City of Winnipeg
Water and Waste Department

Combined Sewer Overflow Management Study

PHASE 3 Technical Memoranda

Appendix No. 4

NEWPCC IMPACTS

April 1999
0510-A-38

Internal Document by:

WARDROP Engineering Inc. and TetrES CONSULTANTS INC.

In Association With:

Gore & Storrie Limited and EMA Services Inc.

1. INTRODUCTION

Appendix No. 4, "NEWPCC Impacts" comprises the attached report entitled "City of Winnipeg, Report for the Combined Sewer Overflow Control Study – Impacts on the North End WPPCC", prepared for Wardrop/Tetr*ES* by CG&S and dated March 1998.

The purpose of this study, leading to the report, was to determine the impacts of three storage dewatering flow options (600, 830 and 1060 ML/d) on the NEWPCC facilities and operations and to develop, in concept, modifications to the plant which would mitigate such impacts. These issues were discussed in Sections 4.3, 4.3.1 and 4.3.2 of the Phase 3, T.M. No. 1.

City of Winnipeg
Report for the
Combined Sewer Overflow Control Study
Impacts on the North End WPCC

Prepared for:
Wardrop Engineering Inc.
TetrES Consultants Inc.

Prepared by:
CH2M Gore & Storrie Limited

CG&S
CH2M Gore & Storrie Limited

March, 1998

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Acknowledgements

The significant effort and contribution over the course of the study by North End WPCC supervisory, operation and laboratory staff is gratefully acknowledged.

The contribution of staff from Wardrop Engineering Inc. and TetrES Consultants Inc. is recognized.

1. Addendum

An erratic conversion of 2300 kg/d to 230000 g/d (should read 2300000 g/d) on Page APP4-5 generates errors in the following areas:

Page ES1-4,	Line 19:	For $25,957,000	read $26,003,000
Page ES1-4,	Line 21:	For $41,399,000	read $41,491,000
Page ES1-5,	Line 3:	For $25,957,000	read $26,003,000
Page ES1-5,	Line 4:	For $41,399,000	read $41,491,000
Page 4-5,	Line 8 up:	For 4.00	read 4.20
Table 4.4, Alternative 5, row 9:		For 920,000	read 966,000
Table 4.4, Alternative 5, row 12:		For 25,957,000	read 26,003,000
Table 4.4, Alternative 6, row 9:		For 1,840,000	read 1,932,000
Table 4.4, Alternative 6, row 12:		For 41,399,000	read 41,491,000
Page 5-1,	Line 19:	For $25,957,000	read $26,003,000
Page 5-1	Line 20:	For $41,399,000	read $41,491,000
Page APP4-5	Line 9:	For 230000	read 2300000
Page APP4-5	Line 9:	For 1,916.7 L/d	read 19,167 L/d
Page APP4-5	Line 10:	For 9.8	read 0.98
Page APP4-5	Line 11:	For A FRP tank of 27,000 L	
		read Three FRP tanks of 27,000 L each	
Page APP4-5	Line 11:	For $18,000	read $54,000
Page APP4-5	Line 17:	For $75,000	read $111,000
Page APP4-6	Line 13:	For 75,000	read 111,000
Page APP4-6	Line 16:	For 743,900	read 779,900
Page APP4-6	Line 17:	For 1,400	read 1,458
Page APP4-6	Line 18:	For 1,200	read 1,256

Page APP4-6	Line 19	For 57,280	read 60,052
Page APP4-6	Line 20:	For 26,780	read 28,076
Page APP4-6	Line 21:	For 830,560	read 870,742
Page APP4-6	Line 22:	For 91,360	read 95,781
Page APP4-6	Line 23:	For 921,910	read 966,523
Page APP4-7	Line 1:	For 921,910	read 966,523
Page APP4-7	Line 1:	For 4.00	read 4.20.

1. Executive Summary

1.1 BACKGROUND

This study was to assess the impacts of combined sewer overflow (CSO) on the NEWPCC. The CSO mixes with the sanitary wastewater, plant recycle flows, hauled wastes and leachate and is treated at the plant. The combined wastewater is termed wet weather combined sewage (WWCS) flow in this report.

The specific objectives for the study are to assess the impacts of three collected WWCS flow rate options, 600 ML/d, 830 ML/d and 1060 /d, on the NEWPCC and upgrade requirements including sludge digestion; identify necessary upgrade requirements of the plant for minimum treatment of the flows exceeding the secondary treatment capacity; and develop conceptual costs for the plant upgrades. A study was also conducted to determine the plant upgrade requirements for treatment of the WWCS flow of 600 ML/d to meet the nitrified effluent criteria of 25 mg/L BOD_5, 30 mg/L SS, and 5 mg/L NH_3-N.

The design of the existing plant was reviewed. According to the Functional Design Report, the most recent upgrade of the plant was designed to serve the anticipate flows and loads to the year 1994. The treatment processes include preliminary treatment, primary treatment and secondary treatment using oxygen activated sludge system and anaerobic sludge digestion. Digested sludge is dewatered by centrifuges. The installed capacity of raw wastewater pumps, screens and aerated grit tanks is sufficient to handle the study flow rates. Upgrading of these facilities was not considered in this study.

The existing primary clarifiers were reported to have a hydraulic capacity of 830 ML/d. At this hydraulic load, the surface overflow rate is 127.6 m^3/m^2.d. This rate appears too high for the primary facility to be operated for co-thickening of waste activated sludge, because the waste activated sludge solids are lighter and are unable to settle out under such high surface overflow rate. With waste activated sludge co-thickening in the primary clarifiers, the surface overflow rate of 60 m^3/m^2.d is normally used. The overflow rate is also too high for chemically enhanced treatment in the primary clarifiers. For this study a surface overflow rate of 40 m^3/m^2.d with ferric or alum was used for the chemically enhanced primary treatment process.

The secondary treatment facility was designed for an effluent quality of 25 mg/L BOD_5 and 30 mg/L TSS at a maximum flow of 589 ML/d. It is noted that under the maximum flow condition although the projected primary effluent BOD_5 was 260 mg/L, the secondary treatment facility was designed for a maximum BOD_5 load of 89,600 kg/d, corresponding to a BOD_5 concentration of only 152 mg/L.

The performance of primary and secondary treatment facilities work together to produce good quality of plant effluent. If the secondary treatment facility is capable of handling low quality of primary effluent, the entire treatment system is still able to produce good quality effluent. The existing secondary treatment facility was designed for a primary effluent BOD_5

of 150 mg/L and TSS of 285 mg/L and a maximum flow of 598 ML/d. It appears that the low quality primary effluent for a short duration was considered in the design.

In 1996, the plant received an annual average flow of 259.5 ML/d, representing 78% of the plant design flow. The average BOD_5 load to the secondary treatment facility was 53,016 kg/d, representing 88.6% of the maximum design BOD_5 load. However, monthly average BOD_5 concentrations in the secondary effluent were consistently greater than 50 mg/L. Investigation of the cause of such high effluent BOD_5 is out of the scope of this study.

1.2 Basic Criteria

Basic criteria used for determination of plant upgrade requirements and associated costs include flows, WWCS quality and effluent requirements. The estimated WWCS quality established for the study is shown below:

Proposed WWCS Quality

WWCS Parameters	Concentration
BOD	212 mg/L
COD	530 mg/L
TSS	250 mg/L
NH_3/NH_4	18 mg/L
TKN	27 mg/L
Total P	3.5 mg/L
Alkalinity	150 mg/L
pH	7.2

The plant effluent requirements for treatment of the WWCS three flow options have been identified as follows:

Secondary Treatment Requirement

Parameters	BOD_5 Removal	Nitrification
TSS	≤ 30 mg/L	≤ 30 mg/L
BOD_5	≤ 25 mg/L	≤ 25 mg/L
NH_3-N	-	≤ 5 mg/L

WWCS flows exceeding the secondary treatment system capacity will receive a minimum of

- Primary treatment or equivalent,

- Solids and floatable disposal; and
- Disinfection of effluent

The effluent guidelines for normal primary treatment are assumed to be 30% BOD_5 removal and 50% TSS removal.

The need for phosphorus removal was not included in the plant assessment. Effluent phosphorus removal is not currently a discharge requirement and is also not expected to be a future requirement.

1.3 Impact of WWCS Flows

The impacts of WWCS flows of 600 ML/d and 830 ML/d on the NEWPCC were assessed using the basic criteria described above. Under these two flow conditions the secondary treatment system is overloaded and the effluent quality will be detrimentally affected. It is certain that the plant cannot handle the WWCS flow of 1060 ML/d without upgrading, because this flow rate is higher than the design flows for both primary and secondary treatment facilities.

1.4 Treatment Alternatives

Alternatives for the plant upgrades that were identified and investigated include the following:

WWCS Flow of 600 ML/d

Alternative 1 - Expansion of Final Clarifiers,

Alternative 2 - Chemically Enhanced Primary Treatment for Entire Flow,

Alternative 3 - Expansion of Primary Clarifiers,

Alternative 4 - Expansion of Secondary Treatment to Produce a Nitrified Effluent,

WWCS Flow of 830 ML/d

Alternative 5 - Expansion of Primary Clarifiers for Treatment of 830 ML/d,

WWCS Flow of 1060 ML/d

Alternative 6 - Expansion of Primary Clarifiers for Treatment of 1060 ML/d.

1.5 Capital Costs

Conceptual capital costs for the plant upgrades were estimated with reference to the most recent contracts completed by CH2M Gore & Storrie Limited. To facilitate cost calculations for this study, unit costs for various unit processes were first established using the construction contract price for the unit processes. The unit costs were then brought up to January 1998 costs using ENR Construction Cost Index and included an allowance of 11% for engineering and construction supervision but excluded land costs, taxes, and piling foundation costs if required. The estimated capital cost for the plant upgrade in each alternative is shown in the following table. Estimated effluent quality for meeting the effluent criteria for each alternative is also shown.

No	Alternative No	Est. Capital Costs	Meeting Effluent Criteria
	600 ML/d		
1.	Alternative 1	$10,427,000	Yes
2.	Alternative 2	$27,856,000	Yes
3.	Alternative 3	$12,483,000	Yes
4.	Alternative 4	$28,810,000	Yes
	830 ML/d		
5.	Alternative 5	$25,957,000	Yes
	1060 ML/d		
6.	Alternative 6	$41,399,000	Yes

1.6 Conclusions

To treat the WWCS flows for meeting the effluent criteria the plant requires upgrading including sludge digestion. The recommended alternatives for plant upgrades are listed as follows:

For treatment of the WWCS flow of 600 ML/d, Alternative 1 - Expansion of Final Clarifiers is the lowest cost alternative and therefore recommended. Expansion of the final clarifiers is required to handle the high mixed liquor solids load from the reactors. Increase of sludge load requires an expansion of the sludge digestion facility. Total estimated capital cost is $10,427,000.

From the result of treatment alternative evaluation for the 600ML/d flow it is understood that expansion of the existing primary treatment facility is the only cost-effective alternative for treatment of the WWCS flow of 830 ML/d and 1060 ML/d. Flow exceeding the existing secondary treatment capacity will be chlorinated and dechlorinated prior to discharge.

Increase of sludge load due to treatment of the WWCS flows requires an expansion of the sludge digestion facility. Expansion of the existing sludge dewatering facility is not required.

Total estimated capital cost for treatment of 830 ML/d is $25,957,000,

Total estimated capital cost for treatment of 1060 ML/d is $41,399,000.

To treat the WWCS flow of 600 ML/d for meeting the nitrified effluent criteria of 25 mg/L BOD_5, 30 mg/L TSS and 5 mg/L NH_3-N, the plant requires an expansion of the secondary treatment and sludge digestion facilities. Total estimated capital cost is $28,810,000.

Based on the accuracy of the cost estimate and the small difference in flows between the current design and the WWCS flow of 600 ML/d, the estimated cost of $28,810,000 can be applied for upgrade of the existing facility to achieve nitrification.

1.7 Recommendation

In 1996 the plant received an average wastewater flow and an average BOD_5 load to the secondary treatment facility of 78% and 88.6% of the design respectively. However, the secondary effluent BOD_5 concentrations were consistently over 50 mg/L, greater than the design of 25 mg/L. It is recommended that a plant audit be carried out to investigate the cause of not meeting the design effluent quality.

SECTION 1

INTRODUCTION

Section 1 - Introduction

1.1 Background

The City of Winnipeg has investigated alternatives for control and treatment of combined sewer overflow (CSO). As a result of the studies to date, it appears that the probable long-term solution to the reduction of CSO impacts on the City's rivers, will be in the form of in-line storage, either alone or in combination with other storage alternatives. The collected CSO will be treated at the North End Water Pollution Control Centre (NEWPCC) before discharge. This will reduce the CSO impacts throughout the City, since about 90% of the combined sewer districts in the City are in the service area of the NEWPCC. The discharge of the collected CSO will however, have significant impacts on the plant.

Three flow options for treatment of the collected CSO at the NEWPCC have been identified:

- 600 ML/d; it represents the design hydraulic capacity of the secondary facility of the NEWPCC. The entire flow would be given secondary treatment. The plant effluent would be the least detrimental to the river,

- 830 ML/d; it represents the design hydraulic capacity of the primary facility of the plant. A portion of the flow exceeding the hydraulic capacity of the secondary treatment facility would receive primary treatment only. It would have the least impact on the operation and configuration of the plant,

- 1060 ML/d; it represents current installed hydraulic capacity of the raw wastewater pumping and headworks. An additional facility would be required for treatment of flow exceeding the current hydraulic capacity of the primary treatment facility. It would have the greatest impact on the configuration of the plant.

Once storage of CSO is in place, the entire plant will operate at peak hydraulic load for longer periods of time than under present conditions. The extended periods of peak hydraulic loads will affect the operation and performance of the plant. Increased sludge quantity due to treatment of CSO will also affect the digester operation. Because of the reserve capacity available in the existing facility, the changes would not likely affect the sludge dewatering facility.

Currently the raw wastewater flow to the NEWPCC includes municipal wastewater, recycle of centrate, hauled wastes of septic tanks and leachate. During runoff periods, the plant continues to receive this raw wastewater flow plus stormwater collected in the combined sewer area. The combined flow to the plant is in effect, a wet weather combined sewage (WWCS) flow. For the purpose of this study a term of WWCS flow instead of CSO is used.

1.2 Study Objectives

The objectives of this study are to assess the impacts of the three WWCS flow rate options, 600 ML/d, 830 ML/d, and 1060 ML/d, on the NEWPCC including sludge digestion facility; identify necessary upgrade requirements of the plant for each option; and develop conceptual costs for the upgrades. Specific objectives include:

- Impact of WWCS flow of 600 ML/d on the current plant and upgrade requirements to meet secondary effluent criteria,
- Upgrade requirements of the plant for treatment of WWCS flow of 600 ML/d to meet nitrified effluent criteria,
- Impact of WWCS flow of 600 ML/d on the existing sludge digestion and sludge dewatering facilities and upgrade requirements,
- Primary treatment and disinfection of WWCS flows exceeding the secondary treatment capacity,
- Chemically enhanced primary treatment and disinfection of WWCS flows exceeding the secondary treatment capacity,
- Impact of WWCS flows of 830 ML/d and 1060 ML/d on the existing sludge digestion and sludge dewatering facilities and upgrade requirements,
- Development of conceptual costs for the plant upgrades.

Impacts of the WWCS flows and the plant effluent on the receiving water are out of the scope of this study.

1.3 Study Methodology

The study was performed in a logical and systematic manner. The key tasks completed are outlined below.

1. Existing sources of information and plant design reports were reviewed to develop an understanding of various unit processes of the plant. A plant tour with a review of plant operating records was performed to become familiar with current plant operation and to establish WWCS characteristics for the study. The information reviewed included:

- Technical Memoranda completed to date for the CSO study,
- Functional Design Reports for the secondary treatment, sludge treatment and sludge dewatering facilities,
- 1996 plant operating data,
- Experience of plant staff,
- Appropriate technical papers, reports, and other plant operational information with respect to treatment of CSO.

2. Appropriate process configurations were developed for treatment of WWCS flows to meet the effluent criteria.
3. Conceptual costs for the plant upgrade requirements were estimated.
4. Conclusions and recommendations were made based on the findings in the study.

SECTION 2

PLANT DESIGN AND PLANT OPERATION

Section 2 - Plant Design and Plant Operation

2.1 Plant Design

The North End Water Pollution Control Centre (NEWPCC) was initially constructed in 1937. Over the years the plant has been upgraded from primary treatment to secondary treatment. The most recent upgrade of the plant was completed in 1989. According to the Functional Design Report, the most recent upgrade was designed to serve the anticipate flows and loads to the year 1994. The treatment processes of the plant include preliminary treatment, primary treatment and secondary treatment using oxygen activated sludge system and anaerobic sludge digestion. Digested sludge is dewatered by centrifuges. Design conditions of the unit processes are provided below.

2.1.1 Raw Wastewater Pumping

Table 2.1 provides a summary of the raw wastewater pump control and capacities.

Table 2.1 - Raw Wastewater Pumps

No. of Units	Speed	MLD
2	Variable	77 - 180
2	Constant	180
1	Constant	107
1	2 - Speed	140/180
Total Installed Capacity		1007
Total Firm Capacity		827

The pumps have a nominally increased capacity at high surge well water levels. The pump cycling and speed variations are computer controlled to maintain a particular set point elevation in the surge well. The set point is adjustable and is normally set low during the wet-weather season to permit maximum storage within the surge well and interceptor sewers.

The raw wastewater pumps discharge to a chamber from which wastewater flows by gravity through the plant. A control gate for by-passing of the treatment system is installed at the chamber.

2.1.2 Screens and Aerated Grit Tanks

There are four bar screens and four parallel aerated grit tanks. The screens are installed in front of the aerated grit tanks. Each aerated grit tank is 46 m x 9.1 m x 4.6 m average depth. Each set of screen and grit tank has a hydraulic capacity of 280 ML/d. The system has a firm capacity of 840 ML/d and an installed capacity of 1120 ML/d.

2.1.3 Primary Clarifiers

There are five primary clarifiers, three circular and two rectangular. The following table lists the sizes of the clarifiers:

Table 2.2 - Primary Clarifiers

Tank No.	Dimension	Area, m^2
1	35 m $\Phi \times$ 3.6 m	962.1
2	35 m $\Phi \times$ 3.6 m	962.1
3	44 m $\Phi \times$ 3.6 m	1,520.5
4	66.5m×23m×3.6 m	1,529.5
5	66.5m×23m×3.6 m	1,529.5
Total		6,503.7

It is reported that these primary clarifiers have a hydraulic capacity of 830 ML/d. At this hydraulic load, the surface overflow rate will be 127.6 m^3/m^2.d. This surface overflow rate appears too high for the primary clarifiers to be operated for co-thickening of waste activated sludge, because the waste activated sludge solids are lighter and are unable to settle out under such high surface overflow rate. With waste activated sludge co-thickening in the primary clarifier, the surface overflow rate of 60 m^3/m^2.d is normally used.

A facility for secondary by-passing is provided at the primary effluent channel. This by-pass operates during wet weather periods when flow exceeds the secondary treatment capacity.

2.1.4 Secondary Treatment Facility

The secondary treatment facility is an oxygen activated sludge treatment system consisting of oxygenation reactors and final clarifiers. The following are the design conditions of the secondary treatment facility:

Table 2.3 - Design Conditions of Secondary Treatment Facility

Parameter	Annual Average	Max. Condition
Flow, ML/d	332	598
P. eff. BOD_5, mg/L	180	260
BOD_5 loading, kg/d	59,800	89,600 (peak 5 day @ 150 mg/L)
P.eff TSS, mg/L	170	285
Max. temperature °C	22	22
Min. temperature °C	11	11
Eff. BOD_5, mg/L	13.4	25 (peak month)
Eff. TSS, mg/L	13.1	30 (peak month)

It is noted that under maximum flow condition of 589 ML/d although the projected primary effluent BOD_5 was 260 mg/L, the secondary treatment facility was designed for a maximum BOD_5 load of 89,600 kg/d, equivalent to a primary effluent BOD_5 concentration of only 150 mg/L. The facility was also designed for an effluent BOD_5 of 25 mg/L and TSS of 30 mg/L at the maximum flow conditions. The same effluent quality is proposed for this assessment.

The performances of primary and secondary treatment facilities work together to produce good quality of plant effluent. If the secondary treatment facility is capable of handling low quality of primary effluent, the entire treatment system is still able to produce good quality effluent. The existing secondary treatment facility was designed for a primary effluent BOD_5 of 150 mg/L and TSS of 285 mg/L and maximum flow of 598 ML/d. It appears that the low quality primary effluent for a short duration was considered in the design.

Oxygen Activated Sludge Reactors

The activated sludge process at this plant includes three oxygenation reactors and 26 final clarifiers. Each reactor is covered and consists of two 4 -stage trains of tanks. Each stage is equipped with a surface mixer for oxygen dissolution. The installed power of the mixers is approximately 37.5 kw in the first stage and 26 kw in each of the subsequent stages. The design conditions of the oxygenation reactors are shown in Table 2.4.

Table 2.4 - Design Conditions of Oxygenation Reactors

Design flow (AAF), ML/d	332
Peak flow, ML/d	589
Number of tanks	6
Size of tanks, m	17.1 x 68.3
Liquid depth, m	4.3
Number of stages per tank	4
Freeboard (gas space), m	1.2
Total tank volume, m^3	30,132.6
Retention:	
at AAF, hrs	2.16
at peak 30-consecutive day flow, hrs	1.4
at peak 5-consecutive day flow, hrs	1.22
F/Mv:	
at AAF	0.71
at 30-day peak load	0.95
at 5-day peak load	1.06
Volumetric loading rate, kg $BOD_5/1000m^3$/day:	
at AAF	1985
at 30-day peak load	2680
at 5-day peak load	2970
MLVSS, mg/L	2800
MLSS, mg/L	4000

Final Clarifiers

There are 26 final clarifiers, 16 rectangular and 10 square. The square clarifiers are the original final settling tanks at the plant. The rectangular clarifiers were retrofitted from the original aeration tanks during the last plant expansion. The dimensions and surface areas of the clarifiers are shown in Table 2.5.

Table 2.5 - Final Clarifiers

Tank No.	No. of Units	Each Tank Dimension	Area of Group
1 to 10	10	20 m square	4,000.0 m^2
11 to 18	8	70.5 m × 9.1 m × 3.65 m	5,132.4 m^2
19 to 26	8	70.5 m × 9.1 m × 3.65 m	5,132.4 m^2
Total			14,264.8 m^2

Under normal operation mixed liquor from Oxygenation Reactor No.1 discharges to the square final clarifiers No.1 to 10. Reactor No. 2 discharges to the retrofitted final clarifiers No. 11 to 18. Reactor No. 3 discharges to the retrofitted final clarifiers No. 19 to 26.

If wastewater flow can be uniformly distributed to the final clarifiers according to their surface area, the surface overflow rate of the final clarifers under design conditions is as follows:

	Overflow Rate, $m^3/m^2.d$
Design Flow, 332 ML/d	23.3
Peak Flow, 598 ML/d	41.9

If any one retrofitted secondary clarifier needs to be drained for service, it will be necessary to drain four clarifers at once, because the dividing walls of the original aeration tanks (before retrofit) were not designed for unbalanced hydraulic pressure. If four retrofitted clarifiers are out of service, mixed liquor flow can be uniformly distributed to the remaining clarifiers, resulting in a surface overflow rate as follows:

	Overflow Rate, $m^3/m^2.d$
Design Flow, 332 ML/d	28.4
Peak Flow, 598 ML/d	51.1

2.1.5 Sludge Digestion

There are 6 sludge digesters. Each has a diameter of 33.5 m and a liquid depth of approximately 8.5 m. Total volume of the digesters is 44,800 m^3.

2.1.6 Sludge Holding Tanks

There are 8 sludge holding tanks with a total volume of 21,400 m^3 shown on the drawings and in the Plant Tour Booklet. Tank No. 2, 3, and 4 are original digesters and are at present mothballed. The actual storage capacity is less than 21,400 m^3.

2.1.7 Gas Storage Tank

There is one spherical gas storage tank. The tank volume is 2,065 m^3.

2.1.8 Sludge Dewatering System

There are 6 centrifuges for sludge dewatering and 6 sludge cake transfer pumps. The design conditions of these equipment are shown below: The sludge cake is utilized on agricultural lands.

<u>Centrifuges</u>

Capacity,	14 L/s/unit
Power,	200 HP/unit
Bowl Speed,	2400 RPM
Typical Solids Content,	in, 3 to 4%,
	out, 25 to 29%

<u>Sludge Cake Pumps</u>

Power,	75 HP/unit
Operating pressure,	1200 to 4480 kPa
Capacity,	4.4 L/s/unit
Number of cake bins,	3
Total holding capacity,	600 m^3.

2.2 Plant Operation

The most recent plant upgrade was designed to serve the anticipated flows and loads to the year 1994. Review of current flows and organic loads to the plant and the plant performance is essential to assess the plant for the treatment of WWCS flows. The review included study of plant operating data and discussion with plant operating staff to understand current operating conditions.

2.2.1 Review of Plant Operating Data

1996 plant operating data were obtained and reviewed. Plant flows and unit process effluent quality in 1996 are summarized in Table 2.6

In 1996, the plant received an average flow of 259.5 ML/d, representing 78% of the plant design flow. The average BOD_5 load to the secondary treatment section was 53,015.8 kg/d, representing 88.6% of the maximum design BOD_5 load. However, monthly average BOD_5 concentrations in secondary effluent were consistently greater than 50 mg/L, exceeding the design effluent BOD_5 of 25 mg/L. Investigation of the cause of the high effluent BOD_5 is out of the scope of this study. It is noted that the plant raw wastewater samples include the recycles of centrate and hauled wastes of septic tanks and leachate.

The plant operating data supplemented with raw wastewater quality data is used to calibrate a computer model and develop WWCS quality. The WWCS flows and quality are then used to assess the impact of WWCS on the treatment system. WWCS quality is site specific and it changes from time to time. Only the plant wastewater data, particularly during the runoff periods, can give the most reliable and representative quality of the WWCS to be treated at the plant.

As shown in the Table 2.6, the 1996 monthly average plant flows were all below the plant design hydraulic capacity. The plant wastewater data useful for development of WWCS quality during runoff period are very limited. As a result, the 1996 plant data can not be used alone to develop WWCS quality for the study. Review of data available in the literature was therefore required for this purpose.

Table 2.6 - 1996 Plant Flows and Influent & Effluent Quality

Month	Plant Flows		Raw Wastewater		Primary Effluent		Primary SOR		Secondary Effluent		Secondary SOR		Final Effluent	
	Average	Max.	BOD	SS	BOD	SS	Average	Max.	BOD	SS	Average	Max.	BOD	SS
	ML/d	ML/d	mg/L	mg/L	mg/L	mg/L	$m^3/m^2/d$	$m^3/m^2/d$	mg/L	mg/L	$m^3/m^2/d$	$m^3/m^2/d$	mg/L	mg/L
Jan. 96	178.7	367.6	385.0	382.0	236.0	101.0	27.5	56.4	50.9	21.7	12.5	25.8	34.4	22.5
Feb. 96	189.7	363.2	360.0	312.0	223.0	107.0	29.2	55.8	51.8	10.5	13.3	25.5	28.7	10.8
Mar. 96	216.8	402.6	250.0	287.0	154.0	102.0	33.3	61.9	50.1	13.8	15.2	28.2	18.8	14.1
Apr. 96	481.8	682.9	-	277.0	-	152.0	74.1	105.0	53.6	19.5	33.8	47.9	-	52.8
May 96	400.4	546.0	-	235.0	-	130.0	61.6	83.9	52.8	13.8	28.1	38.3	-	28.6
Jun. 96	304.1	489.8	-	315.0	-	126.0	46.8	75.3	52.5	14.0	21.3	34.3	-	24.9
Jul. 96	267.3	474.3	-	232.0	-	94.0	41.1	72.9	52.7	12.7	18.7	33.2	-	16.5
Aug. 96	253.2	440.7	-	207.0	-	78.0	38.9	67.8	56.7	13.2	17.7	30.9	-	29.9
Sep. 96	232.1	423.7	-	208.0	-	94.0	35.7	65.1	56.1	19.7	16.3	29.7	-	19.9
Oct. 96	205.1	409.2	-	208.0	-	105.0	31.5	62.9	56.7	14.9	14.4	28.7	-	23.0
Nov. 96	200.5	397.3	-	227.0	-	103.0	30.9	61.1	54.8	20.1	14.1	27.8	-	25.2
Dec. 96	184.1	370.6	-	273.0	-	109.0	28.3	57.0	50.7	17.1	12.9	26.0	-	20.4
Mean	259.5		331.7	263.6	204.3	108.4	39.9		53.3	15.9	18.2		27.3	24.0
St. Dev.	90.1		58.6	51.9	36.0	18.6	13.8		2.2	3.4	6.3		7.9	10.2
N	12.0		3.0	12.0	3.0	12.0	12.0		12.0	12.0	12.0		3.0	12.0

SECTION 3

BASIC CRITERIA FOR ASSESSMENT

Section 3 - Basic Criteria for Assessment

Criteria proposed as a reference for determination of unit process performance under various loading conditions include WWCS quality, and effluent requirement. Methodology for determination of unit process performance is uniformly applied to all treatment alternatives considered. This will ensure that a fair evaluation of all treatment alternatives is achieved.

3.1 Wet Weather Combined Sewage (WWCS) Quality

The plant data are insufficient to develop the WWCS quality for the study. Consequently a review of literature was conducted to compile a background database of CSO quality. This database was used as a reference to develop WWCS quality for the NEWPCC. Table 3.1 is a summary of CSO data from cities in North America where data are available.

The concentrations shown in the table are the average values of drainage areas within the cities. However, data for the four drainage areas in the City of Toronto have been kept separate and are reported as they are shown in the literature. This illustrates that variations in CSO quality within a city are minimal.

To estimate WWCS quality for the study the following considerations were applied:

- 1996 plant operating data of the NEWPCC was used as the basis,
- Raw wastewater samples at the NEWPCC include recycle of centrate, hauled wastes and leachate,
- Dilution will directly affect WWCS quality, the dilution factor was established based on the WWCS flow of 1060 ML/d and the 1996 annual average plant flow of 259.5 ML/d,
- The effect of street washing during runoff period was considered.

Three assumptions were made as follows:

- TSS - an average TSS concentration for those days in 1996 plant operating records when the peak flow rate exceeds 600 ML/d (1996 annual average flow of 259.5 ML/d x 2.5),
- BOD, TKN, NH_3/NH_4, and P - because the plant raw wastewater samples include recycle of centrate, hauled wastes and leachate, it was assumed that about half of the concentrations was from the recycles, hauled wastes and leachate, and the remaining concentrations were from the City. During the runoff period, the city portion is diluted by rainwater,

Table 3.1 - CSO Data

Parameters		Toronto				San Francisco California	Altanta Georgia	Sasramen-to California	Columbus Georgia	Louisville Kentucky	Boston Massach-setts	Cincinnati Ohio	New York New York	Cleveland Ohio	Portland Oregan	Prodence Rhode Island	Seattle Washing-ton
		Western Bridges	Inner Harhour	N. Toronto Det. Tank	To Black Creek												
BOD	mg/L	Est. 24	-	95.2	116	-	15.4	-	43.5	69.1	76.4	-	80.7	81	-	74.5	-
COD	mg/L	9.3	1016	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TSS	mg/L	219	338	170	278	173	85.2	160	255.1	151.7	132	155.4	121	390	59	111	165
NH3+NH4	mg/L	0.6	0.85	-	1.82	-	1.41	-	1.5	-	3.1	-	-	-	-	-	-
TKN	mg/L	5.39	5.96	14.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Total P	mg/L	1.01	1.45	-	0.78	-	0.35	-	0.3	-	-	-	-	2.4	-	-	-
NO2+NO3	mg/L	1.18	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity	mg/L	146	133	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenolics	ug/L	9.56	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH		7.33	7.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-

- During runoff periods, the City portion of concentrations increases by 15% due to the effect of street washing.

The plant raw wastewater concentration data excluding the TSS data were divided, modified as described in the above assumptions and then re-combined to establish the WWCS quality. The estimated WWCS quality shown in Table 3.2 is proposed for determination of plant upgrade requirements and associated costs.

Table 3.2 - Proposed WWCS Quality

WWCS Parameters	Concentration
BOD	212 mg/L
COD	530 mg/L
TSS	250 mg/L
NH_3/NH_4	18 mg/L
TKN	27 mg/L
Total P	3.5 mg/L
Alkalinity	150 mg/L
pH	7.2

3.2 Plant Effluent Criteria

Selection of economical alternatives of plant upgrading for treatment of the WWCS flow will be based on meeting a set of plant effluent criteria. The plant effluent criteria for all WWCS flow options have been identified as follows:

Secondary treatment effluent criteria

- TSS $\leq$ 30 mg/L.
- BOD_5 $\leq$ 25 mg/L,

WWCS flows exceeding the secondary treatment system capacity will receive a minimum of

- Primary treatment or equivalent,
- Solids and floatable disposal; and

- Disinfection of effluent.

The effluent guidelines for normal primary treatment is assumed to be 30% carbonaceous biochemical oxygen demand (BOD_5) removal and 50% total suspended solids (TSS) removal.

One alternative of plant upgrading for treatment of WWCS flow of 600 ML/d requires to produce a nitrified effluent. The plant effluent for this alternative has been identified to meet the following criteria:

- BOD_5 ≤ 25 mg/L,
- TSS ≤ 30 mg/L,
- NH_3-N ≤ 5 mg/L.

Plant effluent phosphorus removal process was not included in the plant assessment. Effluent phosphorus removal is not currently a discharge requirement and is also not expected to be a future requirement.

3.3 Development of Computer Model

After collection of necessary plant physical and wastewater data, a model of the NEWPCC was built in the GPS-X (General Process Simulator). The GPS-X model can be described as a grouping of smaller models for each of the unit processes simulated. In the case of the NEWPCC, the GPS-X model consists of an influent characteristic model, a plug-flow bioreactor model and a secondary clarifier model. Secondary bypass, return sludge and waste sludge flows are simulated and are included in the model mass balance.

Once the basic model is build, a basic calibration of the kinetic and stoichiometric constants used in the model is made. For the NEWPCC average historical data was used for the steady-state calibration. The kinetic and stoichiometric parameters used in the model for this study are shown in Appendix 1.

After calibration, the user can simulate a variety of scenarios in which changes are made to model parameters such as flow rates, flow splits, wastewater characteristics, tank sizes and return and waste sludge rates. The model predicts the impact of these changes on effluent quality and operating parameters (e.g. mixed liquor suspended solids) which are used to assess the plant capacity. The model can be also used to determine tank sizes required for meeting the effluent criteria.

3.4 Determination of Primary Clarifier Requirement

The primary clarifier performance has an impact on the secondary treatment system loading and performance. It also has an impact on the costs of treatment alternatives under consideration. The primary clarifier performance is difficult to predict due to influence by the following conditions:

- Wastewater characteristics,
- Variations of wastewater flows,
- Waste activated sludge, if it is co-thickened in the primary clarifier,
- In-plant recycle flows,
- Chemical pre-treatment of wastewater,
- Operating surface overflow rate,
- Hydraulic detention time.

Preferably the primary clarifier performance is determined by full scale testings. However the full scale testing is out of the scope of this study. Due to constant changes of settling characteristics of raw wastewater particles under various flow conditions a computer model (such as GPS-X model) is less effective to predict the primary clarifier performance. To overcome this shortcoming, the performance of primary clarifiers was estimated by a spreadsheet established using actual plant operating data.

For comparison, another two spreadsheets were also created using data reported in the "EPA Process Design Manual for Suspended Solids Removal" January 1975, one is for de-gritted raw wastewater and the other is for chemically treated raw wastewater. In general, the primary clarifiers at the NEWPCC performed slightly better than that reported in the literature. To estimate the primary clarifier performance for chemical coagulation-flocculation of raw wastewater the spreadsheet created by EPA data was used. The spreadsheets are shown in Figure 1.

Chemical coagulation-flocculation can be used as a means of improving the performance of primary settling facility. The degree of clarification obtained when chemicals are added to raw wastewater depends on the quantity of chemicals used and the care with which the process is monitored and controlled. With chemical coagulation-flocculation it is possible to remove 80 to 90 percent of TSS, 70 to 80 percent of BOD_5. Due to slowly settling rate of chemical floc particles, recommended surface-loading rates for various chemical suspensions to be used in the design of the sedimentation facilities given in the literatures range from 30 $m^3/m^2/d$ to 60 $m^3/m^2/d$. This is an important consideration for chemically enhanced primary treatment of WWCS flows at the NEWPCC, because the existing primary clarifiers were designed and operated at surface loading rates greatly exceeding these rates. For this study report, a surface-loading rate of 40 $m^3/m^2/d$ was used for the chemically enhanced primary treatment process using ferric or alum.

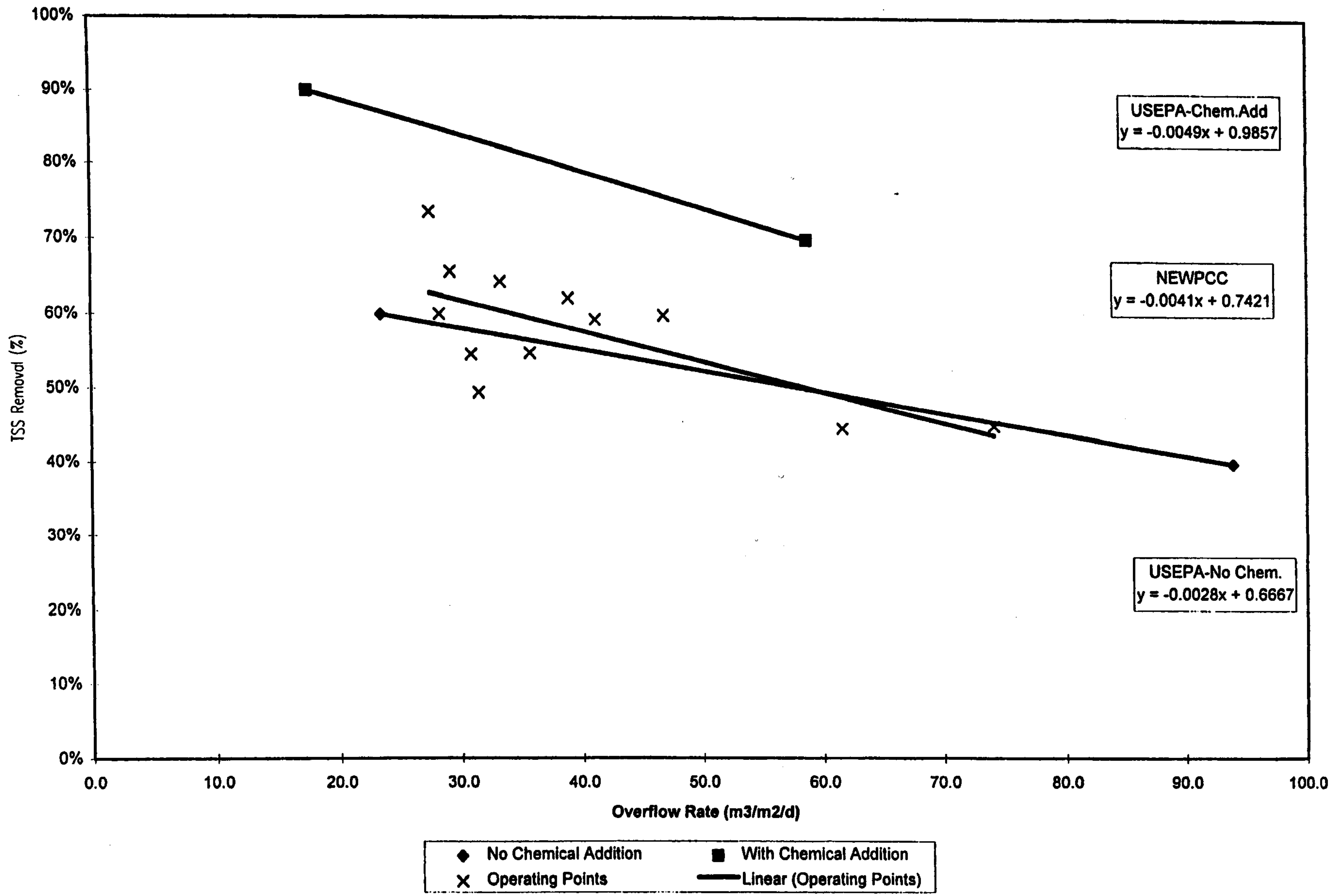

Figure 1 - Primary Clarifier TSS Removal Efficiency

3.5 Determination of Oxygen Activated Sludge Process Requirement

Factors affected the performance of an oxygen activated sludge system include the followings:

- Wastewater characteristics.
- Wastewater temperature,
- Organic loading rate,
- F/Mv or SRT,
- Oxygen supply,
- Hydraulic detention time,
- Variations of organic loads,
- Variations of flows,
- Final clarifier performance
- Return sludge rate,
- Waste sludge rate.

The performance of the oxygen activated sludge system is preferably determined by full scale testing. However full scale testing is time consuming and is out of the scope of this study.

The design point of the existing oxygen activated sludge system was checked with the process design criteria published in a book entitled "The Use of High-Purity Oxygen in the Activated Sludge Process" 1978 CRC Press, Inc. A curve of the organic loading rate and the organic removal rate of the oxygen activated sludge system has been established by Union Carbide Corporation by using a collection of pilot plant data and full scale plant data. This curve is re-produced on Figure 2.

The design conditions of the oxygen activated sludge system at the NEWPCC match with the results obtained from this curve. It is certain that the oxygen activated sludge system at NEWPCC was designed for an effluent BOD_5 of 25 mg/L at a maximum BOD_5 load of 89,600 kg/d. At BOD_5 loads greater than the maximum design value, the system will produce an effluent BOD_5 of greater than 25 mg/L, exceeding the effluent requirement. This design point is also shown on the Functional Design Report.

The requirement of the oxygen activated sludge system for treatment of the WWCS flows is determined by the computer model with the following boundary for the process parameters:

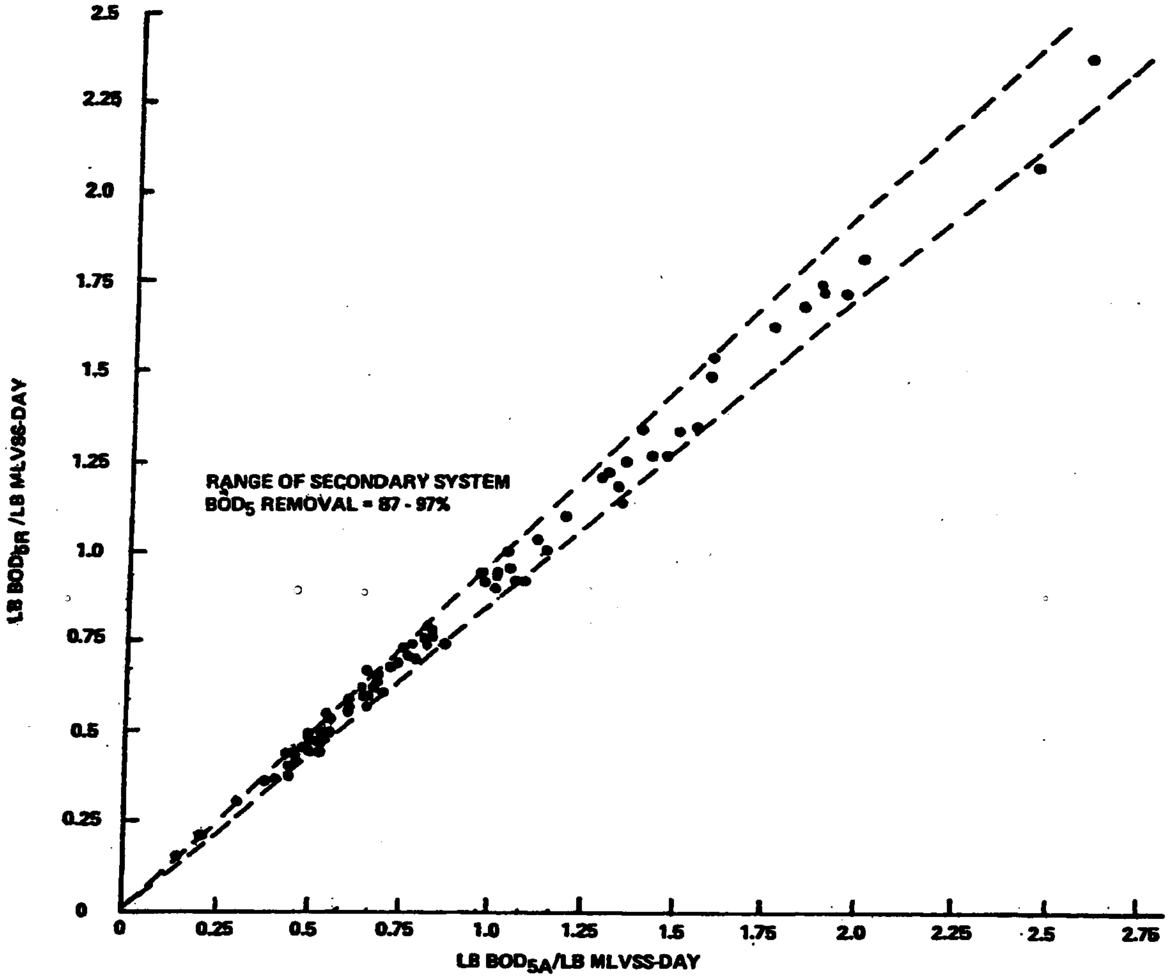

Figure 2 - Specific BOD5 removal rate vs specific BOD5 loading rate
(Courtesy of Union Carbide Corporation)

Parameters	BOD_5 Removal	Nitrification
MLSS	≤ 5000 mg/L	≤ 3600 mg/L
HRT	≥ 1 hour	≥ 3 hours
SOR	≤ 50 $m^3/m^2.d$	≤ 29.5 $m^3/m^2.d$
Solids Load	≤ 240 $kg/m^2.d$	≤ 120 $kg/m^2.d$

3.6 Determination of Sludge Digestion Requirement

The sludge dry solids production for treatment of WWCS flows at the NEWPCC is estimated from four sources including primary sludge, secondary sludge, chemical sludge, and sludge from SEWPCC/WEWPCC.

The projected primary sludge dry solids production is calculated as the product of the flow and the difference between the raw wastewater and the primary effluent total suspended solids concentrations. Test results of the raw wastewater suspended solids indicate a volatile content of 76.5%. A similar volatile content is assumed for the primary sludge.

The secondary sludge dry solids production is calculated as the sum of the non-volatile and volatile solids component of the waste activated sludge (WAS) stream. The non-volatile suspended solids component of the WAS is calculated as the product of the flow and the non-volatile component of the primary effluent total suspended solids. The non-volatile component found in the raw wastewater suspended solids is assumed applicable to the primary effluent and is approximately 23.5% of the primary effluent total solids. The volatile suspended solids yield is calculated as a result of the mass of BOD_5 removed in the secondary treatment process by the computer model. It is assumed that the volatile suspended solids contains 5% of non-biodegradable product.

A third sludge stream contributing to the sludge production is chemical sludge from the chemically enhanced primary treatment alternatives. The chemical sludge solids are calculated based on chemical requirement for suspended solids removal of 61% as reported in the EPA Design Manual "Suspended Solids Removal". The required chemicals are $FeCl_3$ at 37 mg/L and polymer at 0.08 mg/L The projected chemical sludge solids is 32.25 mg/L and is non-volatile.

A fourth sludge stream contributing to the sludge production at the NEWPCC is the SEWPCC/WEWPCC sludge which is hauled to the NEWPCC on a daily basis. 1996 annual average SEWPCC/WEWPCC sludge was 12,094 kg/d with VSS content of 7,484 kg/d.

All sludge solids are stabilized by an anaerobic sludge digestion process. A solids detention time of 10 days was used for determination of sludge digester requirement. This design parameter was also used for determination of the current digesters in the Sludge Expansion

Functional Design Report. A volatile solids reduction of 45% is assumed in the digestion process.

3.7 Determination of Digested Sludge Dewatering Requirement

The existing sludge dewatering facility includes six centrifuges, model PM76000, manufactured and supplied by Sharples. Each machine has a capacity of sludge flow of 1210 m^3/d and solids load of 36,288 kg/d at 3% solids or 48,384 kg/d at 4% solids. Currently the facility is operated 24 hours per day and 7 days per week. Based on the current operation the facility has the following capacity:

	Volume m³/d	Sludge Load at 3%, kg/d	Sludge Load at 4%, kg/d
Installed Capacity	7,257	217,700	290,300
Firm Capacity*	6,048	181,400	241,900

*Firm capacity is assumed for one unit in stand-by duty.

1996 plant operating data indicate that the digesters were operated at solids concentrations of approximately 3% or lower. Most likely the digested sludge has a similar solids concentrations. The solids concentration of 3% was used for establishing the existing centrifuge capacity. Since the treatment of WWCS flow will be an intermittent operation and short duration, the installed capacity of 7,257 m^3/d and 217,700 kg/d can be fully used for treatment. Additional facility will be required only when the digested sludge quantity exceeds the installed capacity.

3.8 Determination of Chlorination and Dechlorination Requirement

The WWCS flows exceeding the secondary treatment capacity will receive primary treatment and disinfection. Due to the primary treatment effluent quality and the intermittent treatment of the WWCS flows chlorination using sodium hypochlorite was considered for the effluent disinfection. In order to produce a non-toxic effluent, dechlorination using sodium bisulfite was also included. The plant secondary effluent disinfection was not included in this study.

SECTION 4

TREATMENT OF WWCS FLOWS

Section 4 - Treatment of WWCS Flows

Three flow rate options, 600 ML/d, 830 ML/d, and 1060 ML/d, of the collected and stored WWCS flows at the NEWPCC have been identified. The impacts of these flows on the NEWPCC and the plant upgrade requirement to treat these flows were investigated.

4.1 Impact of WWCS Flows

The existing plant was designed for a peak flow of 830 ML/d for the primary treatment and a peak flow of 589 ML/d for the secondary treatment. The secondary treatment system was also designed for an effluent BOD_5 of 25 mg/L at a maximum BOD_5 load of 89,600 kg/d. The corresponding BOD_5 concentration at the design peak flow was 152 mg/L. The 1996 plant operating records show that peak flow rate up to the primary treatment design condition occurred only in two events. During the peak flow period by-passing facilities at the plant were not used and the plant did not collect wastewater quality data. The annual average flow and BOD_5 load to the secondary in 1996 were about 78.2% and 88% of the plant design respectively.

The impacts of WWCS flow of 600 ML/d and 830 ML/d on the NEWPCC were assessed using the basic criteria described in the previous section of this report. It is certain that the plant cannot handle the WWCS flow of 1060 ML/d without upgrading because this flow rate is higher than the design flows for both primary and secondary treatment facilities. The impacts of WWCS flow of 600 ML/d and 830 ML/d were calculated and the results are summarized in Table 4.1.

Table 4.1 - Impact of WWCS Flows

WWCS flow, ML/d	600	830
Primary clarifier area, m^2	6503.7	6503.7
Surface overflow rate, $m^3/m^2.d$	92.3	127.6
Estimated primary removal efficiency* BOD_5%	21	17
TSS %	40	32
Estimated primary effluent BOD_5, mg/L	167	176
Estimated primary effluent TSS, mg/L	150	170
BOD_5 load to secondary**, kg/d	100,200	105,600
Max. design BOD_5 load for secondary, kg/d	89,600	89,600

Note: * Efficiency is estimated from curves on Figure 1, BOD_5 is assumed at 53% of TSS.

**BOD_5 load is based on max. flow of 600 ML/d.

Under these two WWCS flow conditions the secondary treatment system is overloaded and the plant effluent quality will be detrimentally affected.

4.2 Plant Upgrading Requirements

Treatment of the WWCS flows to meet the effluent criteria requires plant upgrading. Several alternatives of plant upgrading have been investigated. These include expansion of primary treatment facility with or without chemically enhanced treatment, expansion of secondary treatment facility, and expansion of sludge treatment capacity. Conceptual construction costs for the plant upgrading were also developed. Process design calculations for the plant upgrading requirements were carried out using a computer model supplemented with manual calculations for sludge treatment and dewatering requirements. Computer outputs are included in Appendix 2. Calculation of sludge production is shown in Appendix 3. A brief description of each alternative for treatment of the WWCS flows is provided in the following sections.

4.2.1 WWCS Flow of 600 ML/d

Three alternatives of plant upgrading plus one plant design for producing a nitrified effluent were considered:

Alternative 1 - Expansion of Final Clarifiers

The 600 ML/d WWCS flow is treated in the existing primary and secondary treatment facilities with an expansion of final clarifiers. The existing primary tanks are operated at an overflow rate of 92.3 m^3/m^2.d. It is expected that operation at this overflow rate for extended periods of time will reduce the primary removal efficiency to approximately 21% for BOD_5 and 40% for TSS. Under this condition, a BOD_5 load of 100,200 kg/d will discharge to the secondary treatment facility. Computer model calculated that the existing oxygenation reactors are able to handle this BOD_5 load with an increase in MLSS to 4800 mg/L, however, final clarifier needs expansion due to high solids loading. An additional final clarifier area of 3,923 m^2 is required.

This treatment alternative will generate a total sludge solids of 181,819 kg/d with a volatile solids content of 76%. To stabilize the sludge, an additional primary digester volume of 7,600 m^3 is required. It is estimated that the anaerobic sludge digestion process will reduce the total sludge solids to 99,528 kg/d, less than the installed capacity of the existing sludge dewatering equipment.

The effluent quality of the Alternative 1 design is able to meet the effluent criteria.

Alternative 2 - Chemically Enhanced Primary Treatment for Entire Flow

This alternative is to provide chemically enhanced primary treatment for the WWCS flow. The objective is to increase primary removal efficiency and to reduce organic load to the existing secondary treatment system.

The current primary clarifiers were designed and are operated at an overflow rate not suitable for separation of chemically precipitated particles. These particles settle slowly and require a low surface overflow rate for effective separation from liquid. Therefore expansion of the primary treatment is required.

An additional primary clarifier area of 8,500 m^2 plus a chemical dosing and mixing system is required. A BOD_5 load to the secondary treatment system is expected to reduce to 66,000 kg/d. Expansion of the secondary treatment system is not required. The plant effluent quality is able to meet the effluent criteria.

This treatment alternative will generate a total sludge solids of 200,000 kg/d with a volatile solids content of 69.4%. To stabilize the sludge, an additional primary digester volume of 12,860 m^3 is required. It is estimated that the anaerobic digestion process will reduce the total sludge solids to 137,610 kg/d. Expansion of the existing sludge dewatering facility is not required.

Alternative 3 - Expansion of Primary Clarifiers

This treatment alternative is similar to the Alternative 1 to treat the WWCS flow in the existing primary and secondary treatment facilities with an expansion of primary clarifiers. To increase the primary treatment efficiency for 50% removal of TSS and reduce the BOD_5 load to the secondary an additional primary clarifier area of 6,262 m^2 is required. A BOD_5 load of 90,000 kg/d will be treated in the secondary facility. Expansion of the secondary treatment facility is not required. The plant effluent quality is able to meet the effluent criteria.

This alternative will generate a total sludge solids of 176,534 kg/d with a volatile solids content of 75.5%. An additional primary digester volume of 6,070 m^3 is required to stabilize the sludge solids. It is estimated that the anaerobic digestion process will reduce the sludge solids to 116,564 kg/d. Expansion of the existing sludge dewatering facility is not required.

Alternative 4 - Expansion of Secondary Treatment to Produce A Nitrified Effluent

This alternative is to expand the secondary treatment system using a single-sludge nitrification process to produce a nitrified effluent. Expansion of both oxygenation reactors and final clarifiers is required.

Flow pattern of the single-sludge nitrification system is identical to that of the carbonaceous oxygen-activated sludge design, but the system is required to remove carbonaceous BOD as well as ammonia (NH_3). This is done by providing in the system the proper conditions to cultivate nitrifying bacteria among the more prevalent carbonaceous bacteria in the biomass. Since the nitrifiers grow much more slowly than the carbonaceous micro-organisms, maintenance of the proper conditions consists primarily of assuring that the time which the biomass spends in the reactor system, the sludge retention time (SRT), is at least long enough to provide time for the nitrifiers in the biomass to grow. Single-sludge oxygen nitrification system will typically have 2.5- to 6.0-hr retention times compared with standard design oxygen-activated sludge systems for carbonaceous removal only having 1.0- to 2.5- hr retention times. Therefore the design of the oxygenation reactors for single-sludge nitrification system at the NEWPCC is to provide a retention time of 3.6-hr. An additional reactor volume of 60,088 m^3 is required.

The settling rate of nitrifying biomass is slower than that of carbonaceous biomass. Final clarifier design requires a surface overflow rate lower than that for carbonaceous biomass for effective solid separation. Therefore the final clarifier design is based on a surface overflow rate of 29.5 m^3/m^2.d. An additional final clarifier area of 6,074 m^2 is required.

This alternative will generate a total sludge solids of 166,510 kg/d with a volatile solids content of 73.9%. An additional primary digester volume of 3,186 m^3 is required to stabilize the sludge. It is estimated that the anaerobic digestion process will reduce the sludge solids to 166,510 kg/d. Expansion of the existing sludge dewatering facility is not required.

This alternative is able to meet the design effluent criteria.

4.2.2 WWCS Flow of 830 ML/d

Alternative 5 - Expansion of Primary Clarifiers for Treatment of 830 ML/d

From the result of treatment alternative evaluation for the WWCS flow of 600 ML/d it is obvious that expansion of the existing primary treatment facility is the only cost-effective alternative for treatment of the WWCS flow. The expanded primary treatment facility was designed for a removal efficiency of 30% BOD_5 and 50% TSS. An additional primary clarifier area of 11,156 m^2 is required.

The primary effluent of 600 ML/d will be further treated in the existing secondary treatment facility. The remaining flow of 230 ML/d will be disinfected and bypassed the secondary facility. The BOD_5 load and the operating conditions of the secondary treatment facility are similar to the Alternative 3 and the expansion of the facility is not required.

This alternative will generate a total sludge solids of 207,124 kg/d with a volatile solids content of 75.6%. To stabilize the sludge, an additional primary digester volume of 14,890 m^3 is required. It is estimated that the anaerobic digestion process will reduce the sludge solids to 136,623 kg/d. Expansion of the dewatering facility is not required.

4.2.3 WWCS Flow of 1060 ML/d

Alternative 6 - Expansion of Primary Clarifiers for Treatment of 1060 ML/d

This alternative is similar to the Alternative 5 to expand the existing primary treatment facility to treat the WWCS flow. The expanded primary treatment facility was designed for a removal efficiency of 30% BOD_5 and 50% TSS. An additional primary clarifier area of 16,049 m^2 is required.

The primary effluent of 600 ML/d will be further treated in the existing secondary treatment facility. The remaining flow of 460 ML/d will be disinfected and bypassed the secondary treatment facility. The BOD_5 load and the operating conditions of the secondary treatment facility are similar to the Alternative 3. Expansion of the existing secondary treatment facility is not required.

This alternative will generate a total sludge solids of 247,714 kg/d with a volatile solids content of 72.7%. To stabilize the sludge an additional primary digester volume of 26,587 m^3

is required. It is estimated that the anaerobic digestion process will reduce the sludge solids to 166,682 kg/d. Expansion of the sludge dewatering facility is not required.

4.2.4 Summary of Plant Upgrading Requirement

The additional facilities for plant upgrading for treatment of the WWCS flows are summarized in the Table 4.2. It is assumed that the existing headwork has a sufficient capacity for the WWCS flows, upgrading of the plant headwork is not included. Estimated effluent quality for meeting the effluent criteria for each alternative is also shown in the table.

4.3 Capital Cost Estimate

Conceptual capital costs for the plant upgrading were estimated with reference to the most recent contracts completed by CH2M Gore & Storrie Limited. In order to facilitate cost calculations for this study, unit costs for various unit processes were first established using the construction contract price for the unit processes. The unit costs were then brought up to January 1998 cost using ENR Construction Cost Index and included an allowance of 11% for engineering and construction supervision. However the unit costs do not include land costs, taxes, and piling foundation costs if required. The development of the unit costs is included in Appendix 4. A summary of the unit costs used for the study is listed in Table 4.3.

Table 4.3 - Unit Capital Costs

Unit Process	Unit Cost, $
Primary Clarifier, per m^2 of tank area	1,328.00
Flash Mix & Floc Tank, per m^3 of flow	6.20
Chemical Facility, per m^3 of flow	6.70
Oxygenation Reactor, per m^2 of tank area	1,328.00
Final Clarifier, per m^2 of tank area	1,328.00
Chlorination & Dechlorination, per m^3 of flow	4.00
Sludge Digester, per m^3 of tank volume*	686.50
Dewatering, per kg/d of digested sludge**	878.50

* The unit cost includes control building,
** The unit cost includes building for housing the dewatering equipment

The estimated capital cost for the plant upgrading in each alternative is calculated as the sum of the product of the unit process requirement and the unit cost. A summary of the estimated capital costs for the alternatives investigated is listed in Table 4.4.

Table 4.2 - Plant Upgrading Requirements

Additional Facility Requirement	600 ML/d Alternative 1	600 ML/d Alternative 2	600 ML/d Alternative 3	600 ML/d Alternative 4	830 ML/d Alternative 5	1060 ML/d Alternative 6
Primary Clarifier						
Area, m^2	-	8,500	6,262	-	11,156	16,049
Volume, m^3	-	30,600	22,543	-	40,162	69,011
Oxygen Reactor						
Area, m^2	-	-	-	13,974	-	-
Volume, m3	-	-	-	60,088	-	-
Final Clarifier						
Area, m^2	3,923	-	-	6,074	-	-
Volume, m3	14,123	-	-	21,866	-	-
Digester						
Volume, m3	7,600	12,860	6,070	3,186	14,890	26,578
Dewatering						
Digested Sludge, kg/d	-	-	-	-	-	-
Meeting Effluent Requirement	Yes	Yes	Yes	Yes	Yes	Yes

Table 4.4 - Estimated Capital Costs For Plant Upgrading Requirements

Additional Facilities	600 ML/d				830 ML/d	1060 ML/d
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Primary Clarifiers	-	11,288,000	8,316,000	-	14,815,000	21,313,000
Oxygen Reactors	-	-	-	18,557,000	-	-
Fianl Clarifiers	5,210,000	-	-	8,066,000	-	-
Flash Mix & Floc Tanks	-	3,720,000	-	-	-	-
Chemcial System	-	4,020,000	-	-	-	-
Disinfection*	-	-	-	-	920,000	1,840,000
Sludge Digestion	5,217,000	8,828,000	4,167,000	2,187,000	10,222,000	18,246,000
Sludge Dewatering	-	-	-	-	-	-
Total Estimated Cost, $	10,427,000	27,856,000	12,483,000	28,810,000	25,957,000	41,399,000

Note *Disinfection includes chlorination and dechlorination for secondary bypass flow only

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

Section 5 - Conclusions and Recommendations

5.1 Conclusions

Based on the results of process evaluation for treatment of the WWCS flow at the NEWPCC, the following conclusions can be drawn:

1. The secondary treatment system of the NEWPCC is overloaded under all three flow rates, 600 ML/d, 830 ML/d, and 1060 ML/d. The plant can not produce a secondary effluent quality meeting the effluent criteria of 25 mg/L BOD_5 and 30 mg/L TSS.

2. Three alternatives for treatment of the WWCS flow of 600 ML/d were evaluated. Alternative 1 is the lowest cost alternative and is recommended for consideration. This alternative requires an expansion of the final clarifiers to handle high mixed liquor solids load from the reactors. Expansion of the sludge digestion facility is also required. Total estimated capital cost is $10,427,000.

3. From the result of treatment alternative evaluation for the 600 ML/d flow it is understood that expansion of the primary treatment facility is the only cost-effective alternative for treatment of the WWCS flow of 830 ML/d and 1060 ML/d. Flow exceeding the existing secondary treatment capacity of 600 ML/d will be chlorinated and dechlorinated prior to discharge. Increase of sludge loads due to treatment of the WWCS flows requires an expansion of the sludge digestion facility. Expansion of the sludge dewatering facility is not required.

   Total estimated capital cost for treatment of 830 ML/d is $25,957,000.

   Total estimated capital cost for treatment of 1060 ML/d is $41,399,000

4. To treat the WWCS flow of 600 ML/d for meeting the nitrified effluent criteria of 25 mg/L BOD_5, 30 mg/L TSS and 5 mg/L NH_3-N, the plant requires an expansion of the secondary treatment and sludge digestion facilities. Total estimated capital cost is $28,810,000.

5. Based on the accuracy of the cost estimate and the small difference in flows between the current design and the WWCS flow of 600 ML/d, the estimated cost of $28,810,000 can be applied for upgrade of the existing facility to achieve nitrification.

The above estimated capital costs include an allowance of 11% for engineering and construction supervision but exclude land costs, taxes, and piling foundation if required.

5.2 Recommendations

In 1996, the plant received an average flow and an average BOD_5 load to the secondary treatment facility of 78% and 88.6% of the design respectively. However, secondary effluent

BOD_5 concentrations were consistently over 50 mg/L, greater than the plant design of 25 mg/L. It is recommended that a plant audit be carried out to investigate the cause of the high BOD_5 concentration in the effluent.

APPENDIX 1

KINETIC AND STOICHIOMETRIC PARAMETERS
(common all alternatives)

REPORT

SCENARIO - ALT1

Label: SYSTEM

time		
stopping time		0 d
communication interval		0.05 d
(1)date and time at t=0		1994 yr,m,d,h
(2)date and time at t=0		11 yr,m,d,h
(3)date and time at t=0		1 yr,m,d,h
(4)date and time at t=0		0 yr,m,d,h
(5)date and time at t=0		0 yr,m,d,h
(6)date and time at t=0		0 yr,m,d,h
initial time		0 d
round seconds to full minutes	.false.	
round minutes to quarter hours	.false.	
repeat runs		
number of reruns		0
input files		
input file extension (in offline mode)	dat	
Plant #1 name (for data file)	blank	
Plant #2 name (for data file)	blank	
Plant #3 name (for data file)	blank	
Plant #4 name (for data file)	blank	
Plant #5 name (for data file)	blank	
Plant #6 name (for data file)	blank	
Plant #7 name (for data file)	blank	
Plant #8 name (for data file)	blank	
Plant #9 name (for data file)	blank	
Plant #10 name (for data file)	blank	
output files		
Use global alarm file	.false.	
Alarm file name	blank	
oxygen solubility (if global settings are used)		
Use global physical values	.false.	
tank depth		4.3 m
liquid temperature		13 C
air temperature		20 C
oxygen fraction in air		0.21 -
elevation above sea level		0 m
barometric pressure at sea level		1 atm
base temperature		20 C
acceleration of gravity		9.80665 m/s2
Energy price		0.07 $/kWh
std parameters		
iterate for steady-state	.false.	
number of retries on iteration		0
error limit on individual variables		1.00E-10
iteration termination criteria		10
contract constant		0.982

expand constant	1.003
maximum step size in one iteration	0.5
damping factor on final approach	1
initial perturbation	0.05
convergence output interval	200
std loop counter initial value	0
maximum number of iterations	20000
maximum number of unsuccessful iterations	5000
trim parameters	
print value of dsum	1.00E+10 d
display improved iterations only	.true.
iteration output interval in trim	50000
static	
optimizer control	.false.
objective function based on time series data	.true.
number of optimized parameters	2
number of data points (at least 2)	3
parameter tolerance	1.00E-03
objective function tolerance	1.00E-06
termination value for objective function	0.1
maximum number of optimizer iterations	100
step size in initial guess	0.2
reflection constant	0.95
contraction constant	0.45
expansion constant	1.9
shrink constant	0.5
DPE	
dynamic parameter estimator	.false.
DPE timewindow	1.00E+10 d
on-line run	
On-line run	.false.
Wait for all data to synchronize	.false.
data transfer	
send data to simulator module	.false.
max number of control and output variables	100
max number of datapoints	100
ADF	
max number of ADF coefficients	128
database	
Data base type	GPS-X
Sampling rate from data base	60 s
communication	
g2 communication mode	.false.
network port	22041
gfx input mode	.false.
gfx output mode	.false.
gfx files in PC format	.false.
output into Matlab format	.false.
send warnings to log window	.true.
send optimizer status to log window	.true.
send DPE status to log window	.true.
bounding	

number of iterations in IMPL operator	30	-
error bound in IMPL operator	1.00E-06	-
bottom bound on flows	1.00E-10	m3/d
top bound on flows	1.00E+10	m3/d
bottom bound on initial concentrations	1.00E-06	g/m3
top bound on initial concentrations	1.00E+10	g/m3
bottom bound on concentrations	0	g/m3
top bound on concentrations	1.00E+10	g/m3
bottom bound on derivatives	-1.00E+33	g/m3/d
top bound on derivatives	1.00E+33	g/m3/d
bottom bound on volumes	1.00E-10	m3
ignore dilution rate below this volume	1.00E-01	m3
ignore dilution rate below this layer thickness	1.00E-03	m
top bound on volumes	1.00E+10	m3
bottom bound on parameters	1.00E-10	
top bound on parameters	1.00E+10	
top bound on integers	999999	
protect against division by zero	1.00E-10	
top bound on exponential (xmin)	1.00E+03	g/m3
speed		
low concentration approximate integration	.false.	
relative derivative limit	200	g/m3/d
low concentration limit	0.03	g/m3
damping on negative derivative	0.001	
approximate anoxic DO limit	0	g/m3
smooth pump discharge at discontinuities	.false.	
smoothing period	1.00E-05	d
smooth factor (logistic parameter)	15	-
smooth at flow changes larger than	50	%
general		
pi	3.14159265	
controller sampling time	999	d
controller damping in steady-state	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	
cc5	-2.85E-06	
cc6	2.50E-08	
cc7	-1.62E-04	
cc8	0.004897	
cc9	6.47E-04	
system variables		
numerical solver	Runge-Kutt	-
initial number of integration steps	50	-
minimum integration step size	1.00E-30	days
maximum integration step size	1.00E-01	days

Label: USER

Label: (11,18)

Label: (13,18)

Label: (16,18)

Label: (14,17)

Label: (12,17)

/ stoichiometric /

fractions	
[R1]particulate COD to VSS ratio	1.42 gCOD/gVS
[R1]VSS/TSS ratio	0.8 gVSS/gTS
[R1]BOD5 to BODultimate ratio	0.66 -
heterotrophs	
[R1]Yield	0.666 -
[R1]N content of active mass	0.068 gN/gCOD
[R1]N content of endogenous mass	0.068 gN/gCOD
[R1]P content of active mass	0.021 gP/COD
[R1]P content of endogenous mass	0.021 gP/COD
[R1]Endogenous fraction	0.08 -
autotrophs	
[R1]Yield	0.15 -
[R1]N content of active mass	0.068 gN/gCOD
[R1]N content of endogenous mass	0.068 gN/gCOD
[R1]P content of active mass	0.021 gP/COD
[R1]P content of endogenous mass	0.021 gP/COD
[R1]Endogenous fraction	0.08 -
[R1]particulate COD to VSS ratio	1.42 gCOD/gVS
poly-p organisms	
[R1]Yield	0.639 -
[R1]N content of active mass	0.07 gN/gCOD
[R1]N content of endogenous mass	0.07 gN/gCOD
[R1]N content of soluble unbiod. COD	0.07 gN/gCOD
[R1]P content of active mass, not PP	0.021 gP/COD
[R1]P content of endogenous mass	0.021 gP/COD
[R1]endogenous fraction	0.25 -
[R1]soluble unbiod. fraction	0.2 -
[R1]P uptake/COD utilized, aerobic	1 gP/COD

[R1]P uptake/COD utilized, anoxic	0.2 gP/COD
[R1]P release/fatty acid uptake	0.48 gP/COD
[R1]particulate COD to VSS ratio	1.42 gCOD/gVS

/ kinetic /

heterotrophs	
[R1]Maximum specific growth rate	3.2 1/d
[R1]Half saturation coefficient	5 gCOD/m3
[R1]Organism decay rate	0.62 1/d
[R1]Anoxic hydrolysis factor	0.6 -
[R1]Anoxic growth factor	0.8 -
[R1]Maximum spec. hydrolysis rate	2.81 1/d
[R1]Hydrolysis half saturation	0.15 -
[R1]Ammonification rate	0.016 m3/gCOD/
autotrophs	
[R1]Maximum specific growth rate	0.467 1/d
[R1]Half saturation coefficient	1 gN/m3
[R1]Organism decay rate	0.05 1/d
poly-p organisms	
[R1]Max. spec. growth rate, no P limit	0.9 1/d
[R1]Max. spec. growth rate, P limit	0.42 1/d
[R1]Half saturation coeff., no P limit	0.18 -
[R1]Half saturation coeff., P limit	0.18 -
[R1]Organism decay rate	0.04 1/d
[R1]PP cleavage for maintenance	0.03 1/d
[R1]Lower fatty acid sequestration rate	6 1/d
[R1]Conversion rate of ss to slf	0.04 1/d
[R1]Anoxic growth factor	1 -
switching functions	
[R1]Aerobic/anoxic growth	0.2 gO2/m3
[R1]Ammonia limit	0.05 gN/m3
[R1]Nitrate limit	1 gN/m3
[R1]Soluble phosphorus limit	5 gP/m3
[R1]Poly-P limit	1 gP/m3
[R1]Lower fatty acids limit	1 gCOD/m3
temperature	
[R1]Temperature coefficient for muh	1.035 -
[R1]Temperature coefficient for bh	1.035 -
[R1]Temperature coefficient for mua	1.11 -
[R1]Temperature coefficient for ba	1.029 -
[R1]Temperature coefficient for ka	1.029 -
[R1]Temperature coefficient for kh	1.072 -
[R1]Temperature coefficient for mup	1.123 -
[R1]Temperature coefficient for bp	1.029 -

Label: (15,16)

APPENDIX 2

COMPUTER OUTPUTS

Influent Characteristics for GPSX Modelling

Wastewater Component	Symbols ASM2	Symbols GPSX	Units	From Pro2D	GPS-X Influent CODbased Model	GPS-X Influent State Variables	
Standard Analysis							
$CBOD_5$ Total			mg O2/L	167			
Particulate			mg O2/L	63			
Filtrate			mg O2/L	102			
COD Total		COD	mg COD/L	368	368		
Particulate Bio			mg COD/L	108			
Particulate Non-Bio			mg COD/L	61			
Total Particulate COD		XCOD	mg COD/L	169	197.6		
Filtrate Bio			mg COD/L	174			
Filtrate Non-Bio			mg COD/L	24			
Total filtrate COD		SCOD	mg COD/L	198	170		
TSS Total		TSS	mg TSS/L	150	176		
Biodegradable			mg TSS/L	91			
Non-Biodegradable			mg TSS/L	58			
VSS Total		VSS	mg VSS/L	115	133.5		
Biodegradable			mg VSS/L	73			
Non-Biodegradable			mg VSS/L	41			
TKN		TKN	mg N/L	26	26		
NH3		snh	mg N/L	21			
TPO_4			mg P/L	5			
orthoPO4		sp	mg P/L	3	3		
State Variables							
Dissolved Components							
Dissolved Oxygen	S_{O2}	so	mg O2/L		0	0	
Readily Biodeg. Soluble Substrate	S_F	ss	mg COD/L		139	139	
Fermentation Products (acetate)	S_A	slf	mg COD/L		0	0	
Ammonia	S_{NH4}	snh	mg N/L	21	20.7	20.7	
Nitrate/Nitrite	S_{NO3}	sno	mg N/L	0	0	0	
Phosphate	S_{PO4}	sp	mg P/L	3	3.4	3.4	
Inert, Non-biodegradable organics	Si	si	mg COD/L	24	31	31	
Bicarbonate alkalinity	Salk	-	mole HCO3-	256	-		
Nitrogen	S_{N2}	-	mg N/L				
Particulate Components							
Inert, Non-biodegradable organics	X_I	xi	mg COD/L	61	54.3	54.3	
Unbio. particulates from cell decay	-	xu	mg COD/L		0	0	
Slowly biodegradable substrate	X_S	xs	mg COD/L		143.3	143.3	
Heterotrophic biomass	X_H	xbh	mg COD/L	1.49	0	0	
Phosphorus accumulating organisms	X_{PAO}	xbp	mg COD/L		0	0	
Stored polyphosphate of PAO	X_{PP}	xpp	mg P/L		0	0	
Organic storage products of PAO	X_{PHA}	xbt	mg COD/L		0	0	
Autotrophic nitrifying biomass	X_{AUT}	xba	mg COD/L	0.05	0	0	
Particulate biodeg. Org N	-	xnd	mg N/L	2.92	3.9	3.9	
Soluble biodeg. Org N	-	snd	mg N/L	-0.6	1.3	1.3	
Ferric hydroxide	X_{MeOH}	-	mg TSS/L				
Ferric phosphate	X_{MeP}	-	mg TSS/L				
Particulate material	X_{TSS}		mg TSS/L		176		
Inert Non Organic Particulates		xii	mg TSS/L		42.2	42.2	
Checks for COD balance							
COD unbiodegradable					85.3		
COD biodegradable					283		
Checks for TSS balance							
Assumptions for X_{TSS} calculation	85%			of filtrate biodegradable COD that is readily biodeg			
	20%			of ISS			
Stoichiometry for GPS-X CODbased Influent Model							
VSS/TSS		ivt			0.760		
Particulate COD/VSS		icv			1.480		
BOD5/COD		fbodcod			0.453		
BOD20/BOD5		fbod			1.696	0.590	1.696
NH3/TKN		fnh			0.799		
Particulate Org N/Total Org N		fxn			0.750		
Kinetic and Stoichiometric Coefficients							
Heterotrophs:	PRO2D				General Model		
maximum specific growth rate	mumax	muh		6.00	3.20		
mumax temp. corr. coeff.		theta		1.035	1.035		
half saturation COD		ksh		60.00	5.00		
organism decay rate		bh		0.24	0.62		
decay rate temp. corr. coeff.				1.035	1.035		
anoxic hydrolysis factor		etah		-	0.6		
anoxic growth factor		etag		-	0.8		
heterotrophic organism yield		yh	gCOD/COD	0.666	0.666		
COD/VSS				1.42	1.42		
endogenous fraction	fD	fuh		0.20	0.08		
half saturation O2		koh	mg O2/L	-	0.2		
Autotrophs:							
maximum specific growth rate		mua		0.70	0.467	For DO setpt = 2mg/L	
mumax temp corr. coeff.				1.011	1.011		
half saturation O2		koh		1.300	0.2	Cannot change this value	
half saturation NH3		kna		1.00	1.00		
organism decay rate		ba		0.05	0.05		
autotrophic organism yield		ya		0.15	0.15		
COD/VSS				1.42	1.42		
endogenous fraction		fua		-	0.08		

Influent Characteristics for GPSX Modelling

Wastewater Component	Symbols ASM2	Symbols GPSX	Units	From Pro2D	ASM2 Calculated Values	Summary ASM2 Values	GPS-X Influent CODbased Model	GPS-X Influent State Variables	
Standard Analysis									
$CBOD_5$ Total			mg O2/L	150					
Particulate			mg O2/L	52					
Filtrate			mg O2/L	97					
COD Total		COD	mg COD/L	312			312		
Particulate Bio			mg COD/L	84					
Particulate Non-Bio			mg COD/L	47					
Total Particulate COD		XCOD	mg COD/L	131			157.0		
Filtrate Bio			mg COD/L	157					
Filtrate Non-Bio			mg COD/L	23					
Total filtrate COD		SCOD	mg COD/L	180			155		
TSS Total		TSS	mg TSS/L	117			139		
Biodegradable			mg TSS/L	71					
Non-Biodegradable			mg TSS/L	45					
VSS Total		VSS	mg VSS/L	90			106.1		
Biodegradable			mg VSS/L	57					
Non-Biodegradable			mg VSS/L	32					
TKN		TKN	mg N/L	25			25		
NH3		snh	mg N/L	21					
TPO_4			mg P/L	4					
orthoPO4		sp	mg P/L	3			3		
State Variables									
Dissolved Components									
Dissolved Oxygen	S_{O2}	so	mg O2/L			-	0	0	
Readily Biodeg. Soluble Substrate	S_F	ss	mg COD/L		133	133	124	124	
Fermentation Products (acetate)	S_A	slf	mg COD/L			-	0	0	
Ammonia	S_{NH4}	snh	mg N/L	21		21	21.0	21.0	
Nitrate/Nitrite	S_{NO3}	sno	mg N/L	0		0	0	0	
Phosphate	S_{PO4}	sp	mg P/L	3		3.4	3.4	3.4	
Inert, Non-biodegradable organics	Si	si	mg COD/L	23		23	31	31	
Bicarbonate alkalinity	Salk	-	mole HCO3-	257		257	-		
Nitrogen	S_{N2}	-	mg N/L						
Particulate Components									
Inert, Non-biodegradable organics	X_I	xi	mg COD/L	47		47	39.6	39.6	
Unbio. particulates from cell decay	-	xu	mg COD/L			-	0	0	
Slowly biodegradable substrate	X_S	xs	mg COD/L		108	107.6	117.4	117.4	
Heterotrophic biomass	X_H	xbh	mg COD/L	0.99		1.0	0	0	
Phosphorus accumulating organisms	X_{PAO}	xbp	mg COD/L			-	0	0	
Stored polyphosphate of PAO	X_{PP}	xpp	mg P/L			-	0	0	
Organic storage products of PAO	X_{PHA}	xbt	mg COD/L			-	0	0	
Autotrophic nitrifying biomass	X_{AUT}	xba	mg COD/L	0.04		0	0	0	
Particulate biodeg. Org N	-	xnd	mg N/L	2.28			3.1	3.1	
Soluble biodeg. Org N	-	snd	mg N/L	-0.6			1.0	1.0	
Ferric hydroxide	X_{MeOH}	-	mg TSS/L						
Ferric phosphate	X_{MeP}	-	mg TSS/L						
Particulate material	X_{TSS}		mg TSS/L		139	139	139		
Inert Non Organic Particulates		xii	mg TSS/L				32.8	32.8	
Checks for COD balance									
COD unbiodegradable						70.6	70.6		
COD biodegradable						242	242		
Checks for TSS balance									
Assumptions for X_{TSS} calculation	85%			of filtrate biodegradable COD that is readily biodegradable					
	20%			of ISS					
Stoichiometry for GPS-X CODbased Influent Model									
VSS/TSS		ivt					0.764		
Particulate COD/VSS		icv					1.480		
BOD5/COD		fbodcod					0.479		
BOD20/BOD5		fbod					1.615	0.619	1.615
NH3/TKN		fnh					0.835		
Particulate Org N/Total Org N		fxn					0.750		
Kinetic and Stoichiometric Coefficients									
Heterotrophs:	PRO2D						General Model		
maximum specific growth rate	mumax	muh		6.00			3.20		
mumax temp. corr. coeff.		theta		1.035			1.035		
half saturation COD		ksh		60.00			5.00		
organism decay rate		bh		0.24			0.62		
decay rate temp. corr. coeff.				1.035			1.035		
anoxic hydrolysis factor		etah		-			0.6		
anoxic growth factor		etag		-			0.8		
heterotrophic organism yield		yh	gCOD/COD	0.666			0.666		
COD/VSS				1.42			1.42		
endogenous fraction	fD	fuh		0.20			0.08		
half saturation O2		koh	mg O2/L	-			0.2		
Autotrophs:									
maximum specific growth rate		mua		0.70			0.467	For DO setpt = 2mg/L	
mumax temp corr. coeff.				1.011			1.011		
half saturation O2		koh		1.300			0.2	Cannot change this value	
half saturation NH3		kna		1.00			1.00		
organism decay rate		ba		0.05			0.05		
autotrophic organism yield		ya		0.15			0.15		
COD/VSS				1.42			1.42		
endogenous fraction		fua		-			0.08		

Influent Characteristics for GPSX Modelling

Wastewater Component	Symbols ASM2	Symbols GPSX	Units	From Pro2D	GPS-X Influent CODbased Model	GPS-X Influent State Variables	
Standard Analysis							
$CBOD_5$ Total			mg O2/L	110			
Particulate			mg O2/L	21			
Filtrate			mg O2/L	88			
COD Total		COD	mg COD/L	224	224		
Particulate Bio			mg COD/L	41			
Particulate Non-Bio			mg COD/L	15			
Total Particulate COD		XCOD	mg COD/L	56	79.3		
Filtrate Bio			mg COD/L	145			
Filtrate Non-Bio			mg COD/L	22			
Total filtrate COD		SCOD	mg COD/L	167	144		
TSS Total		TSS	mg TSS/L	49	67		
Biodegradable			mg TSS/L	35			
Non-Biodegradable			mg TSS/L	14			
VSS Total		VSS	mg VSS/L	38	53.6		
Biodegradable			mg VSS/L	28			
Non-Biodegradable			mg VSS/L	10			
TKN		TKN	mg N/L	23	23		
NH3		snh	mg N/L	22			
TPO_4			mg P/L	4			
orthoPO4		sp	mg P/L	4	4		
State Variables							
Dissolved Components							
Dissolved Oxygen	S_{O2}	so	mg O2/L		0	0	
Readily Biodeg. Soluble Substrate	S_F	ss	mg COD/L		113	113	
Fermentation Products (acetate)	S_A	slf	mg COD/L		0	0	
Ammonia	S_{NH4}	snh	mg N/L	22	22.0	22.0	
Nitrate/Nitrite	S_{NO3}	sno	mg N/L	0	0	0	
Phosphate	S_{PO4}	sp	mg P/L	4	3.5	3.5	
Inert, Non-biodegradable organics	Si	si	mg COD/L	22	31	31	
Bicarbonate alkalinity	Salk	-	mole HCO3-	259	-		
Nitrogen	S_{N2}	-	mg N/L				
Particulate Components							
Inert, Non-biodegradable organics	X_I	xi	mg COD/L	15	5.9	5.9	
Unbio. particulates from cell decay	-	xu	mg COD/L		0	0	
Slowly biodegradable substrate	X_S	xs	mg COD/L		73.4	73.4	
Heterotrophic biomass	X_H	xbh	mg COD/L	0.26	0	0	
Phosphorus accumulating organisms	X_{PAO}	xbp	mg COD/L		0	0	
Stored polyphosphate of PAO	X_{PP}	xpp	mg P/L		0	0	
Organic storage products of PAO	X_{PHA}	xbt	mg COD/L		0	0	
Autotrophic nitrifying biomass	X_{AUT}	xba	mg COD/L	0.01	0	0	
Particulate biodeg. Org N	-	xnd	mg N/L	0.62	1.1	1.1	
Soluble biodeg. Org N	-	snd	mg N/L	-0.6	0.4	0.4	
Ferric hydroxide	X_{MeOH}	-	mg TSS/L				
Ferric phosphate	X_{MeP}	-	mg TSS/L				
Particulate material	X_{TSS}		mg TSS/L		67		
Inert Non Organic Particulates		xii	mg TSS/L		13.1	13.1	
Checks for COD balance							
COD unbiodegradable					**36.9**		
COD biodegradable					**187**		
Checks for TSS balance							
Assumptions for X_{TSS} calculation	85%			of filtrate biodegradable COD that is readily biodeg			
	20%			of ISS			
Stoichiometry for GPS-X CODbased Influent Model							
VSS/TSS		ivt			**0.804**		
Particulate COD/VSS		icv			**1.480**		
BOD5/COD		fbodcod			**0.491**		
BOD20/BOD5		fbod			**1.699**	0.589	1.699
NH3/TKN		fnh			**0.938**		
Particulate Org N/Total Org N		fxn			**0.750**		
Kinetic and Stoichiometric Coefficients							
Heterotrophs:	PRO2D				General Model		
maximum specific growth rate	mumax	muh		6.00	3.20		
mumax temp. corr. coeff.		theta		1.035	1.035		
half saturation COD		ksh		60.00	5.00		
organism decay rate		bh		0.24	0.62		
decay rate temp. corr. coeff.				1.035	1.035		
anoxic hydrolysis factor		etah		-	0.6		
anoxic growth factor		etag		-	0.8		
heterotrophic organism yield		yh	gCOD/COD	0.666	0.666		
COD/VSS				1.42	1.42		
endogenous fraction	fD	fuh		0.20	0.08		
half saturation O2		koh	mg O2/L	-	0.2		
Autotrophs:							
maximum specific growth rate		mua		0.70	0.467	For DO setpt = 2mg/L	
mumax temp corr. coeff.				1.011	1.011		
half saturation O2		koh		1.300	0.2	Cannot change this value	
half saturation NH3		kna		1.00	1.00		
organism decay rate		ba		0.05	0.05		
autotrophic organism yield		ya		0.15	0.15		
COD/VSS				1.42	1.42		
endogenous fraction		fua		-	0.08		

REPORT
SCENARIO - ALT1new

Label: SYSTEM		
time		
tstop		0 d
cint		0.05 d
ztime(1)		1994 yr,m,d,h
ztime(2)		11 yr,m,d,h
ztime(3)		1 yr,m,d,h
ztime(4)		0 yr,m,d,h
ztime(5)		0 yr,m,d,h
ztime(6)		0 yr,m,d,h
itcon		0 d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun		0
input files		
extype		2
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth		4.3 m
temp		13 C
airtemp		20 C
pO2con		0.21 -
elev		0 m
patm0		1 atm
tempb20		20 C
g		9.80665 m/s2
eprice		0.07 $/kWh
std parameters		
steady	.false.	
retry		0
eps		1.00E-10
sumeps		10
decr		0.982
incr		1.003
maxstepcon		0.5
fdamping		1
pinit		0.05
prin		200
iloop		0
looplm		20000
chstop		5000
trim parameters		
printdsum		1.00E+10 d
primpronly	.true.	
dskip		50000
static		
optmz	.false.	
timeseries	.true.	
ndimm		2
npts		3
peps		1.00E-03
opteps		1.00E-06

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06
cc6	2.50E-08
cc7	-1.62E-04
cc8	0.004897
cc9	6.47E-04
system variables	
ialg	8 -
nstp	50 -
mint	1.00E-30 days
maxt	1.00E-01 days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05 m3/d
sbodpeff	82 gO2/m3
xbodpeff	84.5 gO2/m3
bodpeff	167 gO2/m3
bodupeff	282 gO2/m3
scodpeff	170 gCOD/m3
xcodpeff	198 gCOD/m3
codpeff	368 gCOD/m3
stknpeff	22 gN/m3
tknpeff	25.9 gN/m3
tnpeff	25.9 gN/m3
xiipeff	42.2 g/m3
vsspeff	134 g/m3
xpeff	176 g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	0 m3/d
sbodbypass	84.8 gO2/m3
xbodbypass	47.2 gO2/m3
bodbypass	132 gO2/m3
bodubypass	224 gO2/m3
scodbypass	175 gCOD/m3
xcodbypass	82.2 gCOD/m3
codbypass	257 gCOD/m3
stknbypass	22 gN/m3
tknbypass	24.2 gN/m3
tnbypass	24.2 gN/m3
xiibypass	20.2 g/m3
vssbypass	55.5 g/m3
xbypass	75.8 g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	5.95E+05	m3/d
sbodFeff	1.58	gO2/m3
xbodFeff	12.4	gO2/m3
bodFeff	14	gO2/m3
boduFeff	21.2	gO2/m3
scodFeff	33.4	gCOD/m3
xcodFeff	25.3	gCOD/m3
codFeff	58.7	gCOD/m3
stknFeff	15	gN/m3
tknFeff	15.1	gN/m3
tnFeff	15.1	gN/m3
xiiFeff	4.46	g/m3
vssFeff	17.8	g/m3
xFeff	22.3	g/m3
cn states		
siFeff	31	g COD/m3
ssFeff	2.4	g COD/m3
xiFeff	5.91	g COD/m3
xsFeff	4.72	g COD/m3
xbhFeff	14	g COD/m3
xbaFeff	4.69E-09	g COD/m3
xuFeff	0.637	g COD/m3
soFeff	7.08	g O2/m3
snoFeff	1.00E-06	g N/m3
snhFeff	12	g N/m3
sndFeff	2.98	g N/m3
xndFeff	0.192	g N/m3
p states		
xbpFeff	4.69E-09	g COD/m3
xbtFeff	4.67E-09	g COD/m3
xppFeff	4.67E-09	g P/m3
slfFeff	0.000727	g COD/m3
spFeff	0.565	g P/m3

Label: (14,17)

/ physical /

real dimensions		
*aSeff	18188	m2
hmSeff	3.65	m
hfSeff	1.6	m
model dimensions		
nSeff	10	

/ operational /

underflow		
proprecSeff	.true.	
cvarr	peff	
recfracSeff	0.28	-
qconRAS	67930	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvars	blank	
samplintconblankRAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminRAS	1000	m3/d
qmaxRAS	100000	m3/d
pumped flow		
*qconWAS	5200	m3/d

decanterSeff	.false.	
outputSeff(1)	0	
outputSeff(2)	0	
outputSeff(3)	0	
outputSeff(4)	0	
outputSeff(5)	0	
outputSeff(6)	0	
outputSeff(7)	0	
outputSeff(8)	0	
outputSeff(9)	0	
outputSeff(10)	1	
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblankWAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminWAS	0	m3/d
qmaxWAS	10000	m3/d
model parameters		
xtSeff	2000	gTSS/m3
hscritSeff	0.1	m

/ settling /

double exponential parameters		
svionSeff	.true.	
sviSeff	100	ml/g
clarifSeff	0.5	-
vbndSeff	274	m/d
vmaxconSeff	410	m/d
rhinconSeff	0.0004	m3/gTSS
rfloconSeff	0.0025	m3/gTSS
fnsSeff	0.001	-
xminmaxSeff	20	gTSS/m3
flow distribution		
vumiSeff	100	m/d
vumaSeff	300	m/d

/ flow, composite and state variables /

qSeff	5.95E+05	m3/d
sbodSeff	1.58	gO2/m3
xbodSeff	12.4	gO2/m3
bodSeff	14	gO2/m3
boduSeff	21.2	gO2/m3
scodSeff	33.4	gCOD/m3
xcodSeff	25.3	gCOD/m3
codSeff	58.7	gCOD/m3
stknSeff	15	gN/m3
tknSeff	15.1	gN/m3
tnSeff	15.1	gN/m3
xiiSeff	4.46	g/m3
vssSeff	17.8	g/m3
xSeff	22.3	g/m3
cn states		
siSeff	31	g COD/m3
ssSeff	2.4	g COD/m3
xiSeff	5.91	g COD/m3
xsSeff	4.72	g COD/m3
xbhSeff	14	g COD/m3
xbaSeff	4.69E-09	g COD/m3
xuSeff	0.637	g COD/m3
soSeff	7.08	g O2/m3
snoSeff	1.00E-06	g N/m3
snhSeff	12	g N/m3

sndSeff	2.98 g N/m3
xndSeff	0.192 g N/m3
p states	
xbpSeff	4.69E-09 g COD/m3
xbtSeff	4.67E-09 g COD/m3
xppSeff	4.67E-09 g P/m3
slfSeff	0.000727 g COD/m3
spSeff	0.565 g P/m3

Label: (12,17)

/ physical /

real dimensions	
nR1	4
vsetupR1	1
vlconR1(1)	7533.15 m3
vlconR1(2)	7533.15 m3
vlconR1(3)	7533.15 m3
vlconR1(4)	7533.15 m3
vmconR1	30132.6 m3
fvconR1(1)	0.25 -
fvconR1(2)	0.25 -
fvconR1(3)	0.25 -
fvconR1(4)	0.25 -
oxygen solubility (if individual settings are used)	
depthR1	4.3 m
tempR1	13 C
airtempR1	20 C
pO2conR1	0.21 -

/ operational /

aeration control	
ctrlsolR1	.false.
pidformsolR1	1
controllersolR1	3
samplintconsolR1R1	999 d
setpsolR1(1)	2
setpsolR1(2)	2
setpsolR1(3)	2
setpsolR1(4)	2
gainsolR1	1
ticonsolR1	5 d
tdconsolR1	0.1 d
cellR1	0
directsolR1	.true.
nokicksolR1	.false.
Setup	
aermethodR1	2
alphaR1(1)	0.6 -
alphaR1(2)	0.7 -
alphaR1(3)	0.7 -
alphaR1(4)	0.8 -
betaR1	0.95 -
tklaR1	1.024 -
Kla	
klaconR1(1)	100 1/d
klaconR1(2)	100 1/d
klaconR1(3)	100 1/d
klaconR1(4)	100 1/d
klalminR1(1)	0 1/d
klalminR1(2)	0 1/d
klalminR1(3)	0 1/d
klalminR1(4)	0 1/d
klalmaxR1(1)	300 1/d
klalmaxR1(2)	300 1/d
klalmaxR1(3)	300 1/d
klalmaxR1(4)	300 1/d

Mechanical	
powerconR1(1)	627.2 kW
powerconR1(2)	440 kW
powerconR1(3)	440 kW
powerconR1(4)	440 kW
etapowerR1	3.5 kgO2/kWh
Diffused	
fraircon R1(1)	0.25 -
fraircon R1(2)	0.25 -
fraircon R1(3)	0.25 -
fraircon R1(4)	0.25 -
qairsumconR1	100000 m3/d
etasolR1	0.07 -
pumped flow control	
qcon4	5200 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank4	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin4	0 m3/d
qmax4	100 m3/d
Internal flow distribution	
inputR1(1)	1 -
inputR1(2)	0 -
inputR1(3)	0 -
inputR1(4)	0 -
recinputR1(1)	1 -
recinputR1(2)	0 -
recinputR1(3)	0 -
recinputR1(4)	0 -

/ flow, composite and state variables /

qR1	7.68E+05 m3/d
sbodR1	1.58 gO2/m3
xbodR1	2.66E+03 gO2/m3
bodR1	2.66E+03 gO2/m3
boduR1	4.03E+03 gO2/m3
scodR1	33.4 gCOD/m3
xcodR1	5.43E+03 gCOD/m3
codR1	5.46E+03 gCOD/m3
stknR1	15 gN/m3
tknR1	56.1 gN/m3
tnR1	56.1 gN/m3
xiiR1	955 g/m3
vssR1	3.82E+03 g/m3
xR1	4.78E+03 g/m3
cn states	
siR1	31 g COD/m3
ssR1	2.4 g COD/m3
xiR1	1.27E+03 g COD/m3
xsR1	1.01E+03 g COD/m3
xbhR1	3.01E+03 g COD/m3
xbaR1	1.00E-06 g COD/m3
xuR1	136 g COD/m3
soR1	7.08 g O2/m3
snoR1	1.00E-06 g N/m3
snhR1	12 g N/m3
sndR1	2.98 g N/m3
xndR1	41.2 g N/m3
p states	
xbpR1	1.00E-06 g COD/m3
xbtR1	1.00E-06 g COD/m3
xppR1	1.00E-06 g P/m3

slfR1	0.000727 g COD/m3
spR1	0.565 g P/m3

Label: (15,16)

/ physical /

real dimensions

vm26	10000 m3

oxygen solubility (if individual settings are used)

depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control

ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.

Setup

aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -

Kla

klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d

Mechanical

powercon26	0 kW
etapower26	1.3 kgO2/kWh

Diffused

qaircon26	0 m3/d
etasot26	0.07 -

pumped flow control

qcon27	5200 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	5.20E+03 m3/d
sbod26	1.58 gO2/m3
xbod26	1.17E+04 gO2/m3
bod26	1.17E+04 gO2/m3
bodu26	1.78E+04 gO2/m3
scod26	33.4 gCOD/m3
xcod26	2.40E+04 gCOD/m3
cod26	2.40E+04 gCOD/m3

stkn26	15	gN/m3
tkn26	197	gN/m3
tn26	197	gN/m3
xii26	4.22E+03	g/m3
vss26	1.69E+04	g/m3
x26	2.11E+04	g/m3
cn states		
si26	31	g COD/m3
ss26	2.4	g COD/m3
xi26	5.59E+03	g COD/m3
xs26	4.47E+03	g COD/m3
xbh26	1.33E+04	g COD/m3
xba26	4.44E-06	g COD/m3
xu26	603	g COD/m3
so26	10.6	g O2/m3
sno26	1.00E-06	g N/m3
snh26	12	g N/m3
snd26	2.98	g N/m3
xnd26	182	g N/m3
p states		
xbp26	4.44E-06	g COD/m3
xbt26	4.42E-06	g COD/m3
xpp26	4.42E-06	g P/m3
slf26	0.000727	g COD/m3
sp26	0.565	g P/m3

REPORT
SCENARIO - ALT2

Label: SYSTEM		
time		
tstop	0	d
cint	0.05	d
ztime(1)	1994	yr,m,d,h
ztime(2)	11	yr,m,d,h
ztime(3)	1	yr,m,d,h
ztime(4)	0	yr,m,d,h
ztime(5)	0	yr,m,d,h
ztime(6)	0	yr,m,d,h
itcon	0	d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun	0	
input files		
extype	2	
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth	4.3	m
temp	13	C
airtemp	20	C
pO2con	0.21	-
elev	0	m
patm0	1	atm
tempb20	20	C
g	9.80665	m/s2
eprice	0.07	$/kWh
std parameters		
steady	.false.	
retry	0	
eps	1.00E-10	
sumeps	10	
decr	0.982	
incr	1.003	
maxstepcon	0.5	
fdamping	1	
pinit	0.05	
prin	200	
iloop	0	
looplm	20000	
chstop	5000	
trim parameters		
printdsum	1.00E+10	d
primpronly	.true.	
dskip	50000	
static		
optmz	.false.	
timeseries	.true.	
ndimm	2	
npts	3	
peps	1.00E-03	
opteps	1.00E-06	

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06	
cc6	2.50E-08	
cc7	-1.62E-04	
cc8	0.004897	
cc9	6.47E-04	
system variables		
ialg	8	-
nstp	50	-
mint	1.00E-30	days
maxt	1.00E-01	days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05	m3/d
sbodpeff	66.6	gO2/m3
xbodpeff	43.2	gO2/m3
bodpeff	110	gO2/m3
bodupeff	186	gO2/m3
scodpeff	144	gCOD/m3
xcodpeff	79.3	gCOD/m3
codpeff	223	gCOD/m3
stknpeff	22.4	gN/m3
tknpeff	23.5	gN/m3
tnpeff	23.5	gN/m3
xiipeff	13.1	g/m3
vsspeff	53.6	g/m3
xpeff	66.6	g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	0	m3/d
sbodbypass	84.8	gO2/m3
xbodbypass	47.2	gO2/m3
bodbypass	132	gO2/m3
bodubypass	224	gO2/m3
scodbypass	175	gCOD/m3
xcodbypass	82.2	gCOD/m3
codbypass	257	gCOD/m3
stknbypass	22	gN/m3
tknbypass	24.2	gN/m3
tnbypass	24.2	gN/m3
xiibypass	20.2	g/m3
vssbypass	55.5	g/m3
xbypass	75.8	g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	5.96E+05	m3/d
sbodFeff	1.27	gO2/m3
xbodFeff	17.3	gO2/m3
bodFeff	18.6	gO2/m3
boduFeff	28.2	gO2/m3
scodFeff	32.9	gCOD/m3
xcodFeff	28.7	gCOD/m3
codFeff	61.6	gCOD/m3
stknFeff	16.4	gN/m3
tknFeff	16.5	gN/m3
tnFeff	16.5	gN/m3
xiiFeff	5.05	g/m3
vssFeff	20.2	g/m3
xFeff	25.2	g/m3
cn states		
siFeff	31	g COD/m3
ssFeff	1.92	g COD/m3
xiFeff	1.42	g COD/m3
xsFeff	4.44	g COD/m3
xbhFeff	21.8	g COD/m3
xbaFeff	1.05E-08	g COD/m3
xuFeff	0.978	g COD/m3
soFeff	8.93	g O2/m3
snoFeff	1.00E-06	g N/m3
snhFeff	14.5	g N/m3
sndFeff	1.91	g N/m3
xndFeff	0.162	g N/m3
p states		
xbpFeff	1.05E-08	g COD/m3
xbtFeff	1.04E-08	g COD/m3
xppFeff	1.05E-08	g P/m3
slfFeff	0.000465	g COD/m3
spFeff	1.51	g P/m3

Label: (14,17)

/ physical /

real dimensions		
aSeff	14264.8	m2
hmSeff	3.65	m
hfSeff	1.6	m
model dimensions		
nSeff	10	

/ operational /

underflow		
proprecSeff	.true.	
cvarr	peff	
recfracSeff	0.28	-
qconRAS	67930	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvars	blank	
samplintconblankRAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminRAS	1000	m3/d
qmaxRAS	100000	m3/d
pumped flow		
*qconWAS	4500	m3/d

decanterSeff	.false.	
outputSeff(1)	0	
outputSeff(2)	0	
outputSeff(3)	0	
outputSeff(4)	0	
outputSeff(5)	0	
outputSeff(6)	0	
outputSeff(7)	0	
outputSeff(8)	0	
outputSeff(9)	0	
outputSeff(10)	1	
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblankWAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminWAS	0	m3/d
qmaxWAS	10000	m3/d
model parameters		
xtSeff	2000	gTSS/m3
hscritSeff	0.1	m
/ settling /		
double exponential parameters		
svionSeff	.true.	
sviSeff	100	ml/g
clarifSeff	0.5	-
vbndSeff	274	m/d
vmaxconSeff	410	m/d
rhinconSeff	0.0004	m3/gTSS
rfloconSeff	0.0025	m3/gTSS
fnsSeff	0.001	-
xminmaxSeff	20	gTSS/m3
flow distribution		
vumiSeff	100	m/d
vumaSeff	300	m/d
/ flow, composite and state variables /		
qSeff	5.96E+05	m3/d
sbodSeff	1.27	gO2/m3
xbodSeff	17.3	gO2/m3
bodSeff	18.6	gO2/m3
boduSeff	28.2	gO2/m3
scodSeff	32.9	gCOD/m3
xcodSeff	28.7	gCOD/m3
codSeff	61.6	gCOD/m3
stknSeff	16.4	gN/m3
tknSeff	16.5	gN/m3
tnSeff	16.5	gN/m3
xiiSeff	5.05	g/m3
vssSeff	20.2	g/m3
xSeff	25.2	g/m3
cn states		
siSeff	31	g COD/m3
ssSeff	1.92	g COD/m3
xiSeff	1.42	g COD/m3
xsSeff	4.44	g COD/m3
xbhSeff	21.8	g COD/m3
xbaSeff	1.05E-08	g COD/m3
xuSeff	0.978	g COD/m3
soSeff	8.93	g O2/m3
snoSeff	1.00E-06	g N/m3
snhSeff	14.5	g N/m3

sndSeff	1.91	g N/m3
xndSeff	0.162	g N/m3
p states		
xbpSeff	1.05E-08	g COD/m3
xbtSeff	1.04E-08	g COD/m3
xppSeff	1.05E-08	g P/m3
slfSeff	0.000465	g COD/m3
spSeff	1.51	g P/m3

Label: (12,17)

/ physical /

real dimensions		
nR1	4	
vsetupR1	1	
vlconR1(1)	7533.15	m3
vlconR1(2)	7533.15	m3
vlconR1(3)	7533.15	m3
vlconR1(4)	7533.15	m3
vmconR1	30133	m3
fvconR1(1)	0.25	-
fvconR1(2)	0.25	-
fvconR1(3)	0.25	-
fvconR1(4)	0.25	-
oxygen solubility (if individual settings are used)		
depthR1	4.3	m
tempR1	13	C
airtempR1	20	C
pO2conR1	0.21	-

/ operational /

aeration control		
ctrlsolR1	.false.	
pidformsolR1	1	
controllersolR1	3	
samplintconsolR1R1	999	d
setpsolR1(1)	2	
setpsolR1(2)	2	
setpsolR1(3)	2	
setpsolR1(4)	2	
gainsolR1	1	
ticonsolR1	5	d
tdconsolR1	0.1	d
cellR1	0	
directsolR1	.true.	
nokicksolR1	.false.	
Setup		
aermethodR1	2	
alphaR1(1)	0.6	-
alphaR1(2)	0.7	-
alphaR1(3)	0.7	-
alphaR1(4)	0.8	-
betaR1	0.95	-
tklaR1	1.024	-
Kla		
klaconR1(1)	100	1/d
klaconR1(2)	100	1/d
klaconR1(3)	100	1/d
klaconR1(4)	100	1/d
klalminR1(1)	0	1/d
klalminR1(2)	0	1/d
klalminR1(3)	0	1/d
klalminR1(4)	0	1/d
klalmaxR1(1)	300	1/d
klalmaxR1(2)	300	1/d
klalmaxR1(3)	300	1/d
klalmaxR1(4)	300	1/d

Mechanical		
powerconR1(1)	627.2	kW
powerconR1(2)	440	kW
powerconR1(3)	440	kW
powerconR1(4)	440	kW
etapowerR1	3.5	kgO2/kWh
Diffused		
fraironR1(1)	0.25	-
fraironR1(2)	0.25	-
fraironR1(3)	0.25	-
fraironR1(4)	0.25	-
qairsumconR1	100000	m3/d
etasolR1	0.07	-
pumped flow control		
qcon4	4500	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblank4	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qmin4	0	m3/d
qmax4	100	m3/d
Internal flow distribution		
inputR1(1)	1	-
inputR1(2)	0	-
inputR1(3)	0	-
inputR1(4)	0	-
recinputR1(1)	1	-
recinputR1(2)	0	-
recinputR1(3)	0	-
recinputR1(4)	0	-

/ flow, composite and state variables /

qR1	7.68E+05	m3/d
sbodR1	1.27	gO2/m3
xbodR1	1.66E+03	gO2/m3
bodR1	1.66E+03	gO2/m3
boduR1	2.52E+03	gO2/m3
scodR1	32.9	gCOD/m3
xcodR1	2.75E+03	gCOD/m3
codR1	2.78E+03	gCOD/m3
stknR1	16.4	gN/m3
tknR1	31.9	gN/m3
tnR1	31.9	gN/m3
xiiR1	483	g/m3
vssR1	1.93E+03	g/m3
xR1	2.42E+03	g/m3
cn states		
siR1	31	g COD/m3
ssR1	1.92	g COD/m3
xiR1	136	g COD/m3
xsR1	425	g COD/m3
xbhR1	2.09E+03	g COD/m3
xbaR1	1.00E-06	g COD/m3
xuR1	93.6	g COD/m3
soR1	8.93	g O2/m3
snoR1	1.00E-06	g N/m3
snhR1	14.5	g N/m3
sndR1	1.91	g N/m3
xndR1	15.5	g N/m3
p states		
xbpR1	1.00E-06	g COD/m3
xbtR1	1.00E-06	g COD/m3
xppR1	1.00E-06	g P/m3

slfR1	0.000465 g COD/m3
spR1	1.51 g P/m3

Label: (15,16)

/ physical /

real dimensions	
vm26	10000 m3
oxygen solubility (if individual settings are used)	
depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control	
ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.
Setup	
aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -
Kla	
klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d
Mechanical	
powercon26	0 kW
etapower26	1.3 kgO2/kWh
Diffused	
qaircon26	0 m3/d
etasol26	0.07 -
pumped flow control	
qcon27	4500 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	4.50E+03 m3/d
sbod26	1.27 gO2/m3
xbod26	7.33E+03 gO2/m3
bod26	7.33E+03 gO2/m3
bodu26	1.11E+04 gO2/m3
scod26	32.9 gCOD/m3
xcod26	1.21E+04 gCOD/m3
cod26	1.22E+04 gCOD/m3

stkn26	16.4 gN/m3
tkn26	84.9 gN/m3
tn26	84.9 gN/m3
xii26	2.13E+03 g/m3
vss26	8.54E+03 g/m3
x26	1.07E+04 g/m3
cn states	
si26	31 g COD/m3
ss26	1.92 g COD/m3
xi26	600 g COD/m3
xs26	1.88E+03 g COD/m3
xbh26	9.23E+03 g COD/m3
xba26	4.44E-06 g COD/m3
xu26	414 g COD/m3
so26	10.6 g O2/m3
sno26	1.00E-06 g N/m3
snh26	14.5 g N/m3
snd26	1.91 g N/m3
xnd26	68.5 g N/m3
p states	
xbp26	4.44E-06 g COD/m3
xbt26	4.42E-06 g COD/m3
xpp26	4.43E-06 g P/m3
slf26	0.000465 g COD/m3
sp26	1.51 g P/m3

REPORT
SCENARIO - ALT3new

Label: SYSTEM

time		
tstop	0	d
cint	0.05	d
ztime(1)	1994	yr,m,d,h
ztime(2)	11	yr,m,d,h
ztime(3)	1	yr,m,d,h
ztime(4)	0	yr,m,d,h
ztime(5)	0	yr,m,d,h
ztime(6)	0	yr,m,d,h
itcon	0	d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun	0	
input files		
extype	2	
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth	4.3	m
temp	13	C
airtemp	20	C
pO2con	0.21	-
elev	0	m
patm0	1	atm
tempb20	20	C
g	9.80665	m/s2
eprice	0.07	$/kWh
std parameters		
steady	.false.	
retry	0	
eps	1.00E-10	
sumeps	10	
decr	0.982	
incr	1.003	
maxstepcon	0.5	
fdamping	1	
pinit	0.05	
prin	200	
iloop	0	
looplm	20000	
chstop	5000	
trim parameters		
printdsum	1.00E+10	d
primpronly	.true.	
dskip	50000	
static		
optmz	.false.	
timeseries	.true.	
ndimm	2	
npts	3	
peps	1.00E-03	
opteps	1.00E-06	

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06
cc6	2.50E-08
cc7	-1.62E-04
cc8	0.004897
cc9	6.47E-04
system variables	
ialg	8 -
nstp	50 -
mint	1.00E-30 days
maxt	1.00E-01 days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05 m3/d
sbodpeff	76.8 gO2/m3
xbodpeff	72.7 gO2/m3
bodpeff	149 gO2/m3
bodupeff	241 gO2/m3
scodpeff	155 gCOD/m3
xcodpeff	157 gCOD/m3
codpeff	312 gCOD/m3
stknpeff	22 gN/m3
tknpeff	25.1 gN/m3
tnpeff	25.1 gN/m3
xiipeff	32.8 g/m3
vsspeff	106 g/m3
xpeff	139 g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	0 m3/d
sbodbypass	84.8 gO2/m3
xbodbypass	47.2 gO2/m3
bodbypass	132 gO2/m3
bodubypass	224 gO2/m3
scodbypass	175 gCOD/m3
xcodbypass	82.2 gCOD/m3
codbypass	257 gCOD/m3
stknbypass	22 gN/m3
tknbypass	24.2 gN/m3
tnbypass	24.2 gN/m3
xiibypass	20.2 g/m3
vssbypass	55.5 g/m3
xbypass	75.8 g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	5.95E+05	m3/d
sbodFeff	1.51	gO2/m3
xbodFeff	15.5	gO2/m3
bodFeff	17	gO2/m3
boduFeff	25.8	gO2/m3
scodFeff	33.3	gCOD/m3
xcodFeff	30.7	gCOD/m3
codFeff	64	gCOD/m3
stknFeff	15.7	gN/m3
tknFeff	16	gN/m3
tnFeff	16	gN/m3
xiiFeff	5.41	g/m3
vssFeff	21.6	g/m3
xFeff	27.1	g/m3
cn states		
siFeff	31	g COD/m3
ssFeff	2.28	g COD/m3
xiFeff	6.38	g COD/m3
xsFeff	5.39	g COD/m3
xbhFeff	18.2	g COD/m3
xbaFeff	7.09E-09	g COD/m3
xuFeff	0.806	g COD/m3
soFeff	7.88	g O2/m3
snoFeff	1.00E-06	g N/m3
snhFeff	13	g N/m3
sndFeff	2.75	g N/m3
xndFeff	0.218	g N/m3
p states		
xbpFeff	7.09E-09	g COD/m3
xbtFeff	7.06E-09	g COD/m3
xppFeff	7.07E-09	g P/m3
slfFeff	0.000623	g COD/m3
spFeff	0.927	g P/m3

Label: (14,17)

/ physical /

real dimensions		
aSeff	14264.8	m2
hmSeff	3.65	m
hfSeff	1.6	m
model dimensions		
nSeff	10	

/ operational /

underflow		
proprecSeff	.true.	
cvarr	peff	
recfracSeff	0.28	-
qconRAS	67930	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvars	blank	
samplintconblankRAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminRAS	1000	m3/d
qmaxRAS	100000	m3/d
pumped flow		
*qconWAS	5000	m3/d

decanterSeff	.false.
outputSeff(1)	0
outputSeff(2)	0
outputSeff(3)	0
outputSeff(4)	0
outputSeff(5)	0
outputSeff(6)	0
outputSeff(7)	0
outputSeff(8)	0
outputSeff(9)	0
outputSeff(10)	1
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblankWAS	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qminWAS	0 m3/d
qmaxWAS	10000 m3/d
model parameters	
xtSeff	2000 gTSS/m3
hscritSeff	0.1 m

/ settling /

double exponential parameters	
svionSeff	.true.
sviSeff	100 ml/g
clarifSeff	0.5 -
vbndSeff	274 m/d
vmaxconSeff	410 m/d
rhinconSeff	0.0004 m3/gTSS
rfloconSeff	0.0025 m3/gTSS
fnsSeff	0.001 -
xminmaxSeff	20 gTSS/m3
flow distribution	
vumiSeff	100 m/d
vumaSeff	300 m/d

/ flow, composite and state variables /

qSeff	5.95E+05 m3/d
sbodSeff	1.51 gO2/m3
xbodSeff	15.5 gO2/m3
bodSeff	17 gO2/m3
boduSeff	25.8 gO2/m3
scodSeff	33.3 gCOD/m3
xcodSeff	30.7 gCOD/m3
codSeff	64 gCOD/m3
stknSeff	15.7 gN/m3
tknSeff	16 gN/m3
tnSeff	16 gN/m3
xiiSeff	5.41 g/m3
vssSeff	21.6 g/m3
xSeff	27.1 g/m3
cn states	
siSeff	31 g COD/m3
ssSeff	2.28 g COD/m3
xiSeff	6.38 g COD/m3
xsSeff	5.39 g COD/m3
xbhSeff	18.2 g COD/m3
xbaSeff	7.09E-09 g COD/m3
xuSeff	0.806 g COD/m3
soSeff	7.88 g O2/m3
snoSeff	1.00E-06 g N/m3
snhSeff	13 g N/m3

sndSeff	2.75 g N/m3
xndSeff	0.218 g N/m3
p states	
xbpSeff	7.09E-09 g COD/m3
xbtSeff	7.06E-09 g COD/m3
xppSeff	7.07E-09 g P/m3
slfSeff	0.000623 g COD/m3
spSeff	0.927 g P/m3

Label: (12,17)

/ physical /

real dimensions	
nR1	4
vsetupR1	1
vlconR1(1)	7533.15 m3
vlconR1(2)	7533.15 m3
vlconR1(3)	7533.15 m3
vlconR1(4)	7533.15 m3
vmconR1	30132.6 m3
fvconR1(1)	0.25 -
fvconR1(2)	0.25 -
fvconR1(3)	0.25 -
fvconR1(4)	0.25 -
oxygen solubility (if individual settings are used)	
depthR1	4.3 m
tempR1	13 C
airtempR1	20 C
pO2conR1	0.21 -

/ operational /

aeration control	
ctrlsolR1	.false.
pidformsolR1	1
controllersolR1	3
samplintconsolR1R1	999 d
setpsolR1(1)	2
setpsolR1(2)	2
setpsolR1(3)	2
setpsolR1(4)	2
gainsolR1	1
ticonsolR1	5 d
tdconsolR1	0.1 d
cellR1	0
directsolR1	.true.
nokicksolR1	.false.
Setup	
aermethodR1	2
alphaR1(1)	0.6 -
alphaR1(2)	0.7 -
alphaR1(3)	0.7 -
alphaR1(4)	0.8 -
betaR1	0.95 -
tklaR1	1.024 -
Kla	
klaconR1(1)	100 1/d
klaconR1(2)	100 1/d
klaconR1(3)	100 1/d
klaconR1(4)	100 1/d
klalminR1(1)	0 1/d
klalminR1(2)	0 1/d
klalminR1(3)	0 1/d
klalminR1(4)	0 1/d
klalmaxR1(1)	300 1/d
klalmaxR1(2)	300 1/d
klalmaxR1(3)	300 1/d
klalmaxR1(4)	300 1/d

Mechanical	
powerconR1(1)	627.2 kW
powerconR1(2)	440 kW
powerconR1(3)	440 kW
powerconR1(4)	440 kW
etapowerR1	3.5 kgO2/kWh
Diffused	
frairconR1(1)	0.25 -
frairconR1(2)	0.25 -
frairconR1(3)	0.25 -
frairconR1(4)	0.25 -
qairsumconR1	100000 m3/d
etasolR1	0.07 -
pumped flow control	
qcon4	5000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank4	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin4	0 m3/d
qmax4	100 m3/d
Internal flow distribution	
inputR1(1)	1 -
inputR1(2)	0 -
inputR1(3)	0 -
inputR1(4)	0 -
recinputR1(1)	1 -
recinputR1(2)	0 -
recinputR1(3)	0 -
recinputR1(4)	0 -

/ flow, composite and state variables /

qR1	7.68E+05 m3/d
sbodR1	1.51 gO2/m3
xbodR1	2.20E+03 gO2/m3
bodR1	2.20E+03 gO2/m3
boduR1	3.34E+03 gO2/m3
scodR1	33.3 gCOD/m3
xcodR1	4.36E+03 gCOD/m3
codR1	4.39E+03 gCOD/m3
stknR1	15.7 gN/m3
tknR1	46.7 gN/m3
tnR1	46.7 gN/m3
xiiR1	767 g/m3
vssR1	3.07E+03 g/m3
xR1	3.83E+03 g/m3
cn states	
siR1	31 g COD/m3
ssR1	2.28 g COD/m3
xiR1	904 g COD/m3
xsR1	763 g COD/m3
xbhR1	2.57E+03 g COD/m3
xbaR1	1.00E-06 g COD/m3
xuR1	114 g COD/m3
soR1	7.88 g O2/m3
snoR1	1.00E-06 g N/m3
snhR1	13 g N/m3
sndR1	2.75 g N/m3
xndR1	31 g N/m3
p states	
xbpR1	1.00E-06 g COD/m3
xbtR1	1.00E-06 g COD/m3
xppR1	1.00E-06 g P/m3

slfR1	0.000623 g COD/m3
spR1	0.927 g P/m3

Label: (15,16)

/ physical /

real dimensions	
vm26	10000 m3
oxygen solubility (if individual settings are used)	
depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control	
ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.
Setup	
aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -
Kla	
klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d
Mechanical	
powercon26	0 kW
etapower26	1.3 kgO2/kWh
Diffused	
qaircon26	0 m3/d
etasol26	0.07 -
pumped flow control	
qcon27	5000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	5.00E+03 m3/d
sbod26	1.51 gO2/m3
xbod26	9.73E+03 gO2/m3
bod26	9.73E+03 gO2/m3
bodu26	1.47E+04 gO2/m3
scod26	33.3 gCOD/m3
xcod26	1.92E+04 gCOD/m3
cod26	1.93E+04 gCOD/m3

stkn26	15.7	gN/m3
tkn26	152	gN/m3
tn26	152	gN/m3
xii26	3.39E+03	g/m3
vss26	1.35E+04	g/m3
x26	1.69E+04	g/m3
cn states		
si26	31	g COD/m3
ss26	2.28	g COD/m3
xi26	3.99E+03	g COD/m3
xs26	3.37E+03	g COD/m3
xbh26	1.14E+04	g COD/m3
xba26	4.44E-06	g COD/m3
xu26	504	g COD/m3
so26	10.6	g O2/m3
sno26	1.00E-06	g N/m3
snh26	13	g N/m3
snd26	2.75	g N/m3
xnd26	137	g N/m3
p states		
xbp26	4.43E-06	g COD/m3
xbt26	4.41E-06	g COD/m3
xpp26	4.42E-06	g P/m3
slf26	0.000623	g COD/m3
sp26	0.927	g P/m3

REPORT

SCENARIO - ALT4second

Label: SYSTEM		
time		
tstop	0	d
cint	0.05	d
ztime(1)	1994	yr,m,d,h
ztime(2)	11	yr,m,d,h
ztime(3)	1	yr,m,d,h
ztime(4)	0	yr,m,d,h
ztime(5)	0	yr,m,d,h
ztime(6)	0	yr,m,d,h
itcon	0	d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun	0	
input files		
extype	2	
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth	4.3	m
temp	13	C
airtemp	20	C
pO2con	0.21	-
elev	0	m
patm0	1	atm
tempb20	20	C
g	9.80665	m/s2
eprice	0.07	$/kWh
std parameters		
steady	.false.	
retry	0	
eps	1.00E-10	
sumeps	10	
decr	0.982	
incr	1.003	
maxstepcon	0.5	
fdamping	1	
pinit	0.05	
prin	200	
iloop	0	
looplm	20000	
chstop	5000	
trim parameters		
printdsum	1.00E+10	d
primpronly	.true.	
dskip	50000	
static		
optmz	.false.	
timeseries	.true.	
ndimm	2	
npts	3	
peps	1.00E-03	
opteps	1.00E-06	

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06	
cc6	2.50E-08	
cc7	-1.62E-04	
cc8	0.004897	
cc9	6.47E-04	
system variables		
ialg	8	-
nstp	50	-
mint	1.00E-30	days
maxt	1.00E-01	days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05	m3/d
sbodpeff	82	gO2/m3
xbodpeff	90.4	gO2/m3
bodpeff	172	gO2/m3
bodupeff	292	gO2/m3
scodpeff	170	gCOD/m3
xcodpeff	208	gCOD/m3
codpeff	378	gCOD/m3
stknpeff	22	gN/m3
tknpeff	25.9	gN/m3
tnpeff	25.9	gN/m3
xiipeff	44.3	g/m3
vsspeff	140	g/m3
xpeff	185	g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	0	m3/d
sbodbypass	84.8	gO2/m3
xbodbypass	47.2	gO2/m3
bodbypass	132	gO2/m3
bodubypass	224	gO2/m3
scodbypass	175	gCOD/m3
xcodbypass	82.2	gCOD/m3
codbypass	257	gCOD/m3
stknbypass	22	gN/m3
tknbypass	24.2	gN/m3
tnbypass	24.2	gN/m3
xiibypass	20.2	g/m3
vssbypass	55.5	g/m3
xbypass	75.8	g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	5.91E+05 m3/d
sbodFeff	0.916 gO2/m3
xbodFeff	9.29 gO2/m3
bodFeff	10.2 gO2/m3
boduFeff	15.5 gO2/m3
scodFeff	32.4 gCOD/m3
xcodFeff	21.5 gCOD/m3
codFeff	53.9 gCOD/m3
stknFeff	3.08 gN/m3
tknFeff	3.16 gN/m3
tnFeff	10.2 gN/m3
xiiFeff	3.78 g/m3
vssFeff	15.1 g/m3
xFeff	18.9 g/m3
cn states	
siFeff	31 g COD/m3
ssFeff	1.39 g COD/m3
xiFeff	5.81 g COD/m3
xsFeff	1.47 g COD/m3
xbhFeff	11.5 g COD/m3
xbaFeff	1.15 g COD/m3
xuFeff	1.6 g COD/m3
soFeff	7.56 g O2/m3
snoFeff	7.06 g N/m3
snhFeff	0.133 g N/m3
sndFeff	2.95 g N/m3
xndFeff	0.0756 g N/m3
p states	
xbpFeff	5.64E-09 g COD/m3
xbtFeff	5.56E-09 g COD/m3
xppFeff	5.59E-09 g P/m3
slfFeff	4.90E-05 g COD/m3
spFeff	0.819 g P/m3

Label: (14,17)

/ physical /

real dimensions	
*aSeff	20339 m2
hmSeff	3.65 m
hfSeff	1.6 m
model dimensions	
nSeff	10

/ operational /

underflow	
proprecSeff	.true.
cvarr	peff
recfracSeff	0.45 -
qconRAS	67930 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvars	blank
samplintconblankRAS	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qminRAS	1000 m3/d
qmaxRAS	100000 m3/d
pumped flow	
*qconWAS	9000 m3/d

decanterSeff	.false.	
outputSeff(1)	0	
outputSeff(2)	0	
outputSeff(3)	0	
outputSeff(4)	0	
outputSeff(5)	0	
outputSeff(6)	0	
outputSeff(7)	0	
outputSeff(8)	0	
outputSeff(9)	0	
outputSeff(10)	1	
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblankWAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminWAS	0	m3/d
qmaxWAS	10000	m3/d
model parameters		
xtSeff	2000	gTSS/m3
hscritSeff	0.1	m

/ settling /

double exponential parameters		
svionSeff	.true.	
sviSeff	100	ml/g
clarifSeff	0.5	-
vbndSeff	274	m/d
vmaxconSeff	410	m/d
rhinconSeff	0.0004	m3/gTSS
rfloconSeff	0.0025	m3/gTSS
fnsSeff	0.001	-
xminmaxSeff	20	gTSS/m3
flow distribution		
vumiSeff	100	m/d
vumaSeff	300	m/d

/ flow, composite and state variables /

qSeff	5.91E+05	m3/d
sbodSeff	0.916	gO2/m3
xbodSeff	9.29	gO2/m3
bodSeff	10.2	gO2/m3
boduSeff	15.5	gO2/m3
scodSeff	32.4	gCOD/m3
xcodSeff	21.5	gCOD/m3
codSeff	53.9	gCOD/m3
stknSeff	3.08	gN/m3
tknSeff	3.16	gN/m3
tnSeff	10.2	gN/m3
xiiSeff	3.78	g/m3
vssSeff	15.1	g/m3
xSeff	18.9	g/m3
cn states		
siSeff	31	g COD/m3
ssSeff	1.39	g COD/m3
xiSeff	5.81	g COD/m3
xsSeff	1.47	g COD/m3
xbhSeff	11.5	g COD/m3
xbaSeff	1.15	g COD/m3
xuSeff	1.6	g COD/m3
soSeff	7.56	g O2/m3
snoSeff	7.06	g N/m3
snhSeff	0.133	g N/m3

sndSeff	2.95	g N/m3
xndSeff	0.0756	g N/m3
p states		
xbpSeff	5.64E-09	g COD/m3
xbtSeff	5.56E-09	g COD/m3
xppSeff	5.59E-09	g P/m3
slfSeff	4.90E-05	g COD/m3
spSeff	0.819	g P/m3

Label: (12,17)

/ physical /

real dimensions		
nR1	4	
vsetupR1	1	
vlconR1(1)	7533.15	m3
vlconR1(2)	7533.15	m3
vlconR1(3)	7533.15	m3
vlconR1(4)	7533.15	m3
*vmconR1	1.11E+05	m3
fvconR1(1)	0.25	-
fvconR1(2)	0.25	-
fvconR1(3)	0.25	-
fvconR1(4)	0.25	-
oxygen solubility (if individual settings are used)		
depthR1	4.3	m
tempR1	13	C
airtempR1	20	C
pO2conR1	0.21	-

/ operational /

aeration control		
ctrlsolR1	.false.	
pidformsolR1	1	
controllersolR1	3	
samplintconsolR1R1	999	d
setpsolR1(1)	2	
setpsolR1(2)	2	
setpsolR1(3)	2	
setpsolR1(4)	2	
gainsolR1	1	
ticonsolR1	5	d
tdconsolR1	0.1	d
cellR1	0	
directsolR1	.true.	
nokicksolR1	.false.	
Setup		
aermethodR1	2	
alphaR1(1)	0.6	-
alphaR1(2)	0.7	-
alphaR1(3)	0.7	-
alphaR1(4)	0.8	-
betaR1	0.95	-
tklaR1	1.024	-
Kla		
klaconR1(1)	100	1/d
klaconR1(2)	100	1/d
klaconR1(3)	100	1/d
klaconR1(4)	100	1/d
klaminR1(1)	0	1/d
klaminR1(2)	0	1/d
klaminR1(3)	0	1/d
klaminR1(4)	0	1/d
klamaxR1(1)	300	1/d
klamaxR1(2)	300	1/d
klamaxR1(3)	300	1/d
klamaxR1(4)	300	1/d

Mechanical		
*powerconR1(1)	1200.2	kW
*powerconR1(2)	880	kW
*powerconR1(3)	880	kW
*powerconR1(4)	880	kW
etapowerR1	3.5	kgO2/kWh
Diffused		
fraironR1(1)	0.25	-
fraironR1(2)	0.25	-
fraironR1(3)	0.25	-
fraironR1(4)	0.25	-
qairsumconR1	100000	m3/d
etasolR1	0.07	-
pumped flow control		
qcon4	9000	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblank4	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qmin4	0	m3/d
qmax4	100	m3/d
Internal flow distribution		
inputR1(1)	1	-
inputR1(2)	0	-
inputR1(3)	0	-
inputR1(4)	0	-
recinputR1(1)	1	-
recinputR1(2)	0	-
recinputR1(3)	0	-
recinputR1(4)	0	-

/ flow, composite and state variables /

qR1	8.70E+05	m3/d
sbodR1	0.916	gO2/m3
xbodR1	1.67E+03	gO2/m3
bodR1	1.67E+03	gO2/m3
boduR1	2.53E+03	gO2/m3
scodR1	32.4	gCOD/m3
xcodR1	3.86E+03	gCOD/m3
codR1	3.89E+03	gCOD/m3
stknR1	3.08	gN/m3
tknR1	16.7	gN/m3
tnR1	23.7	gN/m3
xiiR1	680	g/m3
vssR1	2.72E+03	g/m3
xR1	3.40E+03	g/m3
cn states		
siR1	31	g COD/m3
ssR1	1.39	g COD/m3
xiR1	1.04E+03	g COD/m3
xsR1	264	g COD/m3
xbhR1	2.06E+03	g COD/m3
xbaR1	207	g COD/m3
xuR1	287	g COD/m3
soR1	7.56	g O2/m3
snoR1	7.06	g N/m3
snhR1	0.133	g N/m3
sndR1	2.95	g N/m3
xndR1	13.6	g N/m3
p states		
xbpR1	1.01E-06	g COD/m3
xbtR1	1.00E-06	g COD/m3
xppR1	1.00E-06	g P/m3

slfR1	4.90E-05 g COD/m3
spR1	0.819 g P/m3

Label: (15,16)

/ physical /

real dimensions	
vm26	10000 m3
oxygen solubility (if individual settings are used)	
depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control	
ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.
Setup	
aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -
Kla	
klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d
Mechanical	
powercon26	0 kW
etapower26	1.3 kgO2/kWh
Diffused	
qaircon26	0 m3/d
etasol26	0.07 -
pumped flow control	
qcon27	9000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	9.00E+03 m3/d
sbod26	0.915 gO2/m3
xbod26	5.19E+03 gO2/m3
bod26	5.19E+03 gO2/m3
bodu26	7.86E+03 gO2/m3
scod26	32.4 gCOD/m3
xcod26	1.20E+04 gCOD/m3
cod26	1.20E+04 gCOD/m3

stkn26	3.08 gN/m3
tkn26	45.3 gN/m3
tn26	52.4 gN/m3
xii26	2.11E+03 g/m3
vss26	8.45E+03 g/m3
x26	1.06E+04 g/m3
cn states	
si26	31 g COD/m3
ss26	1.39 g COD/m3
xi26	3.24E+03 g COD/m3
xs26	820 g COD/m3
xbh26	6.40E+03 g COD/m3
xba26	643 g COD/m3
xu26	892 g COD/m3
so26	10.6 g O2/m3
sno26	7.06 g N/m3
snh26	0.133 g N/m3
snd26	2.95 g N/m3
xnd26	42.2 g N/m3
p states	
xbp26	3.15E-06 g COD/m3
xbt26	3.11E-06 g COD/m3
xpp26	3.12E-06 g P/m3
slf26	4.90E-05 g COD/m3
sp26	0.819 g P/m3

REPORT
SCENARIO - ALT5new

Label: SYSTEM		
time		
tstop	0	d
cint	0.05	d
ztime(1)	1994	yr,m,d,h
ztime(2)	11	yr,m,d,h
ztime(3)	1	yr,m,d,h
ztime(4)	0	yr,m,d,h
ztime(5)	0	yr,m,d,h
ztime(6)	0	yr,m,d,h
itcon	0	d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun	0	
input files		
extype	2	
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth	4.3	m
temp	13	C
airtemp	20	C
pO2con	0.21	-
elev	0	m
patm0	1	atm
tempb20	20	C
g	9.80665	m/s2
eprice	0.07	$/kWh
std parameters		
steady	.false.	
retry	0	
eps	1.00E-10	
sumeps	10	
decr	0.982	
incr	1.003	
maxstepcon	0.5	
fdamping	1	
pinit	0.05	
prin	200	
iloop	0	
looplm	20000	
chstop	5000	
trim parameters		
printdsum	1.00E+10	d
primpronly	.true.	
dskip	50000	
static		
optmz	.false.	
timeseries	.true.	
ndimm	2	
npts	3	
peps	1.00E-03	
opteps	1.00E-06	

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06
cc6	2.50E-08
cc7	-1.62E-04
cc8	0.004897
cc9	6.47E-04
system variables	
ialg	8 -
nstp	50 -
mint	1.00E-30 days
maxt	1.00E-01 days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05 m3/d
sbodpeff	76.8 gO2/m3
xbodpeff	72.7 gO2/m3
bodpeff	149 gO2/m3
bodupeff	241 gO2/m3
scodpeff	155 gCOD/m3
xcodpeff	157 gCOD/m3
codpeff	312 gCOD/m3
stknpeff	22 gN/m3
tknpeff	25.1 gN/m3
tnpeff	25.1 gN/m3
xiipeff	32.8 g/m3
vsspeff	106 g/m3
xpeff	139 g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	2.30E+05 m3/d
sbodbypass	76.8 gO2/m3
xbodbypass	72.7 gO2/m3
bodbypass	149 gO2/m3
bodubypass	241 gO2/m3
scodbypass	155 gCOD/m3
xcodbypass	157 gCOD/m3
codbypass	312 gCOD/m3
stknbypass	22 gN/m3
tknbypass	25.1 gN/m3
tnbypass	25.1 gN/m3
xiibypass	32.8 g/m3
vssbypass	106 g/m3
xbypass	139 g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	8.25E+05 m3/d
sbodFeff	22.7 gO2/m3
xbodFeff	31.2 gO2/m3
bodFeff	54 gO2/m3
boduFeff	85.9 gO2/m3
scodFeff	67.2 gCOD/m3
xcodFeff	65.9 gCOD/m3
codFeff	133 gCOD/m3
stknFeff	17.5 gN/m3
tknFeff	18.5 gN/m3
tnFeff	18.5 gN/m3
xiiFeff	13 g/m3
vssFeff	45.2 g/m3
xFeff	58.2 g/m3
cn states	
siFeff	31 g COD/m3
ssFeff	36.2 g COD/m3
xiFeff	15.6 g COD/m3
xsFeff	36.6 g COD/m3
xbhFeff	13.1 g COD/m3
xbaFeff	5.11E-09 g COD/m3
xuFeff	0.581 g COD/m3
soFeff	5.68 g O2/m3
snoFeff	7.21E-07 g N/m3
snhFeff	15.2 g N/m3
sndFeff	2.26 g N/m3
xndFeff	1.02 g N/m3
p states	
xbpFeff	5.11E-09 g COD/m3
xbtFeff	5.09E-09 g COD/m3
xppFeff	5.10E-09 g P/m3
slfFeff	0.000449 g COD/m3
spFeff	1.62 g P/m3

Label: (14,17)

/ physical /

real dimensions	
aSeff	14264.8 m2
hmSeff	3.65 m
hfSeff	1.6 m
model dimensions	
nSeff	10

/ operational /

underflow	
proprecSeff	.true.
cvarr	peff
recfracSeff	0.28 -
qconRAS	67930 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvars	blank
samplintconblankRAS	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qminRAS	1000 m3/d
qmaxRAS	100000 m3/d
pumped flow	
qconWAS	5000 m3/d

decanterSeff	.false.	
outputSeff(1)	0	
outputSeff(2)	0	
outputSeff(3)	0	
outputSeff(4)	0	
outputSeff(5)	0	
outputSeff(6)	0	
outputSeff(7)	0	
outputSeff(8)	0	
outputSeff(9)	0	
outputSeff(10)	1	
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblankWAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminWAS	0	m3/d
qmaxWAS	10000	m3/d
model parameters		
xtSeff	2000	gTSS/m3
hscritSeff	0.1	m

/ settling /

double exponential parameters		
svionSeff	.true.	
sviSeff	100	ml/g
clarifSeff	0.5	-
vbndSeff	274	m/d
vmaxconSeff	410	m/d
rhinconSeff	0.0004	m3/gTSS
rfloconSeff	0.0025	m3/gTSS
fnsSeff	0.001	-
xminmaxSeff	20	gTSS/m3
flow distribution		
vumiSeff	100	m/d
vumaSeff	300	m/d

/ flow, composite and state variables /

qSeff	5.95E+05	m3/d
sbodSeff	1.51	gO2/m3
xbodSeff	15.5	gO2/m3
bodSeff	17	gO2/m3
boduSeff	25.8	gO2/m3
scodSeff	33.3	gCOD/m3
xcodSeff	30.7	gCOD/m3
codSeff	64	gCOD/m3
stknSeff	15.7	gN/m3
tknSeff	16	gN/m3
tnSeff	16	gN/m3
xiiSeff	5.41	g/m3
vssSeff	21.6	g/m3
xSeff	27.1	g/m3
cn states		
siSeff	31	g COD/m3
ssSeff	2.28	g COD/m3
xiSeff	6.38	g COD/m3
xsSeff	5.39	g COD/m3
xbhSeff	18.2	g COD/m3
xbaSeff	7.09E-09	g COD/m3
xuSeff	0.806	g COD/m3
soSeff	7.88	g O2/m3
snoSeff	1.00E-06	g N/m3
snhSeff	13	g N/m3

sndSeff	2.75 g N/m3
xndSeff	0.218 g N/m3
p states	
xbpSeff	7.09E-09 g COD/m3
xbtSeff	7.06E-09 g COD/m3
xppSeff	7.07E-09 g P/m3
slfSeff	0.000623 g COD/m3
spSeff	0.927 g P/m3

Label: (12,17)

/ physical /

real dimensions	
nR1	4
vsetupR1	1
vlconR1(1)	7533.15 m3
vlconR1(2)	7533.15 m3
vlconR1(3)	7533.15 m3
vlconR1(4)	7533.15 m3
vmconR1	30132.6 m3
fvconR1(1)	0.25 -
fvconR1(2)	0.25 -
fvconR1(3)	0.25 -
fvconR1(4)	0.25 -
oxygen solubility (if individual settings are used)	
depthR1	4.3 m
tempR1	13 C
airtempR1	20 C
pO2conR1	0.21 -

/ operational /

aeration control	
ctrlsolR1	.false.
pidformsolR1	1
controllersolR1	3
samplintconsolR1R1	999 d
setpsolR1(1)	2
setpsolR1(2)	2
setpsolR1(3)	2
setpsolR1(4)	2
gainsolR1	1
ticonsolR1	5 d
tdconsolR1	0.1 d
cellR1	0
directsolR1	.true.
nokicksolR1	.false.
Setup	
aermethodR1	2
alphaR1(1)	0.6 -
alphaR1(2)	0.7 -
alphaR1(3)	0.7 -
alphaR1(4)	0.8 -
betaR1	0.95 -
tklaR1	1.024 -
Kla	
klaconR1(1)	100 1/d
klaconR1(2)	100 1/d
klaconR1(3)	100 1/d
klaconR1(4)	100 1/d
klaminR1(1)	0 1/d
klaminR1(2)	0 1/d
klaminR1(3)	0 1/d
klaminR1(4)	0 1/d
klamaxR1(1)	300 1/d
klamaxR1(2)	300 1/d
klamaxR1(3)	300 1/d
klamaxR1(4)	300 1/d

Mechanical		
powerconR1(1)	627.2	kW
powerconR1(2)	440	kW
powerconR1(3)	440	kW
powerconR1(4)	440	kW
etapowerR1	3.5	kgO2/kWh
Diffused		
fraírconR1(1)	0.25	-
fraírconR1(2)	0.25	-
fraírconR1(3)	0.25	-
fraírconR1(4)	0.25	-
qairsumconR1	100000	m3/d
etasolR1	0.07	-
pumped flow control		
qcon4	5000	m3/d
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblank4	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qmin4	0	m3/d
qmax4	100	m3/d
Internal flow distribution		
inputR1(1)	1	-
inputR1(2)	0	-
inputR1(3)	0	-
inputR1(4)	0	-
recinputR1(1)	1	-
recinputR1(2)	0	-
recinputR1(3)	0	-
recinputR1(4)	0	-

/ flow, composite and state variables /

qR1	7.68E+05	m3/d
sbodR1	1.51	gO2/m3
xbodR1	2.20E+03	gO2/m3
bodR1	2.20E+03	gO2/m3
boduR1	3.34E+03	gO2/m3
scodR1	33.3	gCOD/m3
xcodR1	4.36E+03	gCOD/m3
codR1	4.39E+03	gCOD/m3
stknR1	15.7	gN/m3
tknR1	46.7	gN/m3
tnR1	46.7	gN/m3
xiiR1	767	g/m3
vssR1	3.07E+03	g/m3
xR1	3.83E+03	g/m3
cn states		
siR1	31	g COD/m3
ssR1	2.28	g COD/m3
xiR1	904	g COD/m3
xsR1	763	g COD/m3
xbhR1	2.57E+03	g COD/m3
xbaR1	1.00E-06	g COD/m3
xuR1	114	g COD/m3
soR1	7.88	g O2/m3
snoR1	1.00E-06	g N/m3
snhR1	13	g N/m3
sndR1	2.75	g N/m3
xndR1	31	g N/m3
p states		
xbpR1	1.00E-06	g COD/m3
xbtR1	1.00E-06	g COD/m3
xppR1	1.00E-06	g P/m3

slfR1	0.000623 g COD/m3
spR1	0.927 g P/m3

Label: (15,16)

/ physical /

real dimensions	
vm26	10000 m3
oxygen solubility (if individual settings are used)	
depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control	
ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.
Setup	
aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -
Kla	
klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d
Mechanical	
powercon26	0 kW
etapower26	1.3 kgO2/kWh
Diffused	
qaircon26	0 m3/d
etasol26	0.07 -
pumped flow control	
qcon27	5000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	5.00E+03 m3/d
sbod26	1.51 gO2/m3
xbod26	9.73E+03 gO2/m3
bod26	9.73E+03 gO2/m3
bodu26	1.47E+04 gO2/m3
scod26	33.3 gCOD/m3
xcod26	1.92E+04 gCOD/m3
cod26	1.93E+04 gCOD/m3

stkn26	15.7	gN/m3
tkn26	152	gN/m3
tn26	152	gN/m3
xii26	3.39E+03	g/m3
vss26	1.35E+04	g/m3
x26	1.69E+04	g/m3
cn states		
si26	31	g COD/m3
ss26	2.28	g COD/m3
xi26	3.99E+03	g COD/m3
xs26	3.37E+03	g COD/m3
xbh26	1.14E+04	g COD/m3
xba26	4.44E-06	g COD/m3
xu26	504	g COD/m3
so26	10.6	g O2/m3
sno26	1.00E-06	g N/m3
snh26	13	g N/m3
snd26	2.75	g N/m3
xnd26	137	g N/m3
p states		
xbp26	4.43E-06	g COD/m3
xbt26	4.41E-06	g COD/m3
xpp26	4.42E-06	g P/m3
slf26	0.000623	g COD/m3
sp26	0.927	g P/m3

REPORT

SCENARIO - ALT6new

Label: SYSTEM

time		
tstop	0	d
cint	0.05	d
ztime(1)	1994	yr,m,d,h
ztime(2)	11	yr,m,d,h
ztime(3)	1	yr,m,d,h
ztime(4)	0	yr,m,d,h
ztime(5)	0	yr,m,d,h
ztime(6)	0	yr,m,d,h
itcon	0	d
roundsec	.false.	
roundminute	.false.	
repeat runs		
rerun	0	
input files		
extype	2	
plantname1	blank	
plantname2	blank	
plantname3	blank	
plantname4	blank	
plantname5	blank	
plantname6	blank	
plantname7	blank	
plantname8	blank	
plantname9	blank	
plantname10	blank	
output files		
globalalarmfile	.false.	
afn	blank	
oxygen solubility (if global settings are used)		
global	.false.	
depth	4.3	m
temp	13	C
airtemp	20	C
pO2con	0.21	-
elev	0	m
patm0	1	atm
tempb20	20	C
g	9.80665	m/s2
eprice	0.07	$/kWh
std parameters		
steady	.false.	
retry	0	
eps	1.00E-10	
sumeps	10	
decr	0.982	
incr	1.003	
maxstepcon	0.5	
fdamping	1	
pinit	0.05	
prin	200	
iloop	0	
looplm	20000	
chstop	5000	
trim parameters		
printdsum	1.00E+10	d
primpronly	.true.	
dskip	50000	
static		
optmz	.false.	
timeseries	.true.	
ndimm	2	
npts	3	
peps	1.00E-03	
opteps	1.00E-06	

bestobj	0.1	
itmax	100	
optstep	0.2	
optalpha	0.95	
optbeta	0.45	
optgamma	1.9	
optdelta	0.5	
DPE		
dynpe	.false.	
timewindow	1.00E+10	d
on-line run		
online	.false.	
syncdata	.false.	
data transfer		
datatransfer	.false.	
maxnvars	100	
maxdatapoints	100	
ADF		
adfsize	128	
database		
databasetype	1	
rsample	60	s
communication		
g2	.false.	
portno	22041	
gfxin	.false.	
gfx	.false.	
pc	.false.	
matlab	.false.	
warnings	.true.	
optwarnings	.true.	
dpewarnings	.true.	
bounding		
itnum	30	-
error	1.00E-06	-
minflow	1.00E-10	m3/d
maxflow	1.00E+10	m3/d
miniconc	1.00E-06	g/m3
maxiconc	1.00E+10	g/m3
minconc	0	g/m3
maxconc	1.00E+10	g/m3
minder	-1.00E+33	g/m3/d
maxder	1.00E+33	g/m3/d
minvol	1.00E-10	m3
startvol	1.00E-01	m3
minlayer	1.00E-03	m
maxvol	1.00E+10	m3
minpar	1.00E-10	
maxpar	1.00E+10	
maxint	999999	
padbyz	1.00E-10	
maxexp	1.00E+03	g/m3
speed		
lowconcapprox	.false.	
lowrelder	200	g/m3/d
lowconc	0.03	g/m3
lowconcdamp	0.001	
approxdo	0	g/m3
smoothpump	.false.	
pumpdelay	1.00E-05	d
parsmooth	15	-
pumpsteplimit	50	%
general		
pi	3.14159265	
samplintcon	999	d
pidstddamp	1000	d
SVI correlation constants		
cc1	709.7	
cc2	-4.67	
cc3	0.018	
cc4	2.66E-04	

cc5	-2.85E-06
cc6	2.50E-08
cc7	-1.62E-04
cc8	0.004897
cc9	6.47E-04
system variables	
ialg	8 -
nstp	50 -
mint	1.00E-30 days
maxt	1.00E-01 days

Label: USER

Label: (11,18)

/ operational /

loadtypepeff	1
flowtypepeff	1

/ flow, composite and state variables /

qpeff	6.00E+05 m3/d
sbodpeff	76.8 gO2/m3
xbodpeff	72.7 gO2/m3
bodpeff	149 gO2/m3
bodupeff	241 gO2/m3
scodpeff	155 gCOD/m3
xcodpeff	157 gCOD/m3
codpeff	312 gCOD/m3
stknpeff	22 gN/m3
tknpeff	25.1 gN/m3
tnpeff	25.1 gN/m3
xiipeff	32.8 g/m3
vsspeff	106 g/m3
xpeff	139 g/m3

Label: (13,18)

/ operational /

loadtypebypass	1
flowtypebypass	1

/ flow, composite and state variables /

qbypass	4.60E+05 m3/d
sbodbypass	76.8 gO2/m3
xbodbypass	72.7 gO2/m3
bodbypass	149 gO2/m3
bodubypass	241 gO2/m3
scodbypass	155 gCOD/m3
xcodbypass	157 gCOD/m3
codbypass	312 gCOD/m3
stknbypass	22 gN/m3
tknbypass	25.1 gN/m3
tnbypass	25.1 gN/m3
xiibypass	32.8 g/m3
vssbypass	106 g/m3
xbypass	139 g/m3

Label: (16,18)

/ flow, composite and state variables /

qFeff	1.06E+06 m3/d
sbodFeff	34.5 gO2/m3
xbodFeff	40.2 gO2/m3
bodFeff	74.8 gO2/m3
boduFeff	120 gO2/m3
scodFeff	86.4 gCOD/m3
xcodFeff	85.8 gCOD/m3
codFeff	172 gCOD/m3
stknFeff	18.5 gN/m3
tknFeff	19.9 gN/m3
tnFeff	19.9 gN/m3
xiiFeff	17.3 g/m3
vssFeff	58.5 g/m3
xFeff	75.8 g/m3
cn states	
siFeff	31 g COD/m3
ssFeff	55.4 g COD/m3
xiFeff	20.9 g COD/m3
xsFeff	54.2 g COD/m3
xbhFeff	10.2 g COD/m3
xbaFeff	4.00E-09 g COD/m3
xuFeff	0.454 g COD/m3
soFeff	4.44 g O2/m3
snoFeff	5.64E-07 g N/m3
snhFeff	16.5 g N/m3
sndFeff	1.98 g N/m3
xndFeff	1.47 g N/m3
p states	
xbpFeff	4.00E-09 g COD/m3
xbtFeff	3.98E-09 g COD/m3
xppFeff	3.99E-09 g P/m3
slfFeff	0.000351 g COD/m3
spFeff	2.01 g P/m3

Label: (14,17)

/ physical /

real dimensions	
aSeff	14264.8 m2
hmSeff	3.65 m
hfSeff	1.6 m
model dimensions	
nSeff	10

/ operational /

underflow	
proprecSeff	.true.
cvarr	peff
recfracSeff	0.28 -
qconRAS	67930 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvars	blank
samplintconblankRAS	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qminRAS	1000 m3/d
qmaxRAS	100000 m3/d
pumped flow	
qconWAS	5000 m3/d

decanterSeff	.false.	
outputSeff(1)	0	
outputSeff(2)	0	
outputSeff(3)	0	
outputSeff(4)	0	
outputSeff(5)	0	
outputSeff(6)	0	
outputSeff(7)	0	
outputSeff(8)	0	
outputSeff(9)	0	
outputSeff(10)	1	
ctrlblank	.false.	
pidformblank	1	
controllerblank	3	
cvarp	blank	
samplintconblankWAS	999	d
setpblank	1	
gainblank	1	
ticonblank	1	d
tdconblank	1	d
directblank	.true.	
nokickblank	.false.	
qminWAS	0	m3/d
qmaxWAS	10000	m3/d
model parameters		
xtSeff	2000	gTSS/m3
hscritSeff	0.1	m
/ settling /		
double exponential parameters		
svionSeff	.true.	
sviSeff	100	ml/g
clarifSeff	0.5	-
vbndSeff	274	m/d
vmaxconSeff	410	m/d
rhinconSeff	0.0004	m3/gTSS
rfloconSeff	0.0025	m3/gTSS
fnsSeff	0.001	-
xminmaxSeff	20	gTSS/m3
flow distribution		
vumiSeff	100	m/d
vumaSeff	300	m/d
/ flow, composite and state variables /		
qSeff	5.95E+05	m3/d
sbodSeff	1.51	gO2/m3
xbodSeff	15.5	gO2/m3
bodSeff	17	gO2/m3
boduSeff	25.8	gO2/m3
scodSeff	33.3	gCOD/m3
xcodSeff	30.7	gCOD/m3
codSeff	64	gCOD/m3
stknSeff	15.7	gN/m3
tknSeff	16	gN/m3
tnSeff	16	gN/m3
xiiSeff	5.41	g/m3
vssSeff	21.6	g/m3
xSeff	27.1	g/m3
cn states		
siSeff	31	g COD/m3
ssSeff	2.28	g COD/m3
xiSeff	6.38	g COD/m3
xsSeff	5.39	g COD/m3
xbhSeff	18.2	g COD/m3
xbaSeff	7.09E-09	g COD/m3
xuSeff	0.806	g COD/m3
soSeff	7.88	g O2/m3
snoSeff	1.00E-06	g N/m3
snhSeff	13	g N/m3

sndSeff	2.75	g N/m3
xndSeff	0.218	g N/m3
p states		
xbpSeff	7.09E-09	g COD/m3
xbtSeff	7.06E-09	g COD/m3
xppSeff	7.07E-09	g P/m3
slfSeff	0.000623	g COD/m3
spSeff	0.927	g P/m3

Label: (12,17)

/ physical /

real dimensions		
nR1	4	
vsetupR1	1	
vlconR1(1)	7533.15	m3
vlconR1(2)	7533.15	m3
vlconR1(3)	7533.15	m3
vlconR1(4)	7533.15	m3
vmconR1	30132.6	m3
fvconR1(1)	0.25	-
fvconR1(2)	0.25	-
fvconR1(3)	0.25	-
fvconR1(4)	0.25	-
oxygen solubility (if individual settings are used)		
depthR1	4.3	m
tempR1	13	C
airtempR1	20	C
pO2conR1	0.21	-

/ operational /

aeration control		
ctrlsolR1	.false.	
pidformsolR1	1	
controllersolR1	3	
samplintconsolR1R1	999	d
setpsolR1(1)	2	
setpsolR1(2)	2	
setpsolR1(3)	2	
setpsolR1(4)	2	
gainsolR1	1	
ticonsolR1	5	d
tdconsolR1	0.1	d
cellR1	0	
directsolR1	.true.	
nokicksolR1	.false.	
Setup		
aermethodR1	2	
alphaR1(1)	0.6	-
alphaR1(2)	0.7	-
alphaR1(3)	0.7	-
alphaR1(4)	0.8	-
betaR1	0.95	-
tklaR1	1.024	-
Kla		
klaconR1(1)	100	1/d
klaconR1(2)	100	1/d
klaconR1(3)	100	1/d
klaconR1(4)	100	1/d
klalminR1(1)	0	1/d
klalminR1(2)	0	1/d
klalminR1(3)	0	1/d
klalminR1(4)	0	1/d
klalmaxR1(1)	300	1/d
klalmaxR1(2)	300	1/d
klalmaxR1(3)	300	1/d
klalmaxR1(4)	300	1/d

Mechanical	
powerconR1(1)	627.2 kW
powerconR1(2)	440 kW
powerconR1(3)	440 kW
powerconR1(4)	440 kW
etapowerR1	3.5 kgO2/kWh
Diffused	
fraircon R1(1)	0.25 -
fraircon R1(2)	0.25 -
fraircon R1(3)	0.25 -
fraircon R1(4)	0.25 -
qairsumconR1	100000 m3/d
etasolR1	0.07 -
pumped flow control	
qcon4	5000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank4	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin4	0 m3/d
qmax4	100 m3/d
Internal flow distribution	
inputR1(1)	1 -
inputR1(2)	0 -
inputR1(3)	0 -
inputR1(4)	0 -
recinputR1(1)	1 -
recinputR1(2)	0 -
recinputR1(3)	0 -
recinputR1(4)	0 -

/ flow, composite and state variables /

qR1	7.68E+05 m3/d
sbodR1	1.51 gO2/m3
xbodR1	2.20E+03 gO2/m3
bodR1	2.20E+03 gO2/m3
boduR1	3.34E+03 gO2/m3
scodR1	33.3 gCOD/m3
xcodR1	4.36E+03 gCOD/m3
codR1	4.39E+03 gCOD/m3
stknR1	15.7 gN/m3
tknR1	46.7 gN/m3
tnR1	46.7 gN/m3
xiiR1	767 g/m3
vssR1	3.07E+03 g/m3
xR1	3.83E+03 g/m3
cn states	
siR1	31 g COD/m3
ssR1	2.28 g COD/m3
xiR1	904 g COD/m3
xsR1	763 g COD/m3
xbhR1	2.57E+03 g COD/m3
xbaR1	1.00E-06 g COD/m3
xuR1	114 g COD/m3
soR1	7.88 g O2/m3
snoR1	1.00E-06 g N/m3
snhR1	13 g N/m3
sndR1	2.75 g N/m3
xndR1	31 g N/m3
p states	
xbpR1	1.00E-06 g COD/m3
xbtR1	1.00E-06 g COD/m3
xppR1	1.00E-06 g P/m3

slfR1	0.000623 g COD/m3
spR1	0.927 g P/m3

Label: (15,16)

/ physical /

real dimensions	
vm26	10000 m3
oxygen solubility (if individual settings are used)	
depth26	4 m
temp26	20 C
airtemp26	20 C
pO2con26	0.21 -

/ operational /

aeration control	
ctrlso26	.false.
pidformso26	1
controllerso26	3
samplintconso2626	999 d
setpso26	2
gainso26	1
ticonso26	5 d
tdconso26	0.1 d
directso26	.true.
nokickso26	.false.
Setup	
aermethod26	1
alpha26	0.8 -
beta26	0.95 -
tkla26	1.024 -
Kla	
klacon26	100 1/d
klamin26	0 1/d
klamax26	300 1/d
Mechanical	
powercon26	0 kW
etapower26	1.3 kgO2/kWh
Diffused	
qaircon26	0 m3/d
etasol26	0.07 -
pumped flow control	
qcon27	5000 m3/d
ctrlblank	.false.
pidformblank	1
controllerblank	3
cvarp	blank
samplintconblank27	999 d
setpblank	1
gainblank	1
ticonblank	1 d
tdconblank	1 d
directblank	.true.
nokickblank	.false.
qmin27	0 m3/d
qmax27	100 m3/d

/ flow, composite and state variables /

q26	5.00E+03 m3/d
sbod26	1.51 gO2/m3
xbod26	9.73E+03 gO2/m3
bod26	9.73E+03 gO2/m3
bodu26	1.47E+04 gO2/m3
scod26	33.3 gCOD/m3
xcod26	1.92E+04 gCOD/m3
cod26	1.93E+04 gCOD/m3

stkn26	15.7	gN/m3
tkn26	152	gN/m3
tn26	152	gN/m3
xii26	3.39E+03	g/m3
vss26	1.35E+04	g/m3
x26	1.69E+04	g/m3
cn states		
si26	31	g COD/m3
ss26	2.28	g COD/m3
xi26	3.99E+03	g COD/m3
xs26	3.37E+03	g COD/m3
xbh26	1.14E+04	g COD/m3
xba26	4.44E-06	g COD/m3
xu26	504	g COD/m3
so26	10.6	g O2/m3
sno26	1.00E-06	g N/m3
snh26	13	g N/m3
snd26	2.75	g N/m3
xnd26	137	g N/m3
p states		
xbp26	4.43E-06	g COD/m3
xbt26	4.41E-06	g COD/m3
xpp26	4.42E-06	g P/m3
slf26	0.000623	g COD/m3
sp26	0.927	g P/m3

APPENDIX 3

SLUDGE PRODUCTIONS

1. 600 ML/d (Alternative 1)

BOD = 212 mg/L

TSS = 250 mg/L

TKN = 27 mg/L

NH_3 = 18 mg/L

P_t = 3.5 mg/L

Secondary effluent requirements: BOD ≤ 25 mg/L
TSS ≤ 30 mg/L

Primary clarifier area = 6503.7 m^2

$SOR = \frac{600,000}{6503.7} = 92.3\ m^3/m^2 \cdot d$

Primary effluent quality: BOD = 167 mg/L
TSS = 150 mg/L

BOD load to secondary = 167 × 600 = 100,200 kg/d

By increasing the MLSS from 4000 mg/L to 4780 mg/L and maintaining SRT = 1.31, HRT = 1.2 hrs, the existing oxygenation reactors are able to treat the BOD load.

Model calculates that final clarifier needs expansion. Additional final clarifier area req'd = 3923 m^2

Secondary effluent quality: BOD = 13.9 mg/L
TSS = 22.4 mg/L
NH_3 = 12.0 mg/L

Sludge Production

Primary sludge solids = 600 × (250 - 150) = 60,000 kg/d

Secondary sludge solids:

a) Inert solids = 600 × (1 - 0.765) × 150 = 21,150 kg/d

b) VSS of WAS = 21101 × 5.2 - 21,150 = 88,575 kg/d

Chemical sludge solids = 0

SEWPCC/WEWPCC sludge solids = 12,094 kg/d

VSS = 7,484 kg/d

Total sludge solids = 60,000 + 21,150 + 88,575 + 12094 = 181,819 kg/d

Total sludge VSS = 60,000 × 0.765 + 88,575 × 0.95 + 7484 = 137,530 kg/d

Annual average raw sludge TSS = 3.47% (plant records)

Total sludge volume = $\frac{181,819}{3.47 \times 10}$ = 5,240 m³/d

Design SRT = 10 days, and allow SRT = HRT (no supernating)

Digester volume req'd = 5240 × 10 = 52,400 m³

Existing digester volume = 44,800 m³

Additional digester volume = 52400 - 44800 = <u>7600 m³</u>

Digester Sludge

Assume volatile solids reduction = 45%

Volatile solids remaining = 137,530 × 0.55 = 75,642

Inert solids = 181,819 - 157,941 = 23,878

99,528 kg/d < 217,700 kg/d

2. 600 ML/d (Alternative 2)

Increase primary removal efficiency is achieved by chemically enhanced primary treatment for the entire flow.

Current primary surface overflow rate is too high for settling of chemically treated particles which are lighter than raw sludge solids and settling velocity is slower. They require a lower surface overflow rate. Therefore the primary clarifier need expansion.

Based on max. surface overflow rate = 40 $m^3/m^2 \cdot d$

primary clarifier area required = $\frac{600\,000}{40}$ = 15,000 m^2

Additional primary clarifier area = 15,000 - 6530.7 = **8496 m^2**

Primary effluent quality: BOD = 110 mg/L
TSS = 49 mg/L

BOD load to secondary = 110 × 600 = 66,000 kg/d
MLSS = 2417 mg/L
SRT = 1.51 days
HRT = 1.2 hrs

Secondary effluent quality: BOD = 18.6 mg/L
TSS = 25.2 mg/L
NH_3 = 14.5 mg/L

Sludge Production

Primary sludge solids = 600×(250 - 49) = 120,600

Secondary sludge solids:

a) Inert solids = 600×(1-0.765)×49 = 6909 Kg/d

b) VSS of WAS = 10,673×4.5 - 6909 = 41,120 Kg/d

Chemical sludge solids = 600×32.25 = 19,350 Kg/d

SEWPCC/NEWPCC sludge solids = 12,094 Kg/d

VSS = 7,484 Kg/d

Total sludge solids = 120,600 + 6909 + 41,120 + 19,350 + 12,094 = 200,073 Kg/d

Total sludge VSS = 120600×0.765 + 41,120×0.95 + 7484 = 138,807 Kg/d

Total sludge volume = $\frac{200,073}{3.47 \times 10}$ = 5765.8 m³/d

Additional digester volume = 5765.8×10 - 44,800 = 12858 m³

Digested Sludge

Volatile solids remaining = 138807 × 0.55 = 76,344

Inert solids = 200,073 - 138807 = 61,266

137,610 Kg/d < 217,700 Kg/d

3. 600 ML/d (Alternative 3)

The primary treatment facility is expanded to achieve a removal of 30% BOD and 50% TSS and to reduce BOD load to secondary. Expansion of secondary is not required.

Additional primary clarifier req'd = $\frac{600\,000}{47}$ - 6503.7 = 6262 m^2

Primary effluent quality: BOD = 150 mg/L
TSS = 117 mg/L

BOD load to secondary = 150 × 600 = 90,000 kg/d

Model predicts reactor operating conditions and effluent quality:

MLSS = 3834 mg/L
SRT = 1.37 days
HRT = 1.2 hrs.

Secondary effluent quality: BOD = 17 mg/L
TSS = 27 mg/L
NH_3 = 13 mg/L

Sludge Production

Primary sludge solids = 600 × (250 − 117) = 79,800 kg/d

Secondary sludge solids:

a) Inert solids = 600 × (1 − 0.765) × 117 = 16,497 kg/d

b) VSS of WAS = 16928 × 5 − 16497 = 68,143 kg/d

Chemical sludge solids = 0

SEWPCC/WEWPCC sludge solids = 12,094 kg/d

VSS = 7,484 kg/d

Total sludge solids = 79,800 + 16,497 + 68,143 + 12,094 = 176,534 kg/d

Total sludge VSS = 79,800 × 0.765 + 68143 × 0.95 + 7484 = 133,267 kg/d

Total sludge volume = $\frac{176,534}{3.47 \times 10}$ = 5087.4 m³/d

Additional digester volume = 5087.4 × 10 − 44,800 = 6074 m³

Digested Sludge

Volatile solids remaining = 133 267 × 0.55 = 73,297

Inert solids = 176 534 − 133 267 = 43,267

Digested sludge solids = 116,564 kg/d < 217,700 kg/d

4. 600 Ml/d (Alternative 4) Nitrification Process

Flow = 600,000 m^3/d
BOD = 212 mg/l
TSS = 250 mg/l
TKN = 27 mg/l
NH_3 = 18 mg/l
P_t = 3.5 mg/l

Secondary effluent requirements: BOD = 25 mg/l
TSS = 30 mg/l
NH_3 = 5 mg/l

Primary clarifier area = 6503.7 m^2

$$SOR = \frac{600,000}{6503.7} = 92.3\ m^3/m^2 \cdot d$$

Primary effluent quality: BOD = 167 mg/l
TSS = 150 mg/l

BOD load to secondary = 167 × 600 = 100,200 kg/d

Model calculates additional tankage:
Additional oxygenation reactor = 90,399 - 30,312.6 = 60,086 m^3

Additional final clarifier = 20,339 - 14,264.8 = 6074 m^2

MLSS = 3580 mg/l
SRT = 3.4 days
HRT = 3.6 hrs.

Predicted effluent quality: BOD = 11.2 mg/L
TSS = 19.0 mg/L
NH_3 = 0.16 mg/L

Sludge Production

Primary sludge solids = 600 × (250 − 150) = 60000 kg/d

Secondary sludge solids:
a) Inert solids = 600 × (1 − 0.765) × 150 = 21,150 kg/d
b) VSS of WAS = 15736 × 6 − 21,150 = 73,266 kg/d

Chemical sludge solids = 0

SEWPCC/WEWPCC sludge solids = 12,094 kg/d
VSS = 7,484 kg/d

Total sludge solids = 60,000 + 21,150 + 73,266 + 12,094 = 166,510 kg/d
Total sludge VSS = 60,000 × 0.765 + 73,266 × 0.95 + 7484 = 122,987 kg/d
Total sludge volume = $\frac{166510}{3.47 \times 10}$ = 4798.6 m^3/d

Additional digester volume = 4798.6 × 10 − 44800 = 3186 m^3

Digested Sludge

Volatile solids remaining = 122,987 × 0.55 = 67643
Inert solids = 166510 − 67643 = 98,867

166,510 kg/d < 217,700 kg/d

5. 830 ML/d (Alternative 5)

The primary treatment facility is expanded to achieve a removal of 30% BOD_5 and 50% TSS for the entire flow. Primary effluent flow of 600 ML/d is further treated in the existing secondary treatment facility.

Additional primary clarifier req'd $= \frac{830000}{47} - 6503.7 = 11156\ m^2$

Primary effluent quality: $BOD_5 = 150$ mg/l
TSS = 117 mg/l

BOD load to secondary = 150 × 600 = 90,000 kg/d

Model predicts reactor operating conditions and effluent quality.
MLSS = 3834 mg/l
SRT = 1.37 days
HRT = 1.2 hrs

Secondary effluent quality: BOD = 17 mg/l
TSS = 27 mg/l
NH_3 = 13 mg/l

Combined final effluent quality: BOD = 54 mg/l
TSS = 58.2 mg/l
NH_3 = 15.2 mg/l

Sludge Production

Primary Sludge solids = 830 × (250 − 117) = 110,390 kg/d

Secondary sludge solids:

a) Inert solids = 600 × (1 − 0.765) × 117 = 16497 kg/d

b) VSS of WAS = 16,928 × 5 − 16,497 = 68,143 kg/d

Chemical sludge solids = 0

SEWPCC/NEWPCC sludge solids = 12,094 kg/d

VSS = 7484 kg/d

Total sludge solids = 110,390 + 16497 + 68,143 + 12,094 = 207,124 kg/d

Total sludge VSS = 110,390 × 0.765 + 68,143 × 0.95 + 7484 = 156,668 kg/d

Total sludge volume = $\frac{207124}{3.47 \times 10}$ = 5969 m³/d

Additional digester volume = 5969 × 10 − 44800 = **14,890 m³**

Digested Sludge

Volatile solids remaining = 156,668 × 0.55 = 86,167

Inert solids = 207124 − 156,668 = 50,456

136,623 kg/d < 217,700 kg/d

6. 1060 ML/d (Alternative 6)

This alternative is similar to Alternative 5

Additional primary clarifier req'd = $\frac{1060000}{47} - 6503.7 = 16{,}049\ m^2$

Primary effluent quality: $BOD_5 = 150$ mg/l
$TSS = 117$ mg/l

BOD load to secondary = 150 × 600 = 90,000 kg/d

Model predicts reactor operating conditions and effluent quality:
MLSS = 3834 mg/l
SRT = 1.37 days
HRT = 1.2 hrs

Secondary effluent quality: BOD = 17 mg/l
TSS = 27 mg/l
$NH_3 = 13$ mg/l

Combined final effluent quality: BOD = 74.8 mg/l
TSS = 75.6 mg/l
$NH_3 = 16.5$ mg/l

Sludge Production

Primary effluent solids = 1060 × (250 - 117) = 140,980 Kg/d

Secondary sludge solids:

a) Inert solids = 600 × (1-0.765) × 117 = 16,497 Kg/d

b) VSS of WAS = 16,928 × 5 - 16,497 = 68,143 Kg/d

Chemical sludge solids = 0

SEWPCC / WEWPCC sludge solids = 12,094 Kg/d

VSS = 7,484 Kg/d

Total sludge solids = 140,980 + 16,497 + 68,143 + 12,094 = 247,714 Kg/d

Total sludge VSS = 140,980 × 0.765 + 68143 × 0.95 + 7484 = 180,070 Kg/d

Total sludge volume = $\frac{247,714}{3.47 \times 10}$ = 7138.7 m^3/d

Additional digester volume = 7138.7 × 10 - 44800 = 26587 m^3

Digested Sludge

Volatile solids remaining = 180070 × 0.55 = 99,038

Inert solids = 247,714 - 180,070 = 67,644

166,682 Kg/d

≤ 217,700 Kg/d

APPENDIX 4

DEVELOPMENT OF UNIT COSTS

Appendix 4 - Development of Unit Costs

DEVELOPMENT OF FACILITY UNIT COST

Unit cost of treatment facility was developed with reference to the most recently contracts completed by CH2M Gore & Storrie Limited. Unit cost of various unit processes was first established using the construction contract price for the unit processes. Then the unit cost was brought up to January 1998 cost using ENR Construction Cost Index. The unit cost includes 11% for engineering but excludes land cost, tax and piling.

1. Final Clarifiers

Plant A located in the city north of Toronto was upgraded and expanded in March 1996. The construction work included covered final clarifiers, rotating biological contractors, flash & floc tanks, tertiary filters, and upgrades of various unit processes throughout the plant. Prior to request for tender, quantities were taken off from the design drawings for cost estimate. The cost estimate for the final clarifier of the project is shown in the following:

	Est. Cost, $
Final clarifiers	3,070,663.00
Return sludge pump gallery	153,146.00
Instrumentation, admin. building, 0.187%	6,028.52
Site works, 0.161%	5,190.33
General requirements including bonds, insurance, contractor's overhead & profit, mobilization/demobilization and temporary facilities, 7.7%	248,233.00
Construction contingency, 3.6%	116,057.12
Total	**3,599,317.97**

Structural area of the final clarifiers is 2481 m^2. Estimated cost is therefore $1450.75/$m^2$ excluding tax.

The construction tender was opened in March 1996. Contract price was 22% lower than the estimated cost. The above unit cost is adjusted accordingly. The unit cost is further adjusted using ENR Construction Cost Index and brought up to present cost and includes 11% for engineering and supervision but excludes tax.

The present unit cost for clarifier construction is calculated as follows:

Unit cost = 1450.75 x 0.78 x 5852 / 5537 x 1.11 = \$1327.52/m^2. Say, **\$1328/m^2 of structure area.**

2. Flash & Floc Tanks

The above project includes three flash mix & floc tanks for chemical treatment of wastewater for high phosphorus removal. The cost estimate for this facility of the project is shown in the following:

	Est. Cost, \$
Concrete tank & equipment	639,294.00
Instrumentation, admin. building, 0.187%	1,195.50
Site works, 0.161%	1,029.30
General requirements including bonds, insurance, contractor's overhead & profit, mobilization/demobilization and temporary facilities, 7.7%	49,225.60
Construction contingency, 3.6%	23,014.60
Total	**713,756.00**

The flash mix & floc tanks were designed to treat a peak flow of 106,000 m^3/d. Estimated unit cost is calculated \$6.733/m^3. The contract was signed in March 1996 with a contract price of 22% lower than the estimated cost. The unit cost is adjusted and brought up to present cost using ENR Construction Cost Index and includes 11% for engineering and supervision but excludes tax.

The present unit cost for construction of flash mix and floc tanks is calculated as follows:

Unit cost = 6.733 x 0.78 x 5852 / 5537 x 1.11 = \$6.16/m^3. Say, **\$6.20/m^3 of flow.**

3. Chemical Facility

Plant B located in the city northeast of Toronto was upgraded its chemical facility in October 1996. The project includes storage and dosing facilities for alum and for polymer. The chemical facility was designed to treat an average flow of 54,000 m^3/d and a peak flow of 100,000 m^3/d. Prior to the request for tender capital cost of the project was estimated from quantity taken off from the design drawings. The estimated capital cost of the facility applicable to this CSO project is listed in the following:

	Est. Cost, $
Yard works	56,820.00
Process equipment	145,041.00
Electrical	68,000.00
ICC	40,000.00
Structural	55,230.00
Architectural	200,000.00
HVAC	13,000.00
Chemical resistant coatings	7,440.00
Sub-total	585,531.00
General Requirements:	
Bonds, 1.5%	8,783.00
Insurance, 1.5%	8,873.00
Contractor's overhead/profit, 10%	58,553.00
Mobilization/demobilization (see note)	—
Temporary facilities (see note)	—
Total	**661,650.00**

Note: It is assumed that the chemical facility will be constructed simultaneously with the expansion of primary treatment in NEWPCC. The two items will be included in the major expansion works.

Unit cost = 661,650 / 100,000 = $6.617/m^3.

The construction tender was opened in October 1996. Contract price was 11% lower than the estimated cost. The above unit cost is adjusted accordingly. The unit cost is further updated using ENR Construction Cost Index and includes 11% for engineering and supervision but excludes tax.

The present unit cost is calculated as follows:

Unit cost = 6.617 x 0.89 x 5852 / 5719 x 1.11 = $6.69/m^3. Say, **$6.70/m^3 of flow.**

4. Oxygen Activated Sludge Reactors

There is no good reference for the construction cost of oxygenation reactors. Available information in the office is more than 20 year old and is considered not suitable for use. Since the oxygenation reactor is 1.5 m deeper than the final clarifier but no in-tank equipment. It is believed that the unit cost of final clarifier is applicable to oxygenation reactor.

5. Sludge Digesters

Plant C located in the city northeast of Toronto was expanded its sludge digestion facility in December 1989. The construction work included four digesters, one control building, and all necessary equipment for the sludge digestion. The sizes of the structures are listed as follows:

	Volume, m^3
Digester, 4 - 33.5ϕ x 11.46	40,404.00
Control building, 55 x 16.5 x 8.45	7,668.40
Tunnel, 5.5 x 4 x 87.03	1,914.66
Total	**49,987.06**

The construction contract of the facility was $20,000,000 excluding tax in December 1989. Unit cost in term of the digester volume was calculated $495/m^3$. The unit cost is adjusted using ENR Construction Cost Index and brought up to present cost and includes 11% for engineering and construction supervision but excludes tax.

The present unit cost for the sludge digestion facility is calculated as follows:

Unit cost = 495 x 5852 / 4685 x 1.11 = $686.32/m^3$, Say **$686.5/m^3$ of digester volume.**

6. Sludge Thickening and Dewatering Facility

Plant C also constructed a waste sludge thickening facility and a digested sludge dewatering facility in March 1990. The waste sludge thickening facility was designed for a waste sludge flow of 6,730 m^3/d and solid load of 35,420 kg/d. The digested sludge dewatering facility was designed for a digested sludge flow of 1,860 m^3/d and solid load of 56,080 kg/d. The two facilities were combined into one contract. The contract price for the project are listed as follows:

	Cost, $
Building construction	23,145,000.00
Equipment	12,431,000.00
Total	**35,576,000.00**

The contract price did not include tax. Unit cost in term of digested sludge solid load is calculated $634.38/kg. The unit cost is adjusted using ENR Construction Cost Index and brought up to present cost and includes 11% for engineering and construction supervision but excludes tax.

The present unit cost for the waste sludge thickening and digested sludge dewatering facility is calculated as follows:

Unit cost = 634.38 x 5852 / 4691 x 1.11 = $878.44/kg. Say **$878.50/kg of digested sludge solids.**

7. Chlorination and Dechlorination Facility

Capital costs for chlorination and dechlorination using sodium hypochlorite and sodium bisulfite are estimated as follows:

1. Chlorination Using Sodium Hypochlorite

Based on secondary by-pass flow of 230 ML/d

Assuming chlorine dosage = 10 mg/L

Chlorine required = 230 x 10 = 2300 kg/d

Sodium hypochlorite solution 12%

Sodium hypochlorite solution required = 230000/120 = 1,916.7 L/d

One truck load is approximately 18,900 L and lasts 9.8 days

A FRP tank of 27,000 L	$18,000
Pumps, valves and VFD	$19,000
Control panel	$12,500
Piping	$10,000
Concrete base	$5,500
Electrical	$10,000
Subtotal	$75,000

2. Chlorine Contact Tank

Allow detention time of 15 minutes,

Based on the estimated cost for the chlorine contact tank in the Fax of November 18, 1997. The estimated cost was calculated using a detention time of 30 minutes.

Capital cost = 446000/86 x 230 = $596,400.

3. Dechlorination Using Sodium Bisulfite

Assume residual chlorine = 1.0 mg/L

Sodium bisulfite required = 1.61 x 1.0 x 230 = 370.3 Kg/d

Sodium bisulfite density = 1.30 to 1.36, use 1.30 g/mL

Assume average TRS = 40%

Sodium bisulfite required = 370.3 / (1.3 x 0.4) = 712.1 L/d

One truck is approximately 15,100 L and lasts 21.25 days

A FRP tank of 27,000 L	$18,000
Pumps, valves and VFD	$19,000
Control panel (included)	–
Piping	$10,000
Concrete base	$5,500
Electrical (included)	–
Mixers	$20,000
Subtotal	$72,500

	Est. Cost, $
Chlorination	75,000
Contact Tank	596,400
Dechlorination	72,500
Subtotal	743,900
Instrumentation, admin. Building, 0.187%	1,400
Site works, 0.161%	1,200
General requirements, including bonds, insurance, contractor's overhead and profit, mobilization/demobilization and temporary facility, 7.7%	57,280
Construction contingency, 3.6%	26,780
Subtotal	830,560
Engineering & supervision, 11%	91,360
Total	921,910

Unite cost = 921,910/230,000 = **$ 4.00 per m^3 of flow**