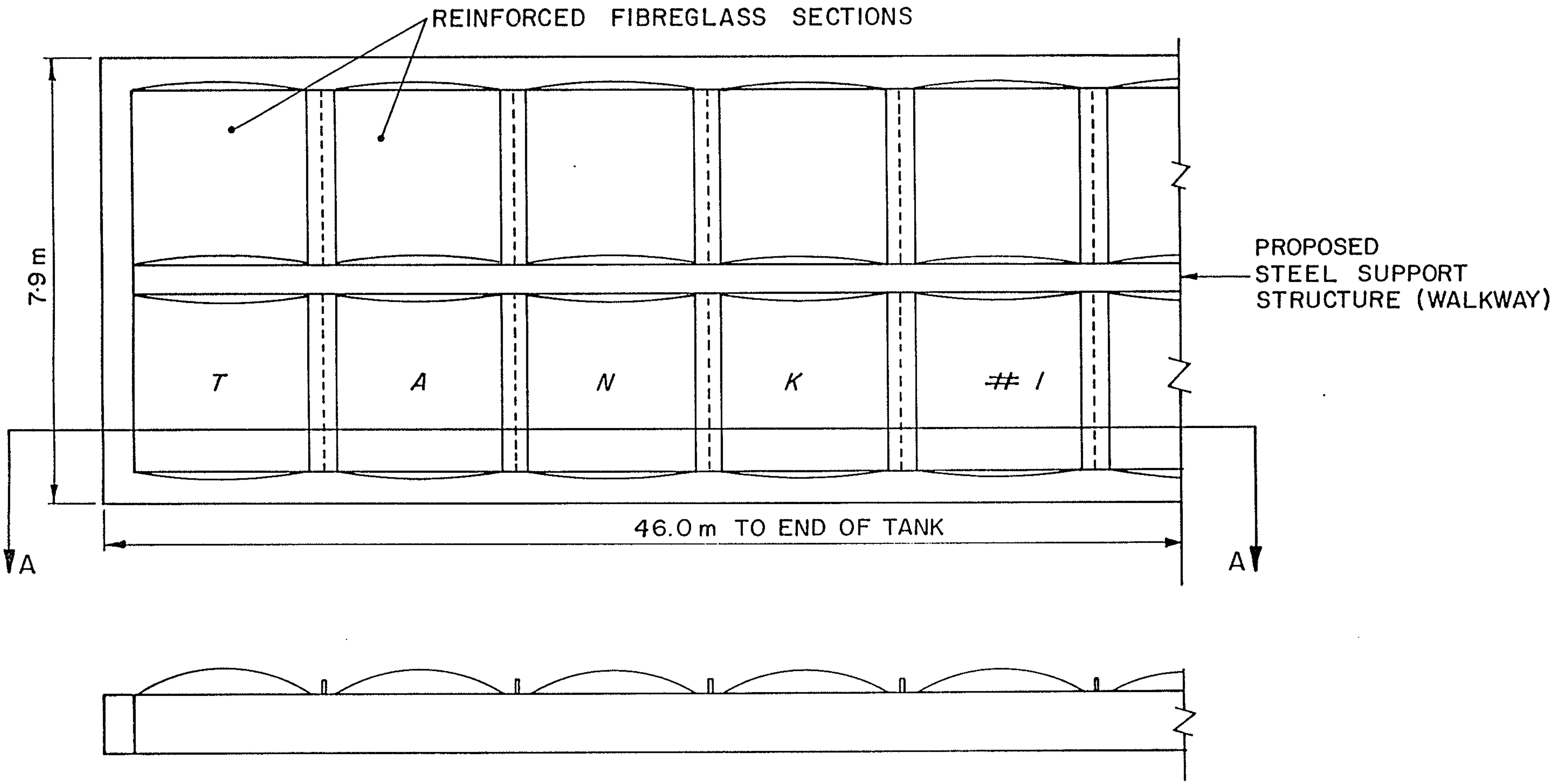
6.1 Tank Covers

The main purpose of installing tank covers is to contain and exhaust hazardous gases from the grit building. These gases are hazardous because they are toxic, corrosive to equipment and odorous to the surrounding area.

The present system draws gases into inlets in the Y-wall and from the Y-wall gases are forced up the 46m stack. When covering the tanks, the Y-wall exhaust system could be used to remove the gases trapped under the covers. The ventilation from the Y-wall system is adequate to remove the air supplied to the sewage by the aeration system. The airflow ventilation from the Y-wall is greater than the airflow supplied by the aeration system. Furthermore, it is likely that air change rates for the building can be reduced once the tanks are covered. This will reduce heating and ventilating costs.

Several options are available for cover material and design. Covers made of fibreglass reinforced resins are used most often because they resist H_2S corrosion (Rigdon. 1984). Another design consideration is that the covers are light weight so that they can be easily removed and reduce structural considerations. Disadvantages of the covers is the reduced ease of maintenance, therefore the covers should be removable so that the swing arm spargers can be raised for maintenance and so that regular maintenance in the tanks can be performed. This includes bar screen repair, drag conveyor repair and manual grit removal (clam shell bucket operation). A backup exhaust fan should be installed for the Y-wall air removal system to provide firm capacity.

A local structural fibreglass company produced a preliminary design for the NEWPCC grit tank covers (see Figure 6.2). The cost estimates of the design are shown in Section 7.0 and funds have been budgeted in 1987 for the works. Installation of the tank covers will be done as first priority in the upgrading of the pretreatment due to worker safety and comfort.



SECTION A-A

NOTE:
DIMENSIONS TO BE DETERMINED
DURING FINAL DESIGN

NORTH END WATER POLLUTION CONTROL CENTRE

TANK COVERS (PROPOSED)

Figure 6.2

7.0 Cost Estimates

The major assumptions made in preparing the cost estimates are:

- the operating costs will not change considerably. The energy and power used will be similar to present operating conditions.

- maintenance costs should stay approximately the same. Maintenance for repairing breakdowns should be decreased allowing more time for preventative maintenance.

- the cost estimates include burdens as follows: finance-6 percent, administration-1 percent, engineering-15 percent, and contingencies at 20 percent.

- all costs are in 1986 Canadian dollars.

Cost estimates include materials, installation, and freight.

Article	Cost Includes	Cost
Rack and Pinion Bar Screens	- four mechanical bar screens	$ 536,000.00
	- continuous conveyor system	$ 246,000.00
Tank Covers	- fibreglass covers and the supporting structure - backup exhaust fan	$ 455,000.00
Chain-and-Flight grit removal system	- conversion of two grit removal systems from the hydrogritter system	$ 37,000.00
*Major Renovations	- clam shell bucket and tracking replacement - aeration blower replacement - coil replacement heating and ventilation units - repair of structural exterior of building	$ 312,000.00
		$1,586,000.00

*These renovations are replacement and repair items.

8.0 Conclusions and Recommendations

8.1 Bar Screens

It is concluded that:

- the bar screens at the NEWPCC are not adequate to meet the required peak capacity of 827 ML/d.
- wastewater flows begin to bypass the bar screens at approximately 500 ML/d.
- the mechanical bar screens are a major maintenance burden relative to other plant equipment and the performance of the bar screens is inadequate for both current and future plant flows.
- debris that should be trapped on the bar screen passes through them.
- the present pretreatment conveyor system is a major maintenance burden relative to other equipment in the plant.
- the anticipated benefits of a separate bar screen building does not warrant its construction due to long range planning considerations.

It is recommended that:

- the mechanical bar screens at the NEWPCC be replaced with climber screens.

- the spacing between the screen bars be decreased from 19mm to 13 mm.

- a continuous path conveyor system replace the present multiple conveyor system.

- this proposed continuous path conveyor system be installed at the same time as the new proposed mechanical bar screens.

- the upgrading proposed for the screen system take place within the existing Grit Building.

8.2 Grit Removal System

It is concluded that:

- the present grit removal process is a maintenance burden relative to other processes at the NEWPCC.

- the recently installed (1984) chain-and-flight grit removal system requires less maintenance than the hydrogritter grit removal system.

- a screw conveyor (auger) grit removal system is not an appropriate replacement for the chain-and-flight system at the NEWPCC.

It is recommended that:

- the remaining two grit systems should be converted to the chain-and-flight system.

- the airflow valves GV80A and GV80B be used to regulate the aeration in the grit portion of the tanks.

- a testing program should be established by the Engineering Division in conjunction with Laboratory Services and Operations Divisions, to determine the airflow and air-roll velocity that would give optimum grit removal.

8.3 Pretreatment Maintenance

It is concluded that:

- maintenance for pretreatment is highly resource consumptive relative to other processes at the NEWPCC.

- drag conveyor chain breakages have been a chronic problem.

- the hydrogritter grit removal system requires more maintenance than the chain-and-flight system.

- the present mechanical bar screens and the pretreatment conveyor system require a high degree of maintenance.

- manpower is limited for a preventative maintenance program because of frequent breakdowns of machinery. Less maintenance intensive unit process equipment would free up manpower for preventative maintenance.

- a high turnover of manpower which requires continuous retraining of work crews, resulting in reduced maintenance effectiveness.

It is recommended that:

- the chain-and-flight system be installed in the remaining two grit tanks.

- climber screens be installed in place of all four existing bar screens to reduce maintenance requirements and improve screening capacity.

- a continuous conveyor system be installed to reduce maintenance requirements.

8.4 Ventilation

It is concluded that:

- hydrogen sulfide is a problem in the pretreatment area.

- the hydrogen sulfide level peaks in the afternoon, restricting staff from entering the building.

- contaminants in addition to hydrogen sulfide may include aerosols, solvents, pathogenic bacteria and viruses.

It is recommended that:

- both the grit and pre-aeration portions of the tanks should be covered to contain and exhaust hazardous gases from the pretreatment building.

- the tank covers be made of reinforced fibreglass or similar material so that they are resistant to H_2S and are light weight for easy removal.

- building ventilation rates be reviewed once the tanks are covered to optimize energy use in heating and blower requirements.

References

1. APHA; AWWA; WCF. Standard Methods for the Examination of Water and Wastewater. 15th Edition (1980).

2. Booy C. 1979. Applied Hydraulics. University of Manitoba.

3. Borowiec A.M., Chack J.J., Lopez A.R., Melbinger N.R. 1984. New York City's Experiences with Mechanically Cleaned Bar Screens. New York.

4. Brater E.F. and H.W. King. 1967. Handbook of Hydraulics. Toronto, New York.

5. Cassiram M. 1985. Personal Communication. Plants Superintendent. City of Winnipeg Waterworks, Waste and Disposal Department.

6. Crawford G. Jr. 1985. Personal Communication. Engineer, Gore and Storrie Ltd. Toronto.

7. Duchominsky, R. 1986. Personal Communication. Supervisor of Industrial Waste Control. City of Winnipeg Waterworks, Waste and Disposal Department.

8. EPA. 1978 Analysis of Operation and Maintenance Costs for Municipal Wastewater Treatment Systems. United States Environmental Protection Agency EPA/430/9-77-015.

9. EPA. 1985. Design Manual: Odor and Corrosion Control in Sanitary Sewage Systems and Treatment Plants. United States Environmental Protection Agency EPA/625/1-85/018.

10. EPA. 1979. Performance Evaluation and Troubleshooting at Municipal Wastewater Treatment Facilities. United States Environmental Protection Agency EPA/68-01-4418.

11. EPA. 1975. Process Design Manual for Suspended Solids Removal. EPA/625/1-0039, United States Environmental Protection Agency.

12. EPA. 1974. Process Design Manual for Upgrading Existing Wastewater Treatment Plants. United States Environmental Protection Agency.

13. Girling, R.M. and D.W. van Es. 1971-1981 Design Notes N.E.S.T.P. Screens (PWS-78).

14. GLUMRB. 1971. Recommended Standards for Sewage Works. Great Lakes-Upper Mississippi River Board of State Sanitary Engineers. Albany, N.Y.

15. GLUMRB. 1978. Recommended Standards for Sewage Works. Albany, N.Y.

16. Hammer, M.J. 1977. Water and Wastewater Technology, Toronto, New York.

17. Holst A.M. 1986. Personal Communication. Superintendent of Maintenance. City of Denver Metropolitan Denver Sewage Disposal. Denver, Colorado.

18. John Meunier Inc. 1983. Grit Chambers. Montreal.

19. Lansdowne, D.K. 1982. Lansdowne's Construction Cost Handbook. London, Toronto.

20. Lysyk, M.V. 1978. Written Communication. Chief Chemist. Province of Manitoba Department of Labour. Workplace Safety and Health Division. Industrial Hygiene Branch. File Number ST-3.1.

21. Main, J. 1985. Personal Communication. North End Water Pollution Control Centre Supervisor. City of Winnipeg Waterworks, Waste and Disposal Department.

22. Mann, R. 1986. Personal Communication. Senior Instrument Technician. City of Winnipeg, Waterworks, Waste and Disposal Department.

23. McCarthy P.L. and C.N. Sawyer. 1967. Chemistry For Sanitary Engineers. Toronto, New York.

24. McGhee T.J. and E.W. Steel. 1979. Water Supply and Sewage. Toronto, New York.

25. Means. 1980. Building Construction Cost Data 1980, Kingston, Mass.

26. Metcalfe and Eddy, Inc. 1979. Wastewater Engineering: Treatment Disposal Reuse. Toronto, New York.

27. New York State Department of Environmental Construction. 1978. Manual of Instruction For Wastewater Treatment Plant Operators (Vol. I and II). Albany, N.Y.

28. Osborne W.C. and C.G. Turner. 1964. Woods Practical Guide to Fan Engineering. Colchester, England.

29. Paterson G. 1985. Personal Communication. North End Water Pollution Control Centre Mechanic Leading Journeyman, City of Winnipeg Waterworks, Waste and Disposal Department.

30. Rex Chainbelt Inc. 1973. Rex Process Equipment. Milwaukee, Wisconsin.

31. Rigdon H.J. 1983. "Corrosion Above the Water Surface in Wastewater Facilities". Corrosion/83, April, 1983.

32. Russell W. 1985. Personal Communication. North End Water Pollution Control Centre, Supervisor, City of Winnipeg Waterworks, Waste and Disposal Department.

33. Scouten R.E. 1982. Written Communication, April 15. Scouten Mitchell Sigurdson Consulting Engineers. File Number ST-3.1.1.2.

34. Sekla L, et al. 1980. Sewage Treatment Plant Workers and Their Environment: A Health Study, Winnipeg. 1980.

35. Serpentix Conveyor Corporation. 1985. Continuous Path Conveying; Volume 15 - Number 4. Westminster, Colorado.

36. Topnik B. 1986. Written Communication. June 24. Research Engineer, Laboratory Services Division. City of Winnipeg Waterworks, Waste and Disposal Department. File Number ST-3.1.2.4.

37. Walker D. 1985. Personal Communication. Sales Representative Sullivan Strong Scott Ltd. Winnipeg.

38. Wardrop and Associates. Odor Control at the North End Water Pollution Control Centre. Winnipeg.

39. Wardrop/MacLaren. 1981. Functional Design Report North End Water Pollution Control Centre Secondary Treatment Expansion. Winnipeg.

40. Wardrop/MacLaren. 1985. Preaeration and Grit Removal Building Manual,(NEWPCC). Winnipeg.

41. WPCF. 1976. Operation of Wastewater Treatment Plants MOP/11. Water Pollution Control Federation.

42. WPCF. 1980. Preliminary Treatment for Wastewater Facilities, OM-2. Water Pollution Control Fed. Washington, D.C., 1980

43. WPCF. 1977. Wastewater Treatment Plant Design MOP/8. Water Pollution Control Federation. Lancaster, Pa.

APPENDIX A

HYDRAULIC TESTS

Appendix A - Hydraulic Tests

Purpose: To observe the hydraulic characteristics of the Grit Chamber. Special consideration should be given to;

a) at what plant flow bypassing occurs.
b) the depth of flow over the effluent weirs.
c) headloss across the bar screens.

Method:

- Have all the plant influent go through one tank.
- Start the test at 110 ML/d and increase at intervals of approximately 15 or 20 ML/d.
- The elevation of the water should be measured at each change in flow (with respect to the bar screens and weirs).
- The sewage level should be recorded when it bypasses the bar screens.
- The test should be performed on a normally operating screen
- Velocity of the air roll in the tanks should be measured.

TABLE A.1 HYDRAULIC TEST RESULTS

Results:

Flow (ML/d)	Water Level Measurements (mm) Headloss through Bar Screens	Depth of Flow over the Weir	Sewage Level from Bypasses	Velocity Air-Roll (m/s) 2. 3.
110 125[1]	38	51	76 under	A - 0.30 B - 0.70
130	51	76	51 under	A - 0.36 B - 0.86
150	76	89	32 under	A - 0.61 B - 1.14
170	89	96	level	A - 0.70 B - 1.52
185	102	107	25 over	A - 0.91 B - 1.83

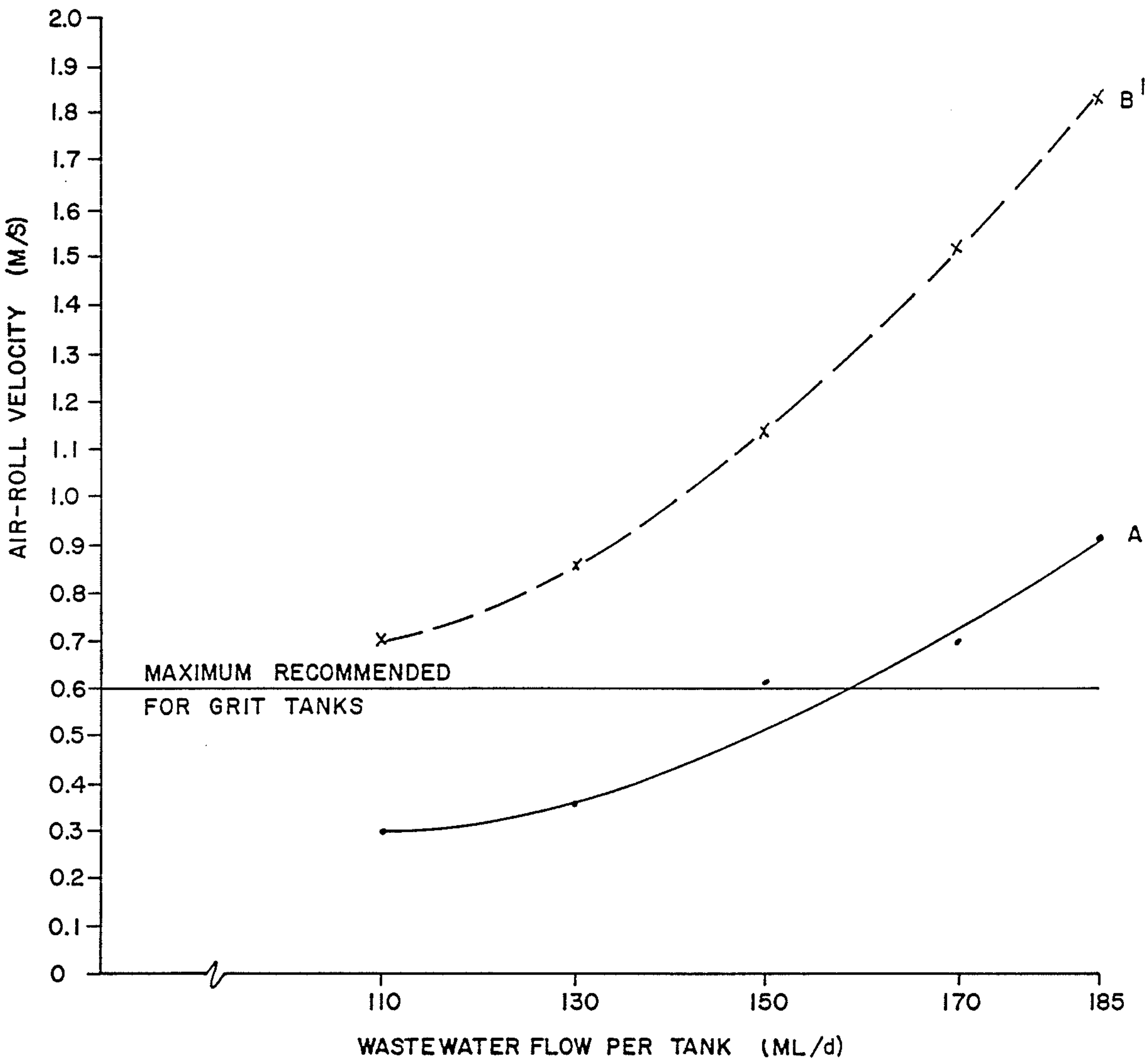
Notes:

A - across Grit tank
B - across Pre-Aeration Tank

1. Wave action produces bypassing.

2. Recommended maximum air roll velocity = 0.6 m/s for grit tanks (EPA guideline).

3. There is no established criterion for air roll velocity in pre-aeration tanks.



A – AIR-ROLL VELOCITY ACROSS GRIT TANK
B – AIR-ROLL VELOCITY ACROSS PRE-AERATION TANK
1 – NO ESTABLISHED STANDARDS FOR PRE-AERATION

NORTH END WATER POLLUTION CONTROL CENTRE

AIR-ROLL VELOCITY VS. WASTEWATER FLOW

Figure A-1

Conclusion: The following are concluded from the results:

- Flow begins to bypass the bar screens at approximately 125 ML/d (flow per tank).
- Air-roll velocity increases with the increase of sewage flow, as shown in Table A.1.
- Air-roll velocity across the grit section is less than the air-roll velocity across the pre-aeration section. The air-roll velocities are within the range of the standards. The air-roll velocity is discussed in more detail in Appendix B.
- The sewage level in the Grit Tank increases with sewage flow. This causes bypassing of the bar screens.
- Headloss through the bar screens increases with sewage flow. The headloss values recorded during this test are within the range of published standards.
- Depth of flow over the weir increases with sewage flow. The effect of the weir hydraulically is discussed in Appendix C.
- The bar screens at the NEWPCC are not adequate to meet the required peak capacity of 827 ML/d.

APPENDIX B

GRIT REMOVAL AND AIR OPTIMIZATION TESTS

APPENDIX B

GRIT REMOVAL AND AIR OPTIMIZATION TESTS

Appendix B - Grit Removal and Air Optimization Tests

Purpose: To determine the effect that air-roll velocity has on grit removal.

Method: 1. The Laboratory Services Division analyzed the raw sewage influent and effluent for percent total suspended solids (Standard Methods. 209 C. Page 96 and volatile suspended solids (Standard Methods. 209 D. Page 97). The lab also analyzed the grit removed for percent total solids (Standard Methods 209A. Page 93), percent Total Volatile Solids (Standard Methods 209D. Page 97), and particle size.

2. The butterfly valves GV-78A and GV-78B were adjusted to regulate the airflow in tanks 3 and 4, while keeping tanks 1 and 2 as control tanks with a constant airflow rate (See Figure 4.4). Airflow was determined by the readings on the differential pressure gauges and systems head curve.

3. The velocity of the air-roll in the tanks was determined by measuring the time a floating piece of styrofoam took to cross a grit tank.

TABLE B.1 - Grit Removal Test Results

DATA						TANK INFLUENT			TANK EFFLUENT		
Date	Sewage Flow(ML/d)	Surface Velocity (M/S)	Airflow Rate (m^3/hr Rate	%VS, Grit Samples	Grit Particle Size 0.297 mm	Total Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Fixed Solids (mg/l)	Total Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l	Fixed Susp. Solids (mg/l)
March 18/85	570	0.82	3100	21	16	567	167	400	583	180	403
19	405	0.76	2970	5	19	365	192	173	347	187	160
20	290	0.61	2970	26	24	283	185	98	332	223	109
21	415	0.58	2675	38	20	193	122	71	190	115	75
22	395	0.55	2335	46	18	402	197	205	412	212	200
June 11	310	0.91	3100	4.1	36	473	282	191	288	197	91
12	295	0.79	3225	1.3	32	313	218	95	350	237	113
13	295	0.73	2820	-	-	268	195	73	262	175	87
14	295	0.64	2675	9.4	29	345	237	108	328	217	111
20	320	0.58	2335	27	26	312	207	105	362	248	114
21	315	0.91	2970	19	25	-	-	-	-	-	-
25	375	0.88	2970	18	24	-	-	-	-	-	-
26	295	0.76	3100	8.7	29	533	297	236	425	298	127
27	260	0.70	2675	6.5	24	240	133	107	275	160	115
28	375	0.64	2460	4.1	15	225	150	75	202	132	70
July 9	295	0.79	2970	31	14	833	393	440	430	253	177
10	270	0.70	2970	26	13	540	260	280	980	580	400
11	265	0.64	2675	12	16	627	333	294	700	467	233
12	265	0.58	2335	31	14	460	233	227	960	573	387

data are for tank 4 *Fixed Suspended Solids = Total Suspended Solids - Volatile Suspended Solids

Results: Are shown in Table B.1

A) Higher percentage volatile suspended solids in the raw sewage corresponds with less grit and more organic material.

B) The analysis of the grit shows that the higher the percent total volatile solids, the lower the percentage of grit.

C) The particle size analysis of the grit showed that, the smaller the "% smaller than .297 mm" the better. This is because material smaller than .297 mm are not considered to be grit (grit has particle sizes 0.2 mm and larger).

Conclusion:

1. The data analysis did not reveal any trends with regard to which airflow setting or air-roll velocity results in optimum grit removal. The lack of control over wastewater flow and airflow rate produced anomalies in the test results.

2. Two of the four weeks were not "normal" operating conditions. The first week was during spring runoff, producing high flows and large quantities of grit. The last week, one of the digesters was draining to the grit tanks. This increased the amount of organic material in the sewage above normal levels.

3. On several testing days the Lab Technician could not enter the Grit Building because of the high H_2S levels. This created "holes" in the data.

4. A future testing program should be established by the Engineering Division in conjunction with the Laboratory Services and Operations Divisions. Established for the testing program should be a definition of grit removal efficiency relevant to the wastewater plant operations in the City of Winnipeg (Topnik. 1986).

APPENDIX C

HYDRAULIC BACKWATER EFFECTS

Appendix C - Hydraulic Backwater Effects

It is important to know if the overflow weir in the Grit Tank has a backwater effect on the operation of the bar screens. Because the overflow weirs may raise water levels sufficiently to cause bypass at the bar screens, it is essential to understand the backwater effects in the pretreatment tanks.

i) Height of flow over the weir

Weir Formula - $Q = CLH^{3/2}$
(Booy. 1979)

C = weir coefficient
L = length of weir (ft)*
H = height of flow over weir (ft)

Note: If the length of the weir (L) is increased then the head above the weir (H) is decreased, for a constant discharge (Q). Finger weirs are therefore preferred over a shorter weir straight across the tank because they offer a greater weir length.

Weir Coefficients (C): Broad-crested Weir Coefficient = 3.09
sharp-crested, Weir Coefficient = 3.33
(Booy. 1979)

Because the overflow weir is partly broad-crested and partly sharp-crested, it is necessary to interpolate to create one coefficient. This can be done by weighting the respective coefficients using the lengths of each weir type.

*Reference uses Imperial units therefore for simplicity, Imperial units were used in the calculations.

length of sharp-crested weir = 51.32 ft.
length of broad-crested weir = 15.33 ft.
total weir length = 66.65 ft.

sharp-crested weighted coefficient = $\frac{51.32}{66.65} \times 3.33 = 2.56$

broad-crested weighted coefficient = $\frac{15.33}{66.65} \times 3.09 = 0.71$

total weighted coefficient = 2.56 +0.71
= 3.27

Weighted Formula: = $Q = 3.27H^{3/2}L$

Q = worst case = maximum discharge
= 827 ML/d/4 tanks = 206.75 ML/d per tank
= 84.5 cfs.
L = 66.65 ft.

$$Q = 3.27\, H^{3/2}L$$

$$84.5 = 3.27\, (H^{3/2})\, 66.65$$

$$.388 = H^{3/2}$$

$$(.388)^{2/3} = H$$

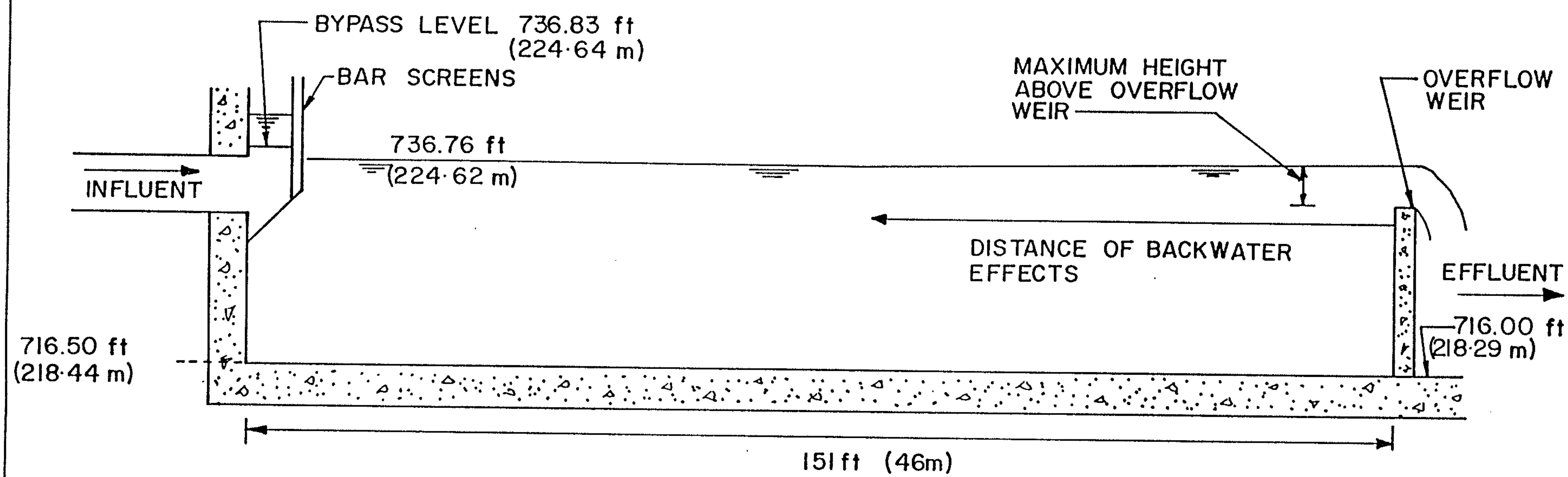
$$H = 0.53 \text{ ft.}$$

ii) Distance of backwater effect (Booy. 1979. and NEP-46 drawing)

Y	=	vertical depth of the wastewater flow (ft.)
	=	tank depth plus backwater effect height, average tank depth = 15 ft.
A	=	cross-sectional area of the tank
	=	y x 30 ($ft.^2$), width of tank = 30 ft.
P	=	wetted perimeter (ft.)
	=	2y + 30
R	=	hydraulic radius (ft.), A/P
C	=	resistance coefficient
	=	$1.486/n \ R^{1/6}$ n = .012 = Mannings coefficient
C^2	=	$15417R^{1/3}$ ($ft./sec.^2$)
V	=	velocity (ft./sec.)
	=	Q/A, Q max. = 84.5 cfs (per tank)
$V^2/2g$	=	velocity head (ft.)
E	=	specific energy head (ft.)
	=	$y + V^2/2g$
S_{fave}	=	friction slope
	=	v^2/C^2R
S^o	=	slope of the tank
	=	.003597
$\triangle X$	=	$\triangle E/So-S_{fave}$.(ft.)
X	=	Distance of backwater effects.
X	=	$\Sigma \triangle X$ (ft.)

Y	A	P	R	C^2	V	$V^2/2g$	E	S_f	$S_{fave.}$	$S_o-S_{fave.}$	$\triangle E$	$\triangle X$	X
15.53	465.9	61.06	7.63	30351	0.181	$5.1x10^{-4}$	15.53	$1.41x10^{-7}$					0
									$1.45x10^{7}$	$3x6x10^{-3}$	0.33	91.67	
15.20	456	60.4	7.55	30245	0.185	$5.3x10^{-4}$	15.20	$1.5x10^{-7}$					91.67
									$1.17x10^{-7}$	$3.6 \ x10^{-3}$	0.20	55.56	
15.0	450	60	7.5	30178	0.188	$5.4x10^{-41}$	15.0	$1.56x10^{-7}$					

Total - 147.23 ft.



NORTH END WATER POLLUTION CONTROL CENTRE

BACKWATER EFFECTS OF OVERFLOW WEIR

Figure C-1

Conclusion: The backwater effect distance is 147 feet from the weir. The length of the tank is 151 feet, therefore there will be no backwater effect on the bar screens even under maximum flow conditions.