SECTION 6.0
CANDIDATE TECHNOLOGIES

6.1 PREAMBLE

In Section 4.0, a long list of possible technologies that could be used to achieve nitrification at the City's three Water Pollution Control Centres (WPCCs) was developed. This Section describes the approach used to produce a short list of candidate technologies for nitrification for each plant to carry forward into the Conceptual Design Phase. In addition, the relevant considerations to accommodate any future requirement to implement Biological Nutrient Removal (BNR) at the three WPCCs are discussed.

6.2 CANDIDATE NITRIFICATION TECHNOLOGIES

6.2.1 Initial Short Listing

In order to reduce the list of possible technologies to a more manageable number, an initial screening was carried out at a Work Shop held on October 4 & 5, 1999 with the City Steering Committee. Each candidate technology was rated (pass or fail) against the following criteria for each of the three WPCCs. NEWPCC Centrate treatment processes were also rated against these criteria.

- Has been applied full scale elsewhere
- Capable of achieving some or all of the various ammonia limits being studied for Winnipeg
- Not overly complex or difficult to operate and maintain
- Environmentally and aesthetically appropriate (e.g. low potential for odour and visual impact)
- Has been proven to be economical in other similar situations
- Generally appropriate given the physical features of the City's three WPCCs
- Ability to treat the expected wet weather flows and loads

Based on the ratings, the technologies were grouped into the following three categories:

CATEGORY 1 – ADVANCE TO NEXT STAGE

- Clearly meets all pass-fail criteria

CATEGORY 2 – CONDITIONAL

- Shows promise but does not meet all criteria
- A parking spot for technologies that can be revisited later if required

CATEGORY 3 – ELIMINATE

- Clearly not appropriate for Winnipeg

The resulting ratings and categorization for each of the three plants and for centrate treatment at the NEWPCC are provided in the following sheets.

PLANT: **NEWPCC**

PROCESS

CRITERIA:	HPO Single Stage Nitrification	HPO Step Feed	HPO with Contact Stabilization Nitrification	Integrated Fixed Film - Hanging	Integrated Fixed Film - Floating	Integrated Immobilization	Membrane Treatment	2Nd Stage Stage Suspended Growth	2nd Stage Biological Aerated Filter (BAF)	2nd Stage Nitrifying Trickling Filter (NTF)	2nd Stage RBC	2nd Stage Nitrifying Fluidized Bed	HPO Two Stage Nitrification	Stripping	Ion Exchange	Breakpoint Chlorination	Periodic - CEPT/RAS Reaeration/Centrate Return	Periodic - Breakpoint Chlorination
Has been applied full-scale elsewhere	P	F	P				F	P	P	P							P	P
Capable of achieving some or all of the various ammonia limits being studied for Winnipeg	P	P (10 mg/l)	P				P	P	P+	P-							P	P
Not overly complex or difficult to operate and maintain	P	P	P				F	P	P-	P+							P	P
Environmentally and aesthetically appropriate (e.g. low potential for odour and visual impact)	P	P	P				P	P	P+	P-							P	P
Has been proven to be economical in other similar situations	P	P	P				F	F	P-	P+							P	P
Generally appropriate given the physical features of the City's 3 WPCCs	P	P	P				P	P	P	P							P	P
Ability to treat the expected wet weather flows	P	P	P+				P	P	P	P							P	P
CATEGORY	1	2 (10mg/l)	1	3	3	3	2	2	1	1	3	3	3	3	3	3	1	1

P - Pass
F - Fail

Category 1 - Advance to next stage. Clearly meets all pass-fail criteria.
Category 2 - Conditional. Shows promise but does not meet all criteria.
A parking spot for technologies that can be revisited later if required.
Category 3 - Eliminate. Clearly not appropriate for Winnipeg.

Notes:
The category 3 processes were identified quickly without a detailed evaluation of each criteria.

PLANT: SEWPCC

PROCESS

CRITERIA:

CRITERIA	HPO Single Stage Nitrification	HPO Step Feed	HPO with Contact Stabilization Nitrification	Integrated Fixed Film - Hanging	Integrated Fixed Film - Floating	Integrated Immobilization	Membrane Treatment	2Nd Stage Stage Suspended Growth	2nd Stage Biological Aerated Filter (BAF)	2nd Stage Nitrifying Trickling Filter (NTF)	2nd Stage RBC	2nd Stage Nitrifying Fluidized Bed	HPO Two Stage Nitrification	Stripping	Ion Exchange	Breakpoint Chlorination	Periodic - CEPT/RAS Reaeration	Periodic - Breakpoint Chlorination
Has been applied full-scale elsewhere	P	F	P				F	P	P	P							P	P
Capable of achieving some or all of the various ammonia limits being studied for Winnipeg	P	P (10 mg/l)	P				P	P	P+	P-							P	P
Not overly complex or difficult to operate and maintain	P	P	P				F	P	P-	P+							P	P
Environmentally and aesthetically appropriate (e.g. low potential for odour and visual impact)	P	P	P				P	P	P+	P-							P	P
Has been proven to be economical in other similar situations	P	P	P				F	F	P-	P+							P	P
Generally appropriate given the physical features of the City's 3 WPCCs	P	P	P				P	P	P	P							P	P
Ability to treat the expected wet weather flows	P	P	P+				P	P	P	P							P	P
CATEGORY	1	2 (10 mg/l)	1	3	3	3	2	2	1	1	3	3	3	3	3	3	1	1

P - Pass

F - Fail

Category 1 - Advance to next stage. Clearly meets all pass-fail criteria.

Category 2 - Conditional. Shows promise but does not meet all criteria.
A parking spot for technologies that can be revisited later if required.

Category 3 - Eliminate. Clearly not appropriate for Winnipeg.

Notes:

The category 3 processes were identified quickly without a detailed evaluation of each criteria.

PLANT: WEWPCC

PROCESS

CRITERIA:	Single Stage Nitrification	Step Feed	Contact Stabilization Nitrification	Integrated Fixed Film - Hanging	Inegrated Fixed Film - Floating	Integrated Immobilization	Membrane Treatment	2Nd Stage Stage Suspended Growth	2nd Stage Biological Aerated Filter (BAF)	2nd Stage Nitrifying Trickling Filter (NTF)	2nd Stage RBC	2nd Stage Nitrifying Fluidized Bed	HPO Two Stage Nitrification	Stripping	Ion Exchange	Breakpoint Chlorination	Lagoons	Periodic - CEPT/RAS Rearation	Periodic - Breakpoint Chlorination
Has been applied full-scale elsewhere	P	F	P				F	P	P	P							P	P	P
Capable of achieving some or all of the various ammonia limits being studied for Winnipeg	P	P (10 mg/l)	P				P	P	P+	P-							P	P	P
Not overly complex or difficult to operate and maintain	P	P	P				F	P	P-	P+							P	P	P
Environmentally and aesthetically appropriate (e.g. low potential for odour and visual impact)	P	P	P				P	P	P+	P-							P	P	P
Has been proven to be eco-nomical in other similar situations	P	P	P				F	F	P-	P+							P	P	P
Generally appropriate given the physical features of the City's 3 WPCCs	P	P	P				P	P	P	P							P	P	P
Ability to treat the expected wet weather flows	P	P	P+				P	P	P	P							P	P	P
CATEGORY	1	2 (10 mg/l)	1	3	3	3	2	2	2	2	3	3	N/A	3	3	3	1	1	1

P - Pass
F - Fail

Category 1 - Advance to next stage. Clearly meets all pass-fail criteria.
Category 2 - Conditional. Shows promise but does not meet all criteria.
A parking spot for technologies that can be revistied later if required.
Category 3 - Eliminate. Clearly not appropriate for Winnipeg.

Notes:
The category 3 processes were identified quickly without a detailed evaluation of each criteria.

PLANT: NEWPCC - CENTRATE

PROCESS

CRITERIA:

	Stripping	Biological Oxidation	MAP								
Has been applied full-scale elsewhere	P	P	P								
Capable of achieving some or all of the various ammonia limits being studied for Winnipeg	P	P	?								
Not overly complex or difficult to operate and maintain	P	P	F								
Environmentally and aesthetically appropriate (e.g. low potential for odour and visual impact)	P	P	P								
Has been proven to be economical in other similar situations	P	P	F								
Generally appropriate given the physical features of the City's 3 WPCCs	P	P	P								
CATEGORY	1 (for Periodic)	1	3								

Category 1 - Advance to next stage. Clearly meets all pass-fail criteria.
Category 2 - Conditional. Shows promise but does not meet all criteria.
A parking spot for technologies that can be revisited later if required.
Category 3 - Eliminate. Clearly not appropriate for Winnipeg.

P - Pass
F - Fail

Notes:

SUMMARY PROCESS SHORT LIST			
	Category 1	**Category 2**	**Category 3**
NEWPCC	HPO Single Stage HPO Contact Stabilization Second Stage BAF/NTF Periodic Control: CEPT/RAS Reaeration/Centrate Return Breakpoint Chlorination	Membranes HPO Step Feed (10 mg/l) Second Stage HPO Second Stage Suspended Growth	IFF – Hanging Integrated Immobilization Second Stage – RBC Second Stage – Fluidized Bed Second Stage – HPO Stripping Ion Exchange Breakpoint Chlor (continuous) Integrated FF – Floating
SEWPCC	HPO Single Stage HPO Contact Stabilization Second Stage BAF or NTF Periodic Control: CEPT/RAS Reaeration Breakpoint Chlorination	Membranes HPO Step Feed (10 mg/l) Second Stage HPO Second Stage Suspended Growth	FF – Hanging Integrated Immobilization Second Stage – RBC Second Stage – Fluidized Bed Second Stage – HPO Stripping Ion Exchange Breakpoint Chlor (continuous) Integrated FF – Floating
WEWPCC	Single /Stage Nitrification Step Feed/RAS Reaeration Lagoons Periodic Control: CEPT/RAS Reaeration Breakpoint Chlorination	Membranes Second Stage BAF/NTF Integrated Fixed Film – Floating	FF – Hanging Integrated Immobilization Second Stage – RBC Second Stage – Fluidized Bed Stripping Ion Exchange Breakpoint Chlor (continuous) Integrated FF – Floating
NEWPCC – Centrate **Other Side Streams** Leachate/Septage	Ammonia Stripping Biological Oxidation Magnesium Ammonia Phosphate (MAP) Precipitation Balancing Load equalization	Membranes Second Stage BAF/NTF	

6.2.2 Preliminary Designs of Technologies

The foregoing initial screening reduced the number of candidate technologies to a more manageable number and identified the technologies that are applicable to each of the plants. In order to further refine the short list, preliminary process sizing and order of magnitude relative cost estimates were generated for each technology. For each candidate technology, the following preliminary design material was developed:

- A process flow diagram and brief written description to depict the technology as applied to specifically to the Winnipeg situation.
- Approximate sizing of the main elements.

- The expected effluent quality in terms of ammonia concentration.
- Order of magnitude relative capital, operating and net present value cost estimates (relative means that the estimates may not be all inclusive, but are sufficient to allow a valid comparison between alternatives).

The preliminary design material is presented on the process description sheets included at the end of this Section 6.0. The preliminary designs and costing information is summarized in the following tables.

Table 6.1: NEWPCC – Summary of Short-Listed Ammonia Removal Options

Option	Target NH_3-N Limit	Reactors	
		Suspended Growth	Other
Existing Plant	None	6 Existing	--
HPO Single Sludge	2 mg/L	6 Existing + 12 New	--
HPO with RAS Reaeration	~10 mg/L	6 Existing + 8 New	--
HPO + Nitrifying Trickling Filters	2 mg/L	6 Existing	4 NTFs
HPO + CEPT + RAS Reaeration*	~10 mg/L	6 Existing + 6 New	CEPT
HPO + Chlorination*	2 mg/L*	6 Existing	Cl_2 / de-Cl_2
Centrate BIOX Treatment	~20 mg/L	6 Existing + 2 New**	--
Centrate NH_3^-H Stripping/ Recovery	~20 mg/L	6 Existing	3 Strip/Adsorb**

* Intermittent as necessary
** For Treating Centrate Only

Table 6.2: WEWPCC – Summary of Short-Listed Ammonia Removal Options

Option	Target NH_3-N Limit	Facilities	
		Suspended Growth	Other
Existing Plant	None	2 Existing	--
Single Stage Nitrification	2 mg/L	2 Existing	1 Clarifier, Reactor Modifications
Step Feed Nitrification	~10 mg/L	2 Existing	Reactor Modifications
Lagoon Nitrification	15 mg/L	2 Existing	Lagoon Piping
CEPT + Single Stage Nitrification*	2 mg/L	2 Existing	CEPT
Breakpoint Chlorination*	2 mg/L*	2 Existing	Cl_2 / de-Cl_2

* Intermittent as necessary

Table 6.3: SEWPCC – Summary of Short-Listed Ammonia Removal Options

Option	Target NH_3-N Limit	Facilities	
		Suspended Growth	Other
Existing Plant	None	2 existing trains	-
HPO Single Stage	2 mg/L	Existing reactors converted plus new reactors/new clarifier	-
HPO Contact Stabilization	~10 mg/L	Existing reactors converted plus new reactors/new clarifier	-
HPO + BAF	8 mg/L	Existing	8 BAFs
CEPT + RAS Reaeration*	~10 mg/L	Existing	CEPT
Breakpoint Chlorination*	2 mg/L*	2 existing trains	CL_2 / de-Cl_2

* Intermittent as necessary

Table 6.4: NEWPCC - Cost Estimates for Short-Listed Ammonia Removal Options

Option	Target NH_3-N Limit	Order of Magnitude Costs		NPV 3.5%/ 40 Yrs.
		Capital Cost	Δ[Power & Chem] Costs	
HPO Single Sludge	2 mg/L	$75 million	$95,000/mo	$99 million
HPO with RAS Reaeration	~10 mg/L	$54 million	$65,000/mo	$71 million
HPO + Nitrifying Trickling Filters	2 mg/L	$97 million	$45,000/mo	$109 million
HPO + Biological Aerated Filters	2 mg/L	$73 million	$70,000/mo	$91 million
HPO + CEPT + RAS Reaeration *	~10 mg/L	$24 million	$250,000/mo	$45 million
HPO + Chlorination *	2 mg/L *	$15.2 million	$1,200,000/mo	$114 million
Centrate BIOX Treatment**	~20 mg/L	$5 million	~ nil	
Centrate NH_3-N Strip/Recov**	~20 mg/L	$10 million		

* Intermittent as Necessary (assumed 1 in 5 years)
** For Treating Centrate Only

Table 6.5: SEWPCC - Cost Estimates for Short-Listed Ammonia Removal Options

Option	Target NH_3-N Limit	Order of Magnitude Costs		NPV 3.5%/ 40 yrs
		Capital Cost	Δ[Power & Chem] Costs	
HPO Single Sludge	2 mg/L	$35 million	$45,000/mo	$47 million
HPO with RAS Reaeration	~10 mg/L	$20 million	$20,000/mo	$25 million
HPO + Nitrifying Trickling Filters	2 mg/L	$42 million	$15,300/mo	$46 million
HPO + Biological Aerated Filters	2 mg/L	$35 million	$20,000/mo	$40 million
HPO + CEPT + RAS Reaeration*	~10 mg/L	$11.6 million	$75,000/mo	$18 million
HPO + Chlorination *	2 mg/L*	$8.3 million	$275,000/mo	$31 million

* Intermittent as Necessary (assumed 1 in 5 years)

Table 6.6: WEWPCC - Cost Estimates For Short-Listed Ammonia Removal Options

Option	Target NH3-N Limit	Order of Magnitude Costs		NPV 3.5%/ 40 yrs
		Capital Cost	Δ[Power & Chem] Costs	
Single Stage Nitrification	2 mg/L	$8.2 million	$3,000/mo	$9 million
Step Feed Nitrification	~5 mg/L	$6.6 million	$3,000/mo	$7 million
Lagoon Nitrification	15 mg/L	$1.0 million	~ nil	$1 million
CEPT + Single Stage Nitrification *	~10 mg/L	$5.7 million	$30,000/mo	$30 million
Breakpoint Chlorination *	2 mg/L	$3.8 million	$80,000/mo	$10 million

* Intermittent as Necessary (assumed 1 in 5 years)

6.2.3 Refined Short Listing

In a second Work Shop held with the City Steering Committee on November 2, 1999, a more rigorous review of the technologies was completed.

Each technology was rated against the following non-economic criteria:

Technical Criteria

Technical criteria are related to the ability of the process to meet the treatment objectives consistently. These criteria are normally reflected in the costs. For example, where a process is judged to be less capable of meeting the performance standards, a greater factor of safety will be included in the design and the costs will be correspondingly higher. However, with any process there remains some risk that it will not perform up to expectations. It is this risk that is reflected in the technical criteria. The following technical criteria were used in evaluating the technologies:

1. **Reliability.** The proven ability of the process to satisfy the process objectives. Demonstration of this capability is derived from experience at plants comparable to the City of Winnipeg facilities. Reliability reflects the proven ability of the process to consistently meet effluent criteria similar to those expected for Winnipeg in comparable climatic conditions at plants of similar size.

2. **Robustness.** The ability of the process to operate successfully under adverse conditions and fluctuating influent characteristics. Processes that are sensitive to fluctuations in the influent wastewater loading and characteristics will prove more difficult to operate and will be less able to consistently meet the stipulated process objectives.

3. **Flexibility.** The ability of a process to be operated in another mode to meet short term requirements, e.g. changes in the influent characteristics.

4. **Impact on other parts of the plant.** The selection of a process influences the remaining processes at the plant. This criterion reflects the need to consider the overall situation when selecting processes for implementation. For example, different wastewater treatment processes generate varying quantities of sludge that must be handled at the plant. The sludge handling units generate return flows that require treatment.

5. **Space requirements.** The ability of the process to fit within the space limitations of the site. In the case of the NEWPCC where the available area on the site is limited, this criterion may eliminate certain options from further consideration.

6. **Expandability.** The ability of the process to be expanded or modified to treat greater flows or to meet more stringent effluent criteria at a future date (i.e. lower ammonia limits, year round control, and nutrient limits). For example, a plant that is currently being upgraded for nitrification may require a further upgrade to BNR in the future.

7. **Constructability.** This relates to the potential impact on existing operations when the new facilities are built, including both the risk of damage to existing structures and safety aspects.

Operational Criteria

Operational criteria include those that affect the effort of, and acceptance by, the plant operating and maintenance staff. A process that is difficult to comprehend or that requires a significant ongoing labour commitment is less likely to be operated with due diligence. When this occurs, notwithstanding the design intent, a process is not a likely to perform to its capabilities. The following operational criteria were used in evaluating treatment alternatives:

1. **Ease of operation.** The “friendliness” of the process to operator control.

2. **Ease of maintenance.** The ease with which process equipment and systems may be removed from service, maintained, and returned to service. This criterion also reflects the frequency and duration of maintenance efforts.

3. **Operator safety.** This criterion reflects the inherent risks to the operating staff of the process components. Although designs will address safety as a crucial issue, the operation or maintenance of certain processes places the operators under various levels of hazard.

4. **Operator environment.** This criterion is a measure of how pleasant or unpleasant the area is immediately adjacent to the process, where operating and maintenance staff will have to perform their duties.

Environmental and Aesthetic Criteria

Environmental and aesthetic criteria relate to the impact of the process on the surrounding area. The following environmental and aesthetic criteria were used in evaluating treatment alternatives:

1. **Traffic.** The amount of vehicle traffic required due to the process option operational characteristics.

2. **Noise.** The potential of a process to generate noise sufficient to disrupt normal activities in adjacent or nearby areas.

3. **Visual.** A measure of the visual impact of the facility on nearby areas.

4. **Odour potential.** The potential for malodorous gas release from a process under normal and upset conditions.

The following process was used during the Work Shop to score the technologies against the foregoing non-economic criteria:

- The criteria were weighted (1 to 10) to reflect the relative importance of each
- Each technology was rated (1 to 5) against each criteria
- The score for each criteria was calculated by multiplying the weight by the score.
- The Total Score for each technology was determined by adding the score for all criteria.

The results of the scoring are summarized in the following table. The detailed evaluation forms are included following the summary table.

Table 6.7: Summary of Scoring of Alternatives

NEWPCC	HPO Single Stage	HPO with RAS Reaeration	Second Stage BAF/NTF	CEPT/RAS Reaeration/ Centrate Return	Breakpoint Chlorination
Total Score	271	241	270	278	249
SEWPCC	HPO Single Stage	HPO with RAS Reaeration	Second Stage BAF/NTF	CEPT/RAS Reaeration	Breakpoint Chlorination
Total Score	290	253	285	286	293
WEWPCC	Single Stage Nitrification	Step Feed	Lagoons	CEPT/RAS Reaeration	Breakpoint Chlorination
Total Score	274	245	237	258	266
NEWPCC Centrate	Biological Oxidation	Stripping and Recovery			
Total Score	306	222			

	EVALUATION FORM		Jan-00						Periodic		Periodic	
	NEWPCC		HPO Single Stage		HPO w RAS Reaer		2nd.Stage BAF/NTF		CEPT/RAS Reaer/Cent		Breakpoint. Cl2	
	column	1	2	3	4	5	6	7	8	9	10	11
	Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
		1 to 10	1 to 5	Col 1 x Col 2	1 to 5	Col 1 x Col 4	1 to 5	Col 1 x Col 6	1 to 5	Col 1 x Col 8	1 to 5	Col 1 x Col 10
	Technical Criteria											
1	Reliability	7	4	28	1	7	5	35	3	21	5	35
2	Robustness	6	3	18	1	6	5	30	3	18	5	30
3	Flexibility	5	4	20	4	20	2	10	3	15	5	25
4	Impact on other parts of the plant	5	3	15	3	15	3	15	2	10	5	25
5	Space Requirements	7	3	21	4	28	2	14	3	21	3	21
6	Expandability/Upgradability	2	5	10	4	8	3	6	4	8	3	6
7	Constructability	3	3	9	4	12	5	15	2	6	4	12
8				0		0		0		0		0
	Sub-Total Weight	**35**										
	Sub-Total Score			**121**		**96**		**125**		**99**		**154**
	Operational Criteria											
1	Ease of Operation	8	3	24	2	16	4	32	2	16	4	32
2	Ease of Maintenance	8	4	32	4	32	2	16	4	32	1	8
3	Operator Safety	7	3	21	3	21	3	21	5	35	2	14
4	Operator Environment	7	3	21	3	21	3	21	5	35	1	7
	Sub-Total Weight	**30**										
	Sub-Total Score			**98**		**90**		**90**		**118**		**61**
	Environmental and Aesthetic Criteria											
1	Traffic	4	3	12	3	12	5	20	5	20	1	4
2	Noise	4	3	12	3	12	3	12	5	20	3	12
3	Visual	3	4	12	5	15	1	3	3	9	2	6
4	Odour Potential	4	4	16	4	16	5	20	3	12	3	12
	Sub-Total Weight	**15**										
	Sub-Total Score			**52**		**55**		**55**		**61**		**34**
	Cost Criteria											
1	Capital			0		0		0		0		0
2	Operating & Maintenance			0		0		0		0		0
3	Other Dnstream Econom Impacts			0		0		0		0		0
	Sub-Total Weight	**0**										
	Sub-Total Score			**0**		**0**		**0**		**0**		**0**
	Total Weight	**80**										
	Total Score			**271**		**241**		**270**		**278**		**249**

EVALUATION FORM SEWPCC		HPO Single Stage		HPO w RAS Reaer		2nd.Stage BAF/NTF		Periodic CEPT/RAS Reaeration		Periodic Breakpoint. Cl2	
column	1	2	3	4	5	6	7	8	9	10	11
Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
	1 to 10	1 to 5	Col 1 x Col 2	1 to 5	Col 1 x Col 4	1 to 5	Col 1 x Col 6	1 to 5	Col 1 x Col 8	1 to 5	Col 1 x Col 10
Technical Criteria											
1 Reliability	7	4	28	1	7	5	35	2	14	5	35
2 Robustness	7	4	28	1	7	5	35	3	21	5	35
3 Flexibility	5	4	20	5	25	2	10	3	15	5	25
4 Impact on other parts of the plant	5	4	20	4	20	5	25	2	10	5	25
5 Space Requirements	5	4	20	5	25	3	15	5	25	3	15
6 Expandability	3	5	15	4	12	3	9	4	12	3	9
7 Constructability	3	3	9	4	12	5	15	3	9	5	15
8			0		0		0		0		0
Sub-Total Weight	**35**										
Sub-Total Score			**140**		**108**		**144**		**106**		**159**
Operational Criteria											
1 Ease of Operation	**8**	3	24	2	16	4	32	3	24	5	40
2 Ease of Maintenance	**8**	4	32	4	32	2	16	4	32	2	16
3 Operator Safety	**7**	3	21	3	21	2	14	4	28	2	14
4 Operator Environment	7	3	21	3	21	3	21	**5**	35	2	14
Sub-Total Weight	**30**										
Sub-Total Score			**98**		**90**		**83**		**119**		**84**
Environmental and Aesthetic Criteria											
1 Traffic	**4**	3	12	3	12	5	20	5	20	3	12
2 Noise	**4**	3	12	3	12	3	12	5	20	5	20
3 Visual	**3**	4	12	5	15	2	6	3	9	2	6
4 Odour Potential	**4**	4	16	4	16	5	20	3	12	3	12
Sub-Total Weight	**15**										
Sub-Total Score			**52**		**55**		**58**		**61**		**50**
Cost Criteria											
1 Capital			0		0		0		0		0
2 Operating & Maintenance			0		0		0		0		0
3 Other Dnstream Econom Impacts			0		0		0		0		0
Sub-Total Weight	**0**										
Sub-Total Score			**0**		**0**		**0**		**0**		**0**
Total Weight	**80**										
Total Score			**290**		**253**		**285**		**286**		**293**

EVALUATION FORM								Periodic		Periodic	
WEWPCC		Single Stage Nitrific.		Step Feed		Lagoons		CEPT/RAS Reaer		Breakpoint. Cl2	
column	1	2	3	4	5	6	7	8	9	10	11
Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
	1 to 10	1 to 5	Col 1 x Col 2	1 to 5	Col 1 x Col 4	1 to 5	Col 1 x Col 6	1 to 5	Col 1 x Col 8	1 to 5	Col 1 x Col 10
Technical Criteria											
1 Reliability	7	5	35	**2**	14	1	7	2	14	5	35
2 Robustness	7	4	28	**3**	21	2	14	2	14	5	35
3 Flexibility	5	4	20	5	25	**1**	5	3	15	5	25
4 Impact on other parts of the plant	5	4	20	3	15	4	20	2	10	3	15
5 Space Requirements	5	3	15	**5**	25	**5**	25	3	15	4	20
6 Expandability	3	4	12	3	9	**1**	3	3	9	5	15
7 Constructability	3	3	9	3	9	4	12	3	9	5	15
8			0		0		0		0		0
Sub-Total Weight	**35**										
Sub-Total Score			**139**		**118**		**86**		**86**		**160**
Operational Criteria											
1 Ease of Operation	**8**	3	24	2	16	4	32	3	24	4	32
2 Ease of Maintenance	**8**	3	24	3	24	4	32	4	32	2	16
3 Operator Safety	**7**	3	21	3	21	3	21	5	35	1	7
4 Operator Environment	7	3	21	3	21	3	21	4	28	2	14
Sub-Total Weight	**30**										
Sub-Total Score			**90**		**82**		**106**		**119**		**69**
Environmental and Aesthetic Criteria											
1 Traffic	**4**	3	12	3	12	3	12	5	20	1	4
2 Noise	**4**	3	12	3	12	3	12	3	12	3	12
3 Visual	**3**	3	9	3	9	3	9	3	9	3	9
4 Odour Potential	**4**	3	12	3	12	3	12	3	12	3	12
Sub-Total Weight	**15**										
Sub-Total Score			**45**		**45**		**45**		**53**		**37**
Cost Criteria											
1 Capital			0		0		0		0		0
2 Operating & Maintenance			0		0		0		0		0
3 Other Dnstream Econom Impacts			0		0		0		0		0
Sub-Total Weight	**0**										
Sub-Total Score			**0**		**0**		**0**		**0**		**0**
Total Weight	**80**										
Total Score			**274**		**245**		**237**		**258**		**266**

EVALUATION FORM

NEWPCC CENTRATE		Biological Oxidation		Stripping/Recovery							
	column	1	2	3	4	5	6	7	8	9	10	11
	Criteria	Weight	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
		1 to 10	1 to 5	Col 1 x Col 2	1 to 5	Col 1 x Col 4	1 to 5	Col 1 x Col 6	1 to 5	Col 1 x Col 8	1 to 5	Col 1 x Col 10
	Technical Criteria											
1	Reliability	7	4	28	4	28		0		0		0
2	Robustness	7	4	28	4	28		0		0		0
3	Flexibility	5	**5**	25	**2**	10		0		0		0
4	Impact on other parts of the plant	5	4	20	3	15		0		0		0
5	Space Requirements	5	3	15	3	15		0		0		0
6	Expandability	3	3	9	3	9		0		0		0
7	Constructability	3	3	9	3	9		0		0		0
8				0		0		0		0		0
	Sub-Total Weight	**35**										
	Sub-Total Score			**134**		**114**		**0**		**0**		**0**
	Operational Criteria											
1	Ease of Operation	**8**	4	32	2	16		0		0		0
2	Ease of Maintenance	**8**	4	32	2	16		0		0		0
3	Operator Safety	**7**	4	28	2	14		0		0		0
4	Operator Environment	7	4	28	3	21		0		0		0
	Sub-Total Weight	**30**										
	Sub-Total Score			**120**		**67**		**0**		**0**		**0**
	Environmental and Aesthetic Criteria											
1	Traffic	**4**	4	16	2	8		0		0		0
2	Noise	**4**	3	12	3	12		0		0		0
3	Visual	**3**	4	12	3	9		0		0		0
4	Odour Potential	**4**	3	12	3	12		0		0		0
	Sub-Total Weight	**15**										
	Sub-Total Score			**52**		**41**		**0**		**0**		**0**
	Cost Criteria											
1	Capital			0		0		0		0		0
2	Operating & Maintenance			0		0		0		0		0
3	Other Dnstream Econom Impacts			0		0		0		0		0
	Sub-Total Weight	**0**										
	Sub-Total Score			**0**		**0**		**0**		**0**		**0**
	Total Weight	**80**										
	Total Score			**306**		**222**		**0**		**0**		**0**

6.2.4 Short Listed Technologies

Based on the foregoing short listing process, the following technologies were identified as candidate technologies to carry forward into the Conceptual Design Phase.

NEWPCC

For the 2 mg/L ammonia level of control, HPO Single Stage Nitrification and HPO + BAF are predicted to have similar total costs. It was agreed that HPO Single Stage will be carried forward to Conceptual Design.

For a less stringent level of ammonia control such as 10 mg/L, HPO with RAS Reaeration could be applicable and will be carried forward for consideration in Conceptual Design.

For periodic ammonia control, HPO plus Chorination is estimated to be far too expensive. HPO plus CEPT with RAS Reareation appears to be a viable alternative and will be carried forward to Conceptual Design for consideration if this level of control is evaluated in more detail.

SEWPCC

For the 2 mg/L ammonia level of control, HPO Single Stage Nitrification and HPO + BAF are predicted to have similar total costs. It was agreed that HPO Single Stage will be carried forward to Conceptual Design.

For a less stringent level of ammonia control such as 10 mg/L, HPO with RAS Reaeration could be applicable and will be carried forward for consideration in Conceptual Design.

For periodic ammonia control, HPO plus Chorination is estimated to be far too expensive. HPO plus CEPT with RAS Reareation appears to be a viable alternative and will be carried forward to Conceptual Design for consideration if this level of control is evaluated in more detail.

WEWPCC

For the 2 mg/L ammonia level of control, Single Stage Nitrification is the most appropriate alternative.

For a less stringent level of control Step Feed Activated /Sludge and nitrification in the lagoon system can be considered.

For periodic ammonia control, CEPT in combination with the single stage nitrification appears to be a viable alternative and will be carried forward to Conceptual Design for consideration if this level of control is evaluated in more detail.

NEWPCC Centrate

Centrate treatment at the NEWPCC will be most effectively achieved using biological oxidation and this process will be carried forward to Conceptual Design.

6.3 CANDIDATE BNR TECHNOLOGIES

This section considers how Winnipeg's three wastewater treatment plants could be upgraded to biological nutrient removal some time after retrofitting the plants for nitrification using the candidate nitrification technologies. A preliminary strategy has been developed for a possible future upgrade to biological nitrogen and/or phosphorus removal for each plant and each candidate technology. The aim of this section is to evaluate the downstream consequences of selecting a particular candidate nitrification technology in the event that the plant is required to be further upgraded to achieve biological nitrogen and/or phosphorus removal at some future date. Descriptions of future BNR upgrade approaches for each plant and each candidate technology, together with the advantages and disadvantages of each, are presented in tabular form at the end of this section. NEWPCC and SEWPCC are discussed together as the upgrade approaches would be very similar.

6.3.1 NEWPCC and SEWPCC

HPO Single Stage Nitrification

Single stage nitrification processes at NEWPCC and SEWPCC could be upgraded to biological nitrogen removal by the construction of an anoxic pre-denitrification zone upstream of the oxygen reactors. Alternatively, the first cell of each HPO reactor could be converted from an aerobic to an anoxic zone. Nitrified mixed liquor would be recycled at a rate of approximately 3 times ADWF from the final HPO cell to the anoxic zone, where it would be denitrified using the influent wastewater as a carbon source. There are several benefits to the incorporation of denitrification into the process. These include recovery of a significant portion of the alkalinity and oxygen consumed during nitrification, a reduced nitrate concentration in the mixed liquor entering the secondary clarifiers, and improved sludge settling characteristics as a result of the selector effect. The principal disadvantage of the process is that the overall bioreactor sludge age, or SRT, must be increased to compensate for the unaerated sludge mass fraction. This would require either the derating of the nitrification process, or the construction of additional bioreactor tankage for the anoxic zones.

Single stage nitrification processes at NEWPCC and SEWPCC could also be upgraded to biological phosphorus removal by the construction of an anoxic RAS denitrification zone and an anaerobic zone upstream of the oxygen reactors. Alternatively, the first cell of each HPO reactor could be converted from an aerobic zone to anoxic and anaerobic zones. This may require further derating of the nitrification process. Side stream primary sludge fermenters are needed to generate the short chain VFAs required for biological phosphorus removal. The upgrade would also require the construction of a separate WAS thickening facility and careful handling of the thickened WAS to ensure that the phosphorus removed is not released back into solution. Because of the sensitivity of the process to high influent concentrations of ammonia and phosphorus, treatment of the return streams for both nitrogen and phosphorus removal may also be required.

A schematic representation of the NEWPCC and SEWPCC HPO single stage nitrification processes after upgrading to biological nitrogen and phosphorus removal presented in Figure 6.1. The bioreactor consists of a RAS denitrification zone, an anaerobic zone and an anoxic zone upstream of the HPO reactors. Nitrified mixed liquor is recycled from the final HPO cell to the anoxic zone. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. The waste primary and waste secondary sludges are handled separately, with the primary sludge being thickened in the primary sludge fermenter, and the WAS being thickened in a dedicated thickening facility.

HPO RAS Reaeration

Upgrading the HPO RAS reaeration processes at the NEWPCC and SEWPCC for biological nitrogen removal and biological phosphorus removal is conceptually very similar to upgrading the single stage nitrification process.

A schematic representation of the NEWPCC and SEWPCC HPO RAS reaeration processes after upgrading to biological nitrogen and phosphorus removal is presented in Figure 6.2. The bioreactor consists of a RAS reaeration zone, a RAS denitrification zone, an anaerobic zone and an anoxic zone upstream of the HPO reactors. Nitrified mixed liquor is recycled from the final HPO cell to the anoxic zone. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. The waste primary and waste secondary sludges are handled separately, with the primary sludge being thickened in the primary sludge fermenter, and the WAS being thickened in a dedicated thickening facility.

UPGRADE OF HPO SINGLE STAGE NITRIFICATION PROCESS TO BNR

NEWPCC & SEWPCCC

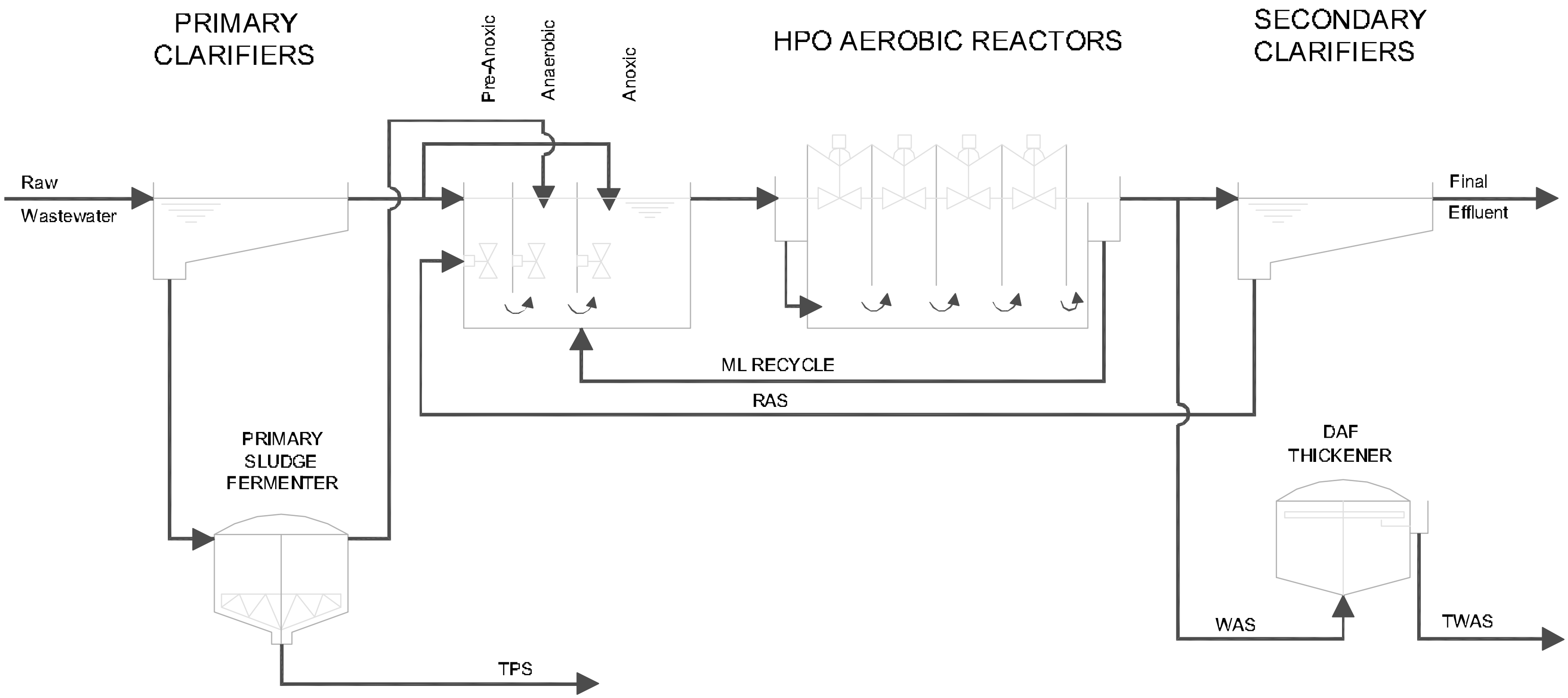


Figure 6.1

UPGRADE OF HPO RAS REAERATION NITRIFICATION PROCESS TO BNR

NEWPCC & SEWPCCC

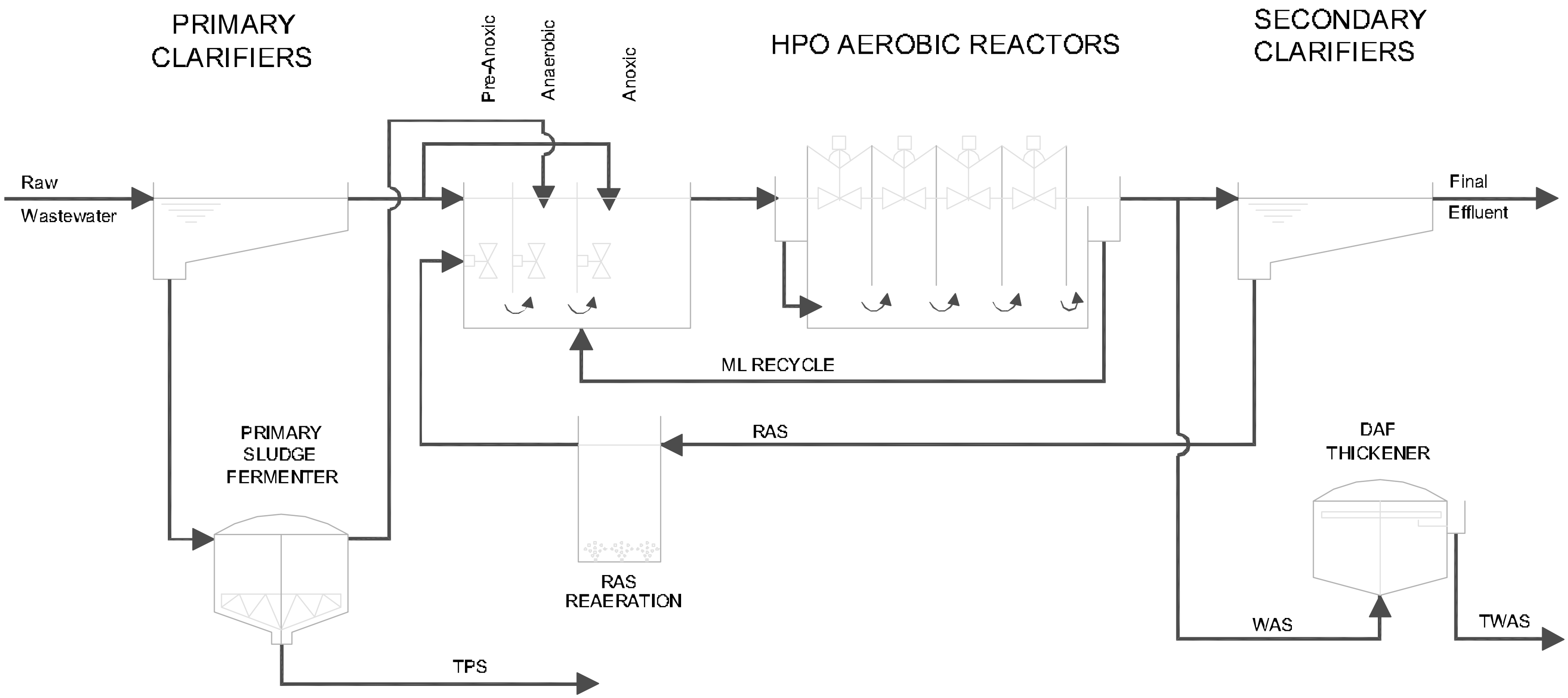


Figure 6.2

Second Stage NTFs or BAFs

A second stage NTF or BAF process at NEWPCC or SEWPCC could only be upgraded to biological nitrogen removal by the construction of a tertiary fixed film denitrification process, e.g. fluidized bed or anaerobic filters. There is little or no carbon available in the NTF/BAF effluent for denitrification, and it is not practical to use the influent wastewater as a carbon source for this purpose. Consequently, an external carbon source (e.g. methanol) must be added to the denitrification process to drive the denitrification reaction. The tertiary denitrification process may also require an intermediate pumpstation to compensate for the head loss through the process. Other disadvantages of the tertiary denitrification process are that it is not possible to recover the oxygen and alkalinity consumed during nitrification, and the additional waste sludge generated in the process.

A second stage NTF or BAF process at NEWPCC or SEWPCC could also be upgraded to biological phosphorus removal by the construction of an anaerobic zone upstream of the oxygen reactors in order to promote biological excess phosphorus removal in the HPO process. Alternatively, the first cell of each HPO reactor could be converted from an aerobic zone to an anaerobic zone. Because the HPO reactor would be operating in a non-nitrifying mode, it is not expected that this would result in a derating of the process. Side stream primary sludge fermenters are needed to generate the short chain VFAs required for biological phosphorus removal. The upgrade would also require the construction of a separate WAS thickening facility and careful handling of the thickened WAS to ensure that the phosphorus removed is not released back into solution. Treatment of the return streams for phosphorus removal may also be required.

A schematic representation of the NEWPCC and SEWPCC second stage NTF or BAF processes after upgrading to biological nitrogen and phosphorus removal is presented in Figure 6.3. The bioreactor consists of an anaerobic zone upstream of the HPO reactors. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. Effluent from the BAF/NTF process is pumped to a fixed film denitrification process in which methanol is used as the carbon source for denitrification. The waste primary and waste secondary sludges are handled separately, with the primary sludge being thickened in the primary sludge fermenter, and the WAS from the bioreactor and tertiary denitrification process being thickened in a dedicated thickening facility.

UPGRADE OF HPO SECOND STAGE NTF PROCESS TO BNR

NEWPCC & SEWPCCC

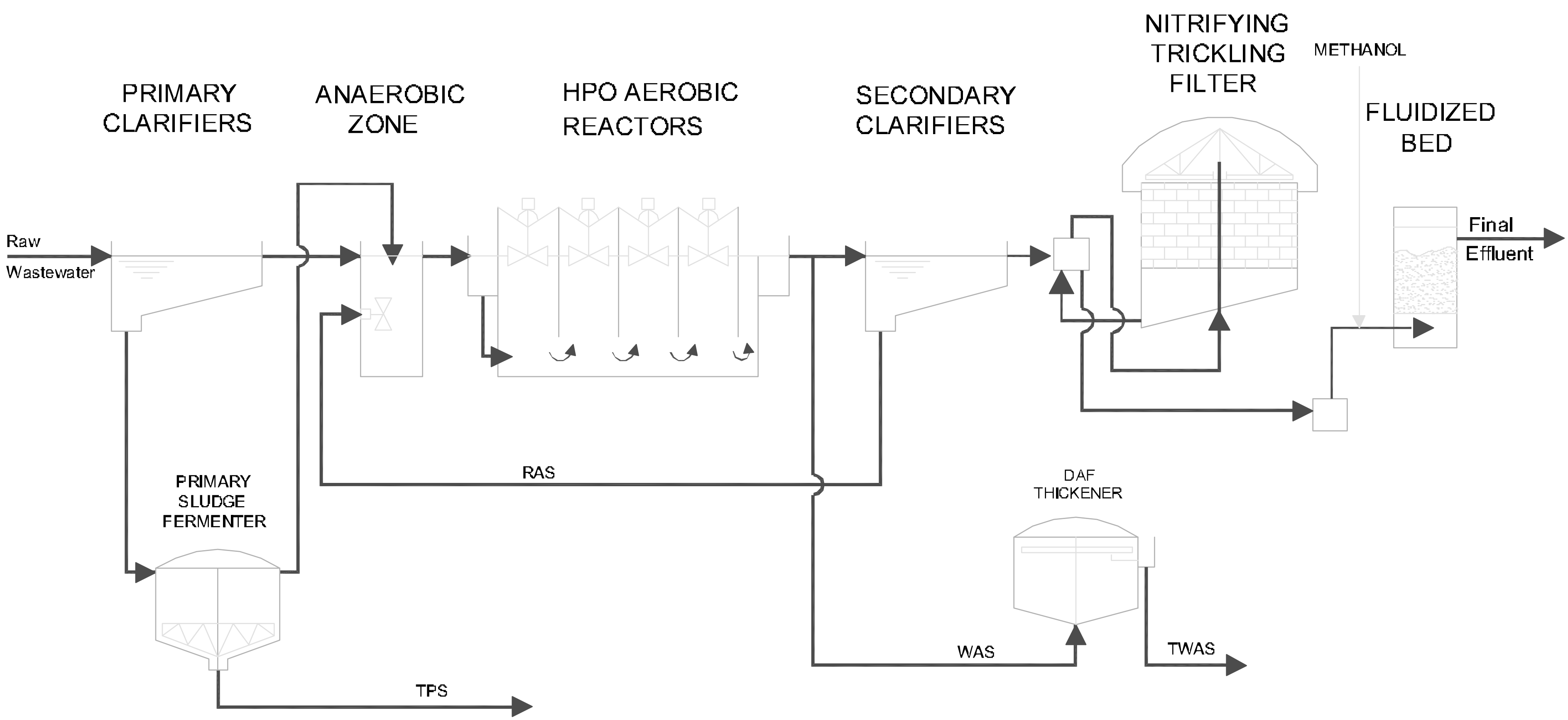


Figure 6.3

Periodic CEPT with RAS Reaeration

In the event that periodic CEPT with RAS reaeration is implemented at the NEWPCC or SEWPCC, it will not be practical to upgrade this plant configuration to either biological nitrogen or biological phosphorus removal in the future. In either case it will not be cost-effective to construct the modifications required for biological nutrient removal for periodic use. Further, it is highly unlikely that either nitrogen or phosphorus removal will be required at the plant only on a periodic basis. However, the use of CEPT will result in chemical phosphorus removal down to effluent concentrations around 1.0 mg/L.

Periodic Ammonia Removal by Breakpoint Chlorination

In the event that periodic ammonia removal by breakpoint chlorination is implemented at the NEWPCC or SEWPCC, it will not be practical to upgrade the plant to either biological nitrogen or biological phosphorus removal in the future. In either case it will not be cost-effective to construct the modifications required for biological nutrient removal for periodic use. Further, it is highly unlikely that either nitrogen or phosphorus removal will be required at the plant only on a periodic basis.

6.3.2 WEWPCC

Single Stage Nitrification

A single stage nitrification process at WEWPCC can be upgraded to biological nitrogen removal by the construction of an anoxic pre-denitrification zone within the existing aeration tanks. Nitrified mixed liquor would be recycled at a rate of approximately 3 times ADWF from the end of the aerobic zone to the anoxic zone, where it is denitrified using the influent wastewater as a carbon source. There are several benefits to the incorporation of denitrification into the process. These include recovery of a significant portion of the alkalinity and oxygen consumed during nitrification, a reduced nitrate concentration in the mixed liquor entering the secondary clarifiers, and improved sludge settling characteristics as a result of the selector effect. The bioreactor sludge age, or SRT, must be increased to compensate for the unaerated sludge mass fraction. However, it is believed that the existing bioreactor has sufficient volume to facilitate this increased SRT.

A single stage nitrification process at WEWPCC could also be upgraded to biological phosphorus removal by the construction of an anaerobic zone within the existing aeration tanks. Side stream primary sludge fermenters are needed to generate the short chain VFAs required for biological phosphorus removal. The upgrade would also require the construction of a separate WAS thickening facility and careful handling of the thickened WAS to ensure that the phosphorus removed is not released back into solution.

A schematic representation of the WEWPCC single stage nitrification process after upgrading to biological nitrogen and phosphorus removal is presented in Figure 6.4. The bioreactor consists of an anaerobic zone, an anoxic zone and an aerobic zone in series. Nitrified mixed liquor is recycled from the end of the aerobic zone to the anoxic zone. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. The waste primary and waste secondary sludges are handled separately, with the primary sludge being thickened in the primary sludge fermenter, and the WAS being thickened in a dedicated thickening facility.

Step Feed Nitrification

A step feed nitrification process at WEWPCC can be upgraded to biological nitrogen removal by the construction of an anoxic zone at the head end of each pass within the existing aeration tanks. The incoming primary effluent would be divided between the anoxic zones. Within each pass, nitrified mixed liquor would be recycled at a rate of approximately 1 times ADWF from the end of the aerobic zone to the anoxic zone, where it is denitrified using the influent wastewater as a carbon source. There are several benefits to the incorporation of denitrification into the process. These include recovery of a significant portion of the alkalinity and oxygen consumed during nitrification, a reduced nitrate concentration in the mixed liquor entering the secondary clarifiers, and improved sludge settling characteristics as a result of the selector effect. The bioreactor sludge age, or SRT, must be increased to compensate for the unaerated sludge mass fraction. However, it is believed that the existing bioreactor has sufficient volume to facilitate this increased SRT.

A step feed nitrification process at WEWPCC could also be upgraded to biological phosphorus removal by the construction of an anaerobic zone in the first pass of the existing aeration tanks. Side stream primary sludge fermenters are needed to generate the short chain VFAs required for biological phosphorus removal. The upgrade would also require the construction of a separate WAS thickening facility and careful handling of the thickened WAS to ensure that the phosphorus removed is not released back into solution.

A schematic representation of the WEWPCC step feed nitrification process after upgrading to biological nitrogen and phosphorus removal is presented in Figure 6.5. The bioreactor consists of an anaerobic zone, an anoxic zone and an aerobic zone in the first pass, and a anoxic zone and an aerobic in each subsequent pass. Within each pass, nitrified mixed liquor is recycled from the end of the aerobic zone to the anoxic

UPGRADE OF SINGLE SLUDGE NITRIFICATION PROCESS TO BNR

WEWPCCC

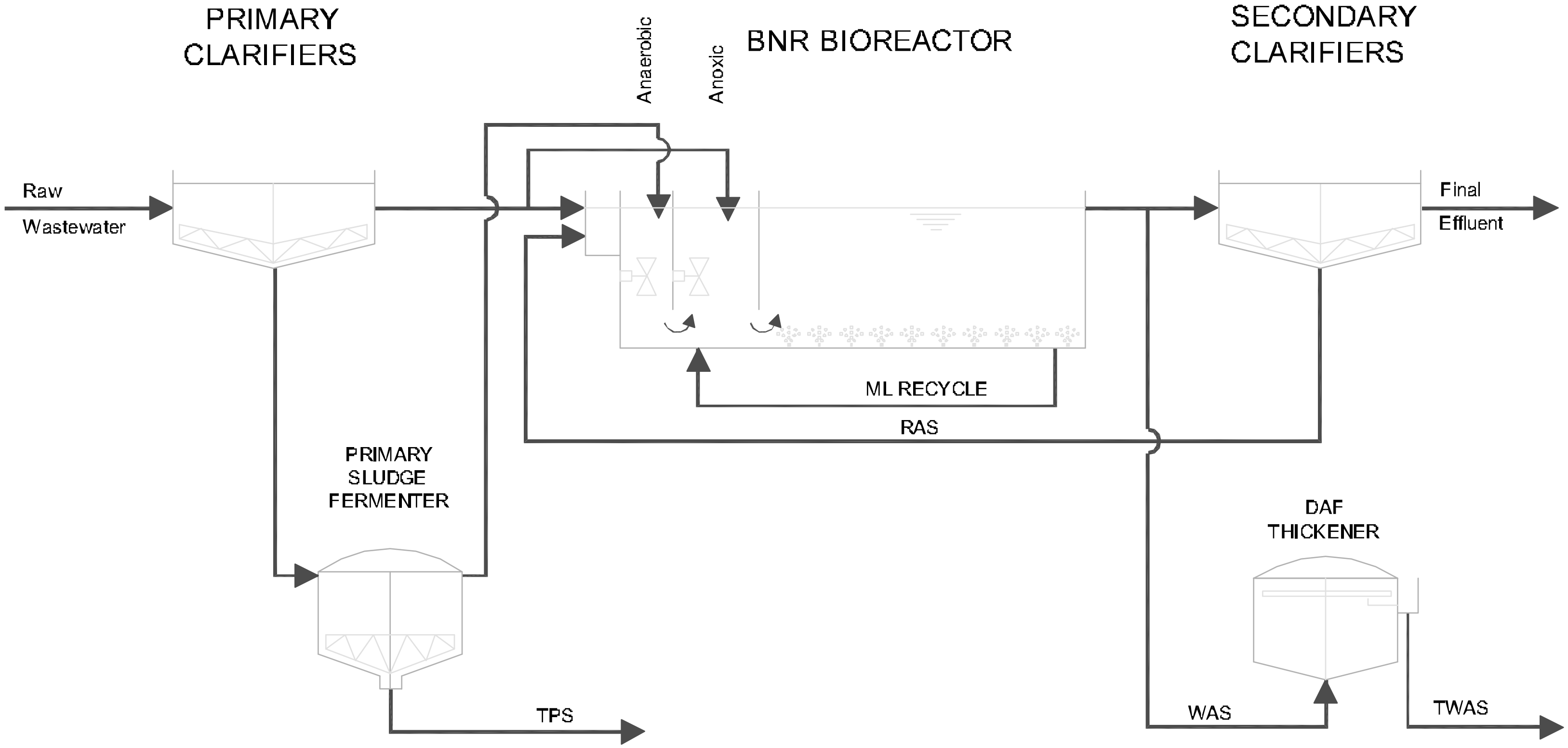


Figure 6.4

UPGRADE OF STEP FEED NITRIFICATION PROCESS TO BNR

WEWPCC

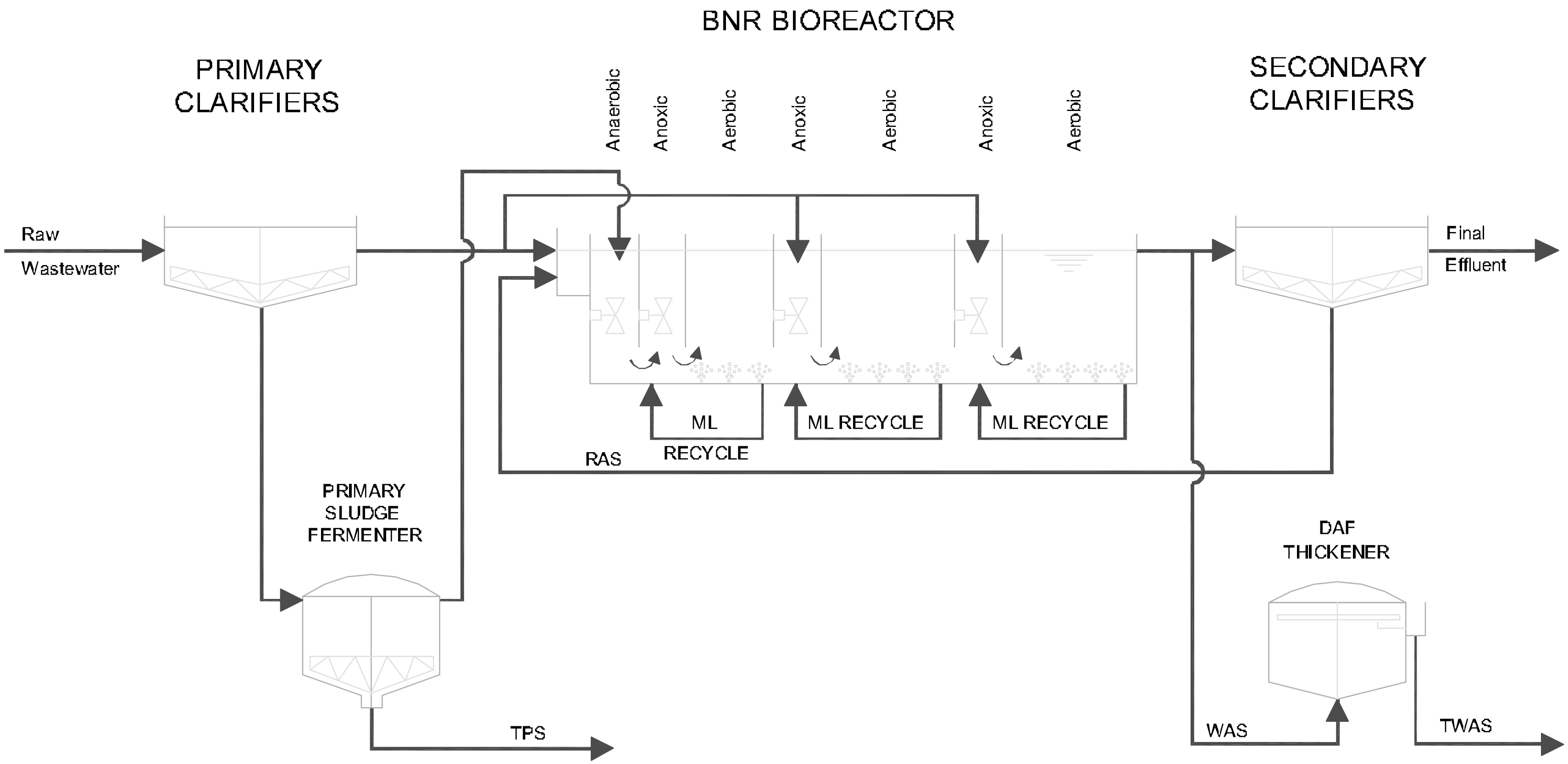


Figure 6.5

zone. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. The waste primary and waste secondary sludges are handled separately, with the primary sludge being thickened in the primary sludge fermenter, and the WAS being thickened in a dedicated thickening facility.

Lagoon Nitrification

A lagoon nitrification process at WEWPCC could only be upgraded to biological nitrogen removal by the construction of a tertiary fixed film denitrification process, e.g. fluidized bed or anaerobic filters to treat the nitrified lagoon effluent. There is little or no carbon available in the lagoon effluent for denitrification, and it is not practical to use the influent wastewater as a carbon source for this purpose. Consequently, an external carbon source (e.g. methanol) must be added to the denitrification process to drive the denitrification reaction. The tertiary denitrification process may also require an intermediate pumpstation to compensate for the head loss through the process. Other disadvantages of the tertiary denitrification process are that it is not possible to recover the oxygen and alkalinity consumed during nitrification, and the additional waste sludge generated in the process. Further, it is doubtful that this process is viable year round as low lagoon effluent temperatures (estimated to be between 2 and 4ºC during the winter and spring) will result in operating problems and low denitrification rates.

A lagoon nitrification process at WEWPCC could also be upgraded to biological phosphorus removal by the construction of an anaerobic zone within the existing aeration tank in order to promote biological excess phosphorus removal in the activated sludge process. Because the bioreactor would be operating in a non-nitrifying mode, it is not expected that this would result in a derating of the process. Side stream primary sludge fermenters are needed to generate the short chain VFAs required for biological phosphorus removal. The upgrade would also require the construction of a separate WAS thickening facility and careful handling of the thickened WAS to ensure that the phosphorus removed is not released back into solution. Treatment of the return streams for phosphorus removal may also be required.

A schematic representation of the WEWPCC lagoon nitrification process after upgrading to biological nitrogen and phosphorus removal is presented in Figure 6.6. The BNR bioreactor consists of an anaerobic zone and an aerobic zone in series. VFA-rich fermenter supernatant from the primary sludge fermenters is discharged to the anaerobic zone. Effluent from the lagoons is pumped to a fixed film denitrification process in which methanol is used as the carbon source for denitrification. The waste primary and waste secondary sludges are handled separately, with the primary sludge

UPGRADE OF TERTIARY LAGOONS TO BNR

WEWPCC

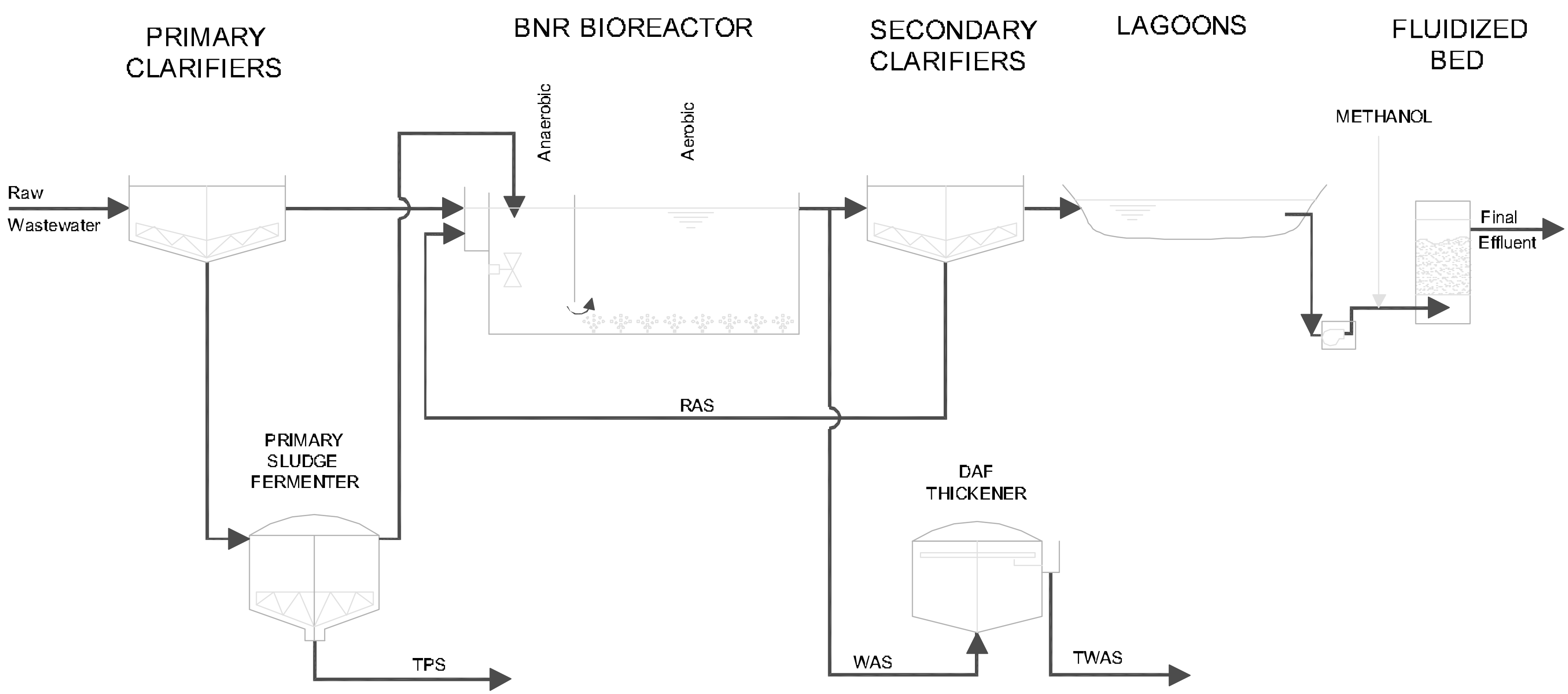


Figure 6.6

being thickened in the primary sludge fermenter, and the WAS from the bioreactor and tertiary denitrification process being thickened in a dedicated thickening facility. It is believed that this BNR upgrading option is not viable as the process will be extremely complex to operate and there is some doubt about whether the tertiary denitrification stage could operate at the low lagoon effluent temperatures.

Periodic CEPT with Single Stage Nitrification

In the event that periodic CEPT with single stage nitrification is implemented at the WEWPCC, it will not be practical to upgrade this plant configuration to either biological nitrogen or biological phosphorus removal in the future. In either case it will not be cost-effective to construct the modifications required for biological nutrient removal for periodic use. Further, it is highly unlikely that either nitrogen or phosphorus removal will be required at the plant only on a periodic basis. However, the use of CEPT will result in chemical phosphorus removals down to effluent concentrations around 1.0 mg/L.

Periodic Ammonia Removal by Breakpoint Chlorination

In the event that periodic ammonia removal by breakpoint chlorination is implemented at the WEWPCC, it will not be practical to upgrade this plant configuration to either biological nitrogen or biological phosphorus removal in the future. In either case it will not be cost-effective to construct the modifications required for biological nutrient removal for periodic use. Further, it is highly unlikely that either nitrogen or phosphorus removal will be required at the plant only on a periodic basis.

PLANT:	**NORTH END WATER POLLUTION CONTROL CENTRE – HPO SINGLE STAGE NITRIFICATION**
STANDARD:	2 mg/L (5 mg/L in winter and wet weather)

PROCESS DESCRIPTION

In this option the NEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) in summer by modifying and expanding the HPO bioreactor to facilitate simultaneous carbonaceous removal and year round nitrification.

The approach used here recognizes the limitations of the existing secondary clarifiers in that additional bioreactor tankage is constructed in order to increase the biomass under aeration and to maintain a workable solids loading rate on the clarifiers. The estimated total bioreactor volume of 90,400 m^3 will be required to provide a hydraulic retention time (HRT) of ~10 hours to maintain a solids retention time (SRT) of 6 to 7 days during the summer months and to 8 to 9 days during winter. A key element of this process is pH control in order to prevent nitrification inhibition. The last aerobic cell will be vented to allow CO_2 stripping to increase the mixed liquor pH by preventing CO_2 accumulation in the mixed liquor. In addition, some alkalinity addition to the primary effluent may be required to buffer pH depression resulting from the nitrification reaction. The bioreactor will be operated at a MLSS of about 3000 mg/L.

A process flow schematic of the proposed upgrade of the NEWPCC to single sludge nitrification is presented in Figure NE-1.1. The design criteria for the upgraded secondary treatment process are presented in Table NE-1.1 on the following page.

A layout of the NEWPCC after upgrading the secondary treatment process to HPO single stage nitrification is presented in Figure NE-1.2. The 12 new HPO reactor modules will be built to the south and southwest of the existing 4 cell bioreactor modules.

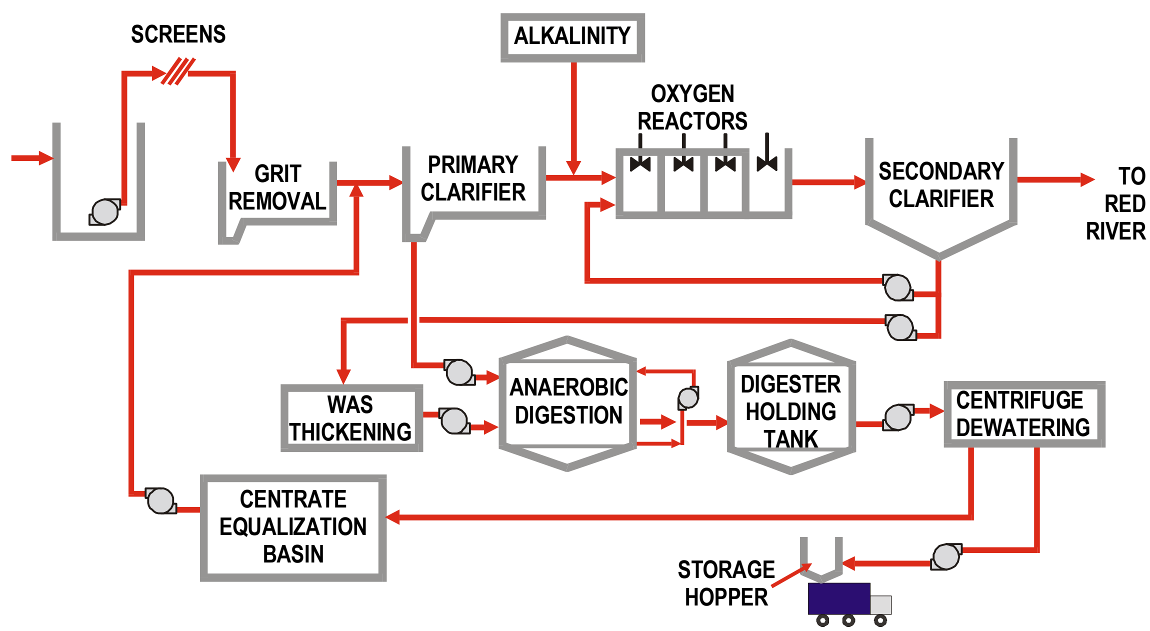
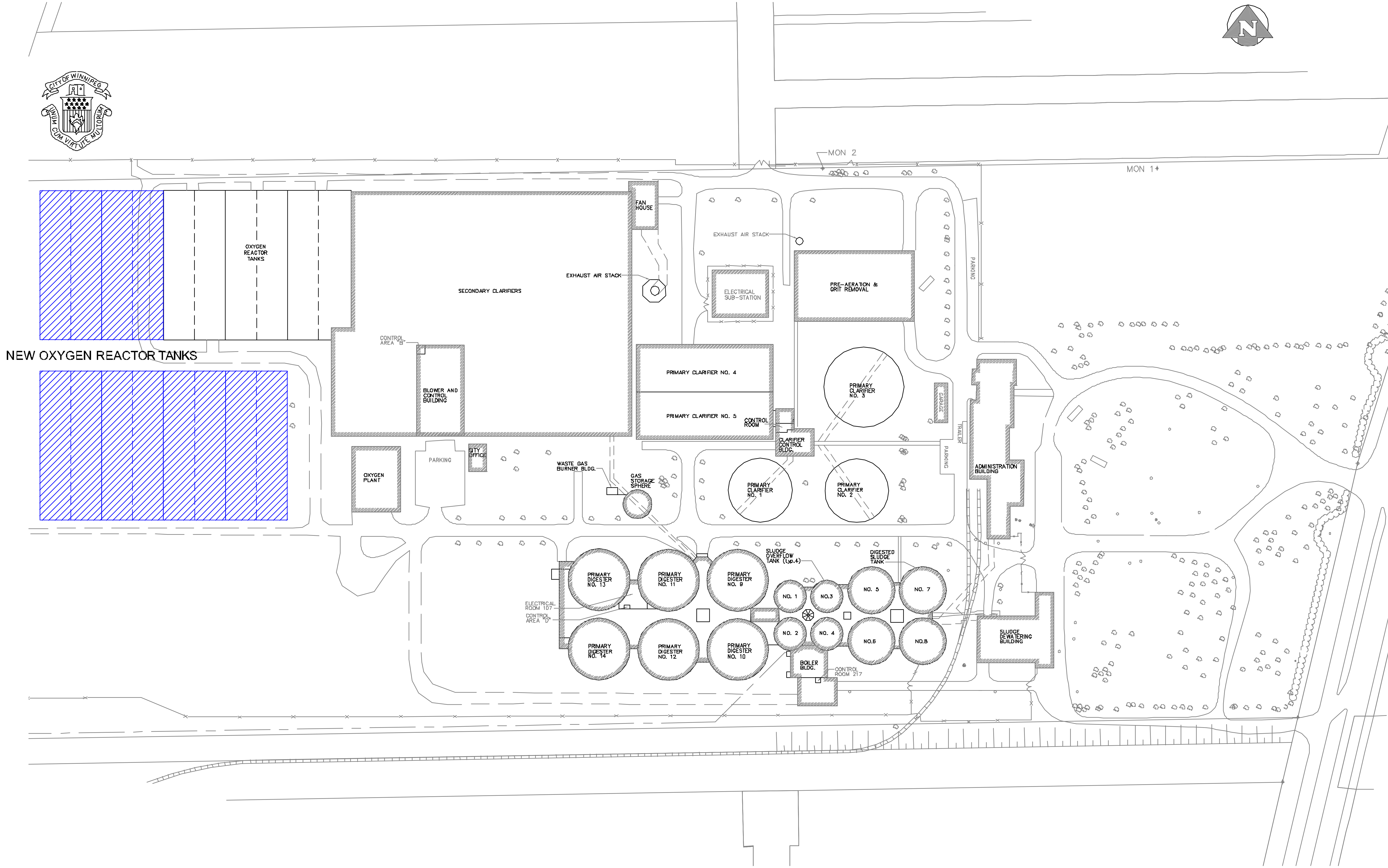


Figure NE-1.1: Single Stage Nitrification at the North End Water Pollution Control Centre



NEWPCC HPO Single Stage Nitrification
Figure NE 1.2

NEWPCC – HPO Single Stage Nitrification (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table NE-1.1: Single Stage Nitrification at the North End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
ADWF, ML/d	302	211
PDWF, ML/d	568	397
PWWF, ML/d	1060	1060
BOD_5 Load		
Average, kg/d (40 percent removal in PSTs)	59.800	32,184
Maximum, kg/d (45 percent removal in PSTs)	-	42,147
TSS Load, kg/d		
Average, kg/d (60 percent removal in PSTs)	56,400	25,972
Maximum, kg/d (65 percent removal in PSTs)	-	45,168
HPO Bioreactor		
Number of reactors	6	18
Total Reactor Volume, m^3	30,132	90,400
HRT at ADWF, h	2.23	10.3
Temperature, min-max, °C	11/22	11/22
SRT (winter), d	-	8 to 9
SRT (summer), d		6 to 7
MLSS, (at avg.), mg/L		3,000
MLSS, (summer), mg/L		2,500
Secondary Clarifiers		
Number of units	10 Square 16 Rectangular	10 Square 16 Rectangular
Diameter, m	Sq - 20 x 20 Rect - 8.23 x 69.35	Sq - 20 x 20 Rect - 8.23 x 69.35
SWD, m	Sq – 4.65 Rect – 3.65	Sq – 4.65 Rect – 3.65
Total area, m^2	Sq – 4,000 Rect - 9,132	Sq – 4,000 Rect - 9,132
OFR @ PDWF, m/h	1.80	1.26
SLR @ PWWFof 598 ML/d and 50% RAS Q, $kg/m^2/h$	11.38	11.38

TECHNICAL CRITERIA

1. Reliability: The reliability of the process is largely dependent on maintaining the mixed liquor pH in the optimum range for nitrification, i.e. between 6.5 and 8.5. Maintaining the process pH in this range can be very tenuous because of the cumulative effects of increased CO_2 production from biological carbonaceous removal and alkalinity depletion from nitrification. As the CO_2 content in the gas phase increases, the CO_2 concentration in the mixed liquor also increases and the process pH is depressed. The pH depression normally found in HPO processes is exacerbated by the alkalinity destruction resulting from nitrification. At pH values below 6.5, the growth rate of the nitrifying organisms is inhibited. Positive pH control is required to keep the system stable and reliable.

NEWPCC – HPO Single Stage Nitrification (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
1. Reliability: (cont'd.)	One of the critical factors in the proposed system will be the ability of the final clarifiers to operate successfully at the higher solids loading rates required during winter. It will be necessary to operate at a higher SRT range of, say, 9 to 10 days in winter in order to maintain nitrifying organisms in the system. Modifications to the final clarifiers may be required in order to operate in this range.
2. Robustness:	Because of the sensitivity of nitrifiers and the potential for inhibition at pH values below 6.5, the process is more susceptible to upsets from flow and load variations than the air activated sludge process. The robustness of the process can be somewhat improved by increasing the bioreactor SRT.
3. Flexibility:	The process will be difficult to modify to meet changing effluent quality requirements as partial nitrification is unstable and poses many operating problems. Once the process is established, changes should not be introduced except to correct process upsets. Bringing basins on and off line will be complicated by the need for longer SRTs should the mixed liquor pH or the mixed liquor temperature be low.
4. Impact on Other Parts of the Plant:	The addition of the 12 new bioreactors and operating the system to achieve nitrification will require an additional ~35 tonnes per day of oxygen. Current oxygen consumption at the North End plant is approximately 33 tonnes per day for BOD5 removal only. Thus it is expected that nitrification will more than double the oxygen requirements to approximately 70 tonnes per day. The current capacity of the cryogenic HPO production unit at the North End plant is 55 tonnes per day. Thus additional oxygen generating capacity will be required. However, if denitrification were included in the process by adding an anoxic zone to the bioreactors, oxygen savings up to about 15 tonnes per of oxygen day could be realized. This would result in utilizing the full oxygen generating capacity of the cryogenic system. Waste activated sludge quantities will be reduced substantially due to the change in operation. Longer SRTs will result in a reduction in WAS of approximately 20 percent.
5. Space Requirements:	Figure NE-1.2 shows that the additional HPO reactors can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. Additional bioreactors could be constructed to handle future unanticipated increases in flows and loads. The plant could be converted to biological phosphorus removal in the future by constructing pre-anoxic and anaerobic zones ahead of the existing bioreactors. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.

NEWPCC – HPO Single Stage Nitrification (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
7. Constructability:	The construction of the new HPO reactors would mostly be external to the existing facilities, and would not cause a major disruption of normal plant operations until channel tie-ins must be done. Some modification and extension to the primary effluent distribution and mixed liquor collection channels would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the oxygen generation equipment (if required) and bioreactor mixers. If anoxic zones are not included in the process, then additional oxygen generating capacity will be required.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Because of the sensitivity of the HPO nitrification process to the mixed liquor pH, the process is more susceptible to upsets resulting from changes to the incoming flows and loads. Additional monitoring and control parameters will be required to maintain plant stability.
2. Ease of Maintenance:	The additional mechanical mixers in the oxic zones and the chemical feed system will increase maintenance requirements. However, there will be no increase in the difficulty of maintenance.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process. However, if chemical addition is required for pH control in the bioreactor, this could result in some additional safety issues depending on the chemical used.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	A minor increase in traffic is expected to bring bulk chemicals to the plant if alkalinity addition is required.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. Architectural finishes would be compatible and thus would cause minimum impact.
4. Odours:	New reactors will be covered and no odours are anticipated. Venting the last oxic cell to atmosphere is unlikely to result in the generation of offensive odours.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors, channel extensions, and the chemical storage and feed facility. It is expected that these units will cost approximately $75 million. This option is the baseline and provides the benchmark against which other options at the North End plant will be measured.

NEWPCC – HPO Single Stage Nitrification (Cont'd.)

COST CRITERIA (Cont'd.)	
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements, power requirements for the reactor mixers, and chemical addition for pH adjustment. A minor savings in O&M costs will be realized as a result of the reduced sludge production in the biological process. The incremental O&M costs will be approximately $1.2 million per year. This cost covers the additional power requirements and some allowance for extra operator time.
3. Other Down-stream Economic Impacts:	The expansion will use a major portion of the land at the northwest corner of the site. However the site is sufficiently large that this should not be a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**NORTH END WATER POLLUTION CONTROL CENTRE - HPO RAS REAERATION**
STANDARD:	10 mg/L (no winter limit)

PROCESS DESCRIPTION

In this option the NEWPCC will be upgraded to meet an effluent NH_3 concentration of 10 mg/L (as N) in summer by expanding the HPO bioreactor and adding a RAS reaeration zone upstream of the mixed liquor zones. RAS reaeration provides the ability to maintain nitrifying organisms in the system without excessive solids loading rates on the final clarifiers. Some sacrifice is made with respect to the achieving of a low effluent ammonia concentration.

The approach used here recognizes the limitations of the existing secondary clarifiers in that additional bioreactor tankage is constructed in order to increase the biomass under aeration and to maintain a workable solids loading rate on the clarifiers. Centrate would be added to the RAS reaeration zone and primary effluent would be step fed around this zone and into the second compartment of each HPO bioreactor. The estimated total bioreactor volume of 70,300 m^3 will be provided of which 25% will be devoted to RAS reaeration to maintain a total solids retention time (SRT) of 7 to 8 days during the summer months and 10 to 11 days during winter.

A key element of this process is pH control in order to prevent nitrification inhibition. The last aerobic cell will be vented to allow CO_2 stripping to increase the mixed liquor pH by preventing CO_2 accumulation in the mixed liquor. In addition, some alkalinity addition to the primary effluent may be required to buffer pH depression resulting from the nitrification reaction. The bioreactor will be operated at a MLSS of about 2,500 mg/L.

A process flow schematic of the proposed upgrade of the NEWPCC to HPO RAS reaeration is presented in Figure NE-2.1. The design criteria for the upgraded secondary treatment process are presented in Table NE-2.1 on the following page.

A layout of the NEWPCC after upgrading the secondary treatment process to HPO RAS reaeration is presented in Figure NE-2.2. The 8 new HPO reactor modules will be built to the south and southwest of the existing 4 cell bioreactor modules.

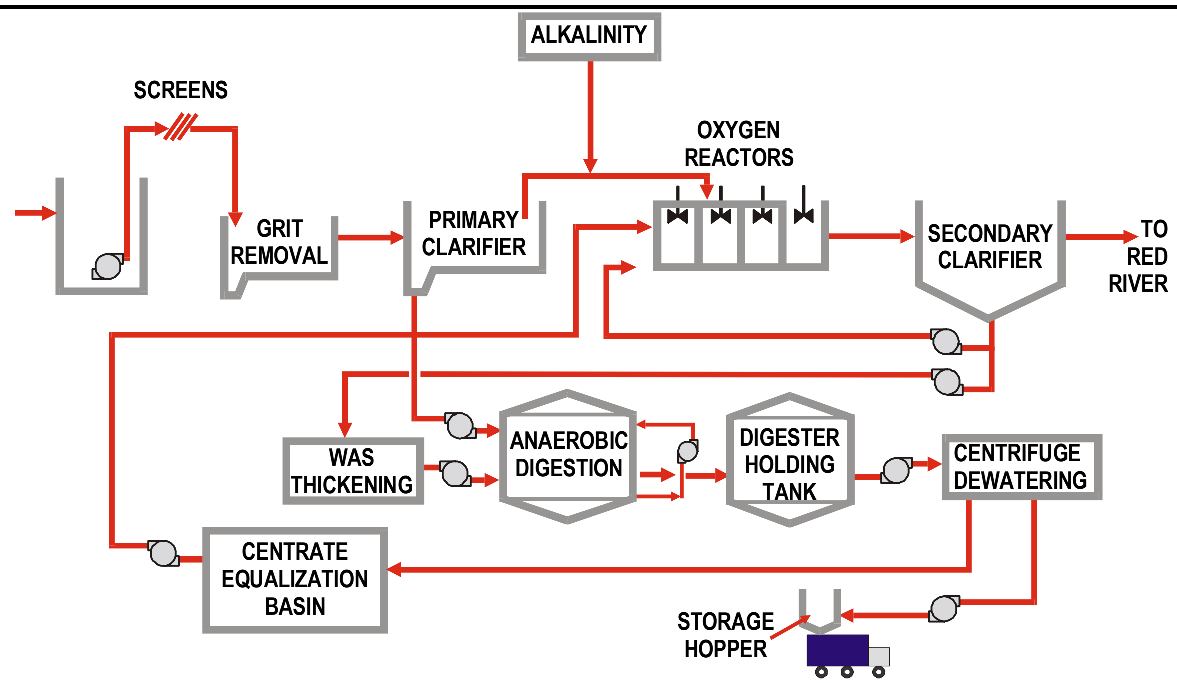
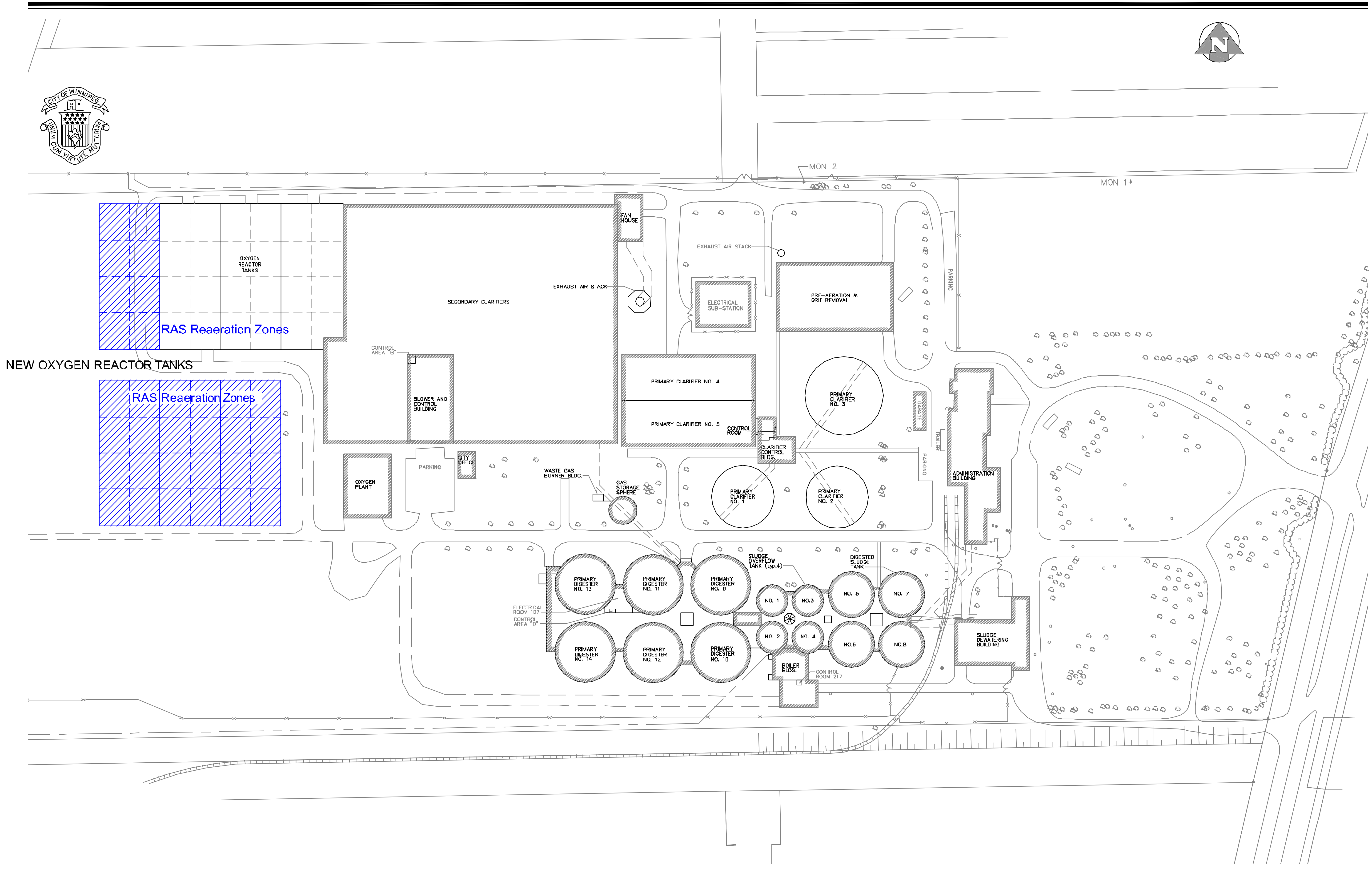


Figure NE-2.1: HPO RAS Reaeration at the North End Water Pollution Control Centre



NEWPCC HPO RAS Reaeration

Figure NE 2.2

NEWPCC – HPO RAS Reaeration (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table NE-2.1: HPO RAS Reaeration at the North End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
ADWF. ML/d	302	211
PDWF, ML/d	568	397
PWWF, ML/d	1060	1060
BOD_5 Load		
Average, kg/d (40 percent removal in PSTs)	59.800	32,184
Maximum, kg/d (45 percent removal in PSTs)	-	42,147
TSS Load, kg/d		
Average, kg/d (60 percent removal in PSTs)	56,400	25,972
Maximum, kg/d (65 percent removal in PSTs)	-	45,168
HPO Bioreactor		
Number of reactors	6	14
Total Reactor Volume, m^3 – mixed liquor	30,132	52,700
HRT at ADWF, h - mixed liquor	2.4	6.0
Temperature, min-max, °C	11/22	11/22
SRT (winter), d	-	10 to 11
SRT (summer), d		7 to 8
MLSS, (at avg.), mg/L		2,600
MLSS, (summer), mg/L		2,300
Secondary Clarifiers		
Number of units	10 Square 16 Rectangular	10 Square 16 Rectangular
Diameter, m	Sq - 20 x 20 Rect - 8.23 x 69.35	Sq - 20 x 20 Rect - 8.23 x 69.35
SWD, m	Sq – 4.65 Rect – 3.65	Sq – 4.65 Rect – 3.65
Total area, m^2	Sq – 4,000 Rect - 9,132	Sq – 4,000 Rect - 9,132
OFR @ PDWF, m/h	1.80	1.26
SLR @ PWWFof 598 ML/d and 50% RAS Q, kg/m^2/h	11.38	11.38

TECHNICAL CRITERIA

1. Reliability:	The reliability of the process is largely dependent on maintaining the mixed liquor pH in the optimum range for nitrification, i.e. between 6.5 and 8.5. Maintaining the process pH in this range can be very tenuous because of the cumulative effects of increased CO_2 production from biological carbonaceous removal and alkalinity depletion from nitrification. As the CO_2 content in the gas phase increases, the CO_2 concentration in the mixed liquor also increases and the process pH is depressed. The pH depression normally found in HPO processes is exacerbated by the alkalinity destruction resulting from nitrification. At pH values below 6.5, the growth rate of the nitrifying organisms is inhibited. Positive pH control is required to keep the system stable and reliable.

NEWPCC – HPO RAS Reaeration (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
1. Reliability: (cont'd.)	One of the critical factors in the proposed system will be the ability of the final clarifiers to operate successfully at the higher solids loading rates required during winter. It will be necessary to operate at a higher SRT range of, say, 9 to 10 days in winter in order to maintain nitrifying organisms in the system. Modifications to the final clarifiers may be required in order to operate in this range.
2. Robustness:	Because of the sensitivity of nitrifiers and the potential for inhibition at pH values below 6.5, the process is more susceptible to upsets from flow and load variations than the air activated sludge process. However the RAS reaeration process is somewhat more robust than the "conventional" HPO process due to the retention of RAS in the reaeration zone for a relatively long HRT.
3. Flexibility:	The process could be modified to meet tighter effluent limits by the addition of more mixed liquor aerobic tankage. Once the process is established, changes should not be introduced except to correct process upsets. Bringing basins on and off line will be complicated by the need for longer SRTs should the mixed liquor pH or the mixed liquor temperature be low.
4. Impact on Other Parts of the Plant:	The addition of the 8 new bioreactors and operating the system to achieve nitrification will require an additional ~20 to ~25 tonnes per day of oxygen. Current oxygen consumption at the North End plant is approximately 33 tonnes per day for BOD5 removal only. Thus it is expected that nitrification will more than double the oxygen requirements to approximately ~55 to ~60 tonnes per day. The current capacity of the cryogenic HPO production unit at the North End plant is 55 tonnes per day. Thus marginally additional oxygen generating capacity may be required. Alternately supplemental liquid oxygen could be purchased as needed. Waste activated sludge quantities will be reduced substantially due to the change in operation. Longer SRTs will result in a reduction in WAS of approximately 20 percent.
5. Space Requirements:	Figure NE-2.2 shows that the additional HPO reactors can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. Additional bioreactors could be constructed to handle future unanticipated increases in flows and loads. The plant could be converted to biological phosphorus removal in the future by constructing pre-anoxic and anaerobic zones ahead of the mixed liquor bioreactor tankage. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.
7. Constructability:	The construction of the new HPO reactors and RAS reaeration tankage would mostly be external to the existing facilities, and would not cause a major disruption of normal plant operations until channel tie-ins must be done. Some modification and extension to the primary effluent distribution and mixed liquor collection channels would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the bioreactor mixers.

NEWPCC – HPO RAS Reaeration (Cont'd.)

OPERATIONAL CRITERIA	
1. Ease of Operation:	Because of the sensitivity of the HPO nitrification process to the mixed liquor pH, the process is more susceptible to upsets resulting from changes to the incoming flows and loads. Additional monitoring and control parameters will be required to maintain plant stability.
2. Ease of Maintenance:	The additional mechanical mixers and the chemical feed system will increase maintenance requirements. However, there will be no increase in the difficulty of maintenance.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process. However, if chemical addition is required for pH control in the bioreactor, this could result in some additional safety issues depending on the chemical used.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	A minor increase in traffic is expected to bring bulk chemicals to the plant if alkalinity addition is required.
2. Noise:	New operating equipment is similar to existing equipment. There will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. Architectural finishes would be compatible and thus would cause minimum impact.
4. Odours:	New reactors will be covered and no odours are anticipated. Venting the last oxic cell to atmosphere is unlikely to result in the generation of offensive odours.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors and RAS reaeration zones, channel extensions, and the chemical storage and feed facility. It is expected that these units will cost approximately $54 million.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements, power requirements for the reactor mixers, and chemical addition for pH adjustment. A minor savings in O&M costs will be realized as a result of the reduced sludge production in the biological process. The incremental O&M costs will be approximately $800,000 per year. This cost covers the additional power requirements and some allowance for extra operator time.
3. Other Down-stream Economic Impacts:	The expansion will use a significant portion of the land at the northwest corner of the site. However the site is sufficiently large that this should not be a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**NORTH END WATER POLLUTION CONTROL CENTRE – SECOND STAGE NITRIFYING TRICKLING FILTERS**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option the NEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) in summer. The secondary effluent tunnel will be intercepted to the east of the existing pre-aeration and grit removal building and pumped to four (4) new nitrifying trickling filters. Each filter will be 50 metres in diameter with 7.2 metres of high density media (135 m^2/m^3). The filters have been sized to remove ammonia at a rate of 0.165 $kg/m^3/d$. The filters would be designed to be flooded regularly to control biomass predators (worms, fly larvae, and snails). Flooding would entail filling the filter with water every week and leaving it for an 8 to 12 hour period. The nitrifying trickling filter system would be designed with effluent recycle to ensure that wetting rates are maintained at relatively high levels. Higher wetting rates enhance the efficiency of this process.

The NTFs would be covered for environmental protection and fans would be provided to circulate air through the media. The recirculation rate for each NTF would be approximately 40 m^3/s to ensure a face velocity of approximately 1.2 m/sec. At this face velocity, good distribution is assured. In addition to recirculation fans, air supply fans will be provided to ensure that the oxygen content of the recirculated air does not decrease below about 19 percent (by weight). To ensure that this level of oxygen depletion is not exceeded, a continual air supply of 4.5 m^3/s per filter will be provided. This air supply will be drawn from the interior of the existing buildings. Exhaust fans will draw 5.0 m^3/s from each filter and return it to the foul air system for dispersal through the plant stack. Extracting air at a rate that is ~10 percent higher than the supply rate will ensure that the enclosure is maintained under a slight negative pressure at all times.

A process flow schematic of the proposed upgrade of the NEWPCC to second stage nitrifying trickling filter nitrification is presented in Figure NE-3.1. The design criteria for the upgraded secondary treatment process are presented in Table NE-3.1 on the following page.

A layout of the NEWPCC after upgrading the secondary treatment process to second stage nitrifying trickling filters is presented in Figure NE-3.2.

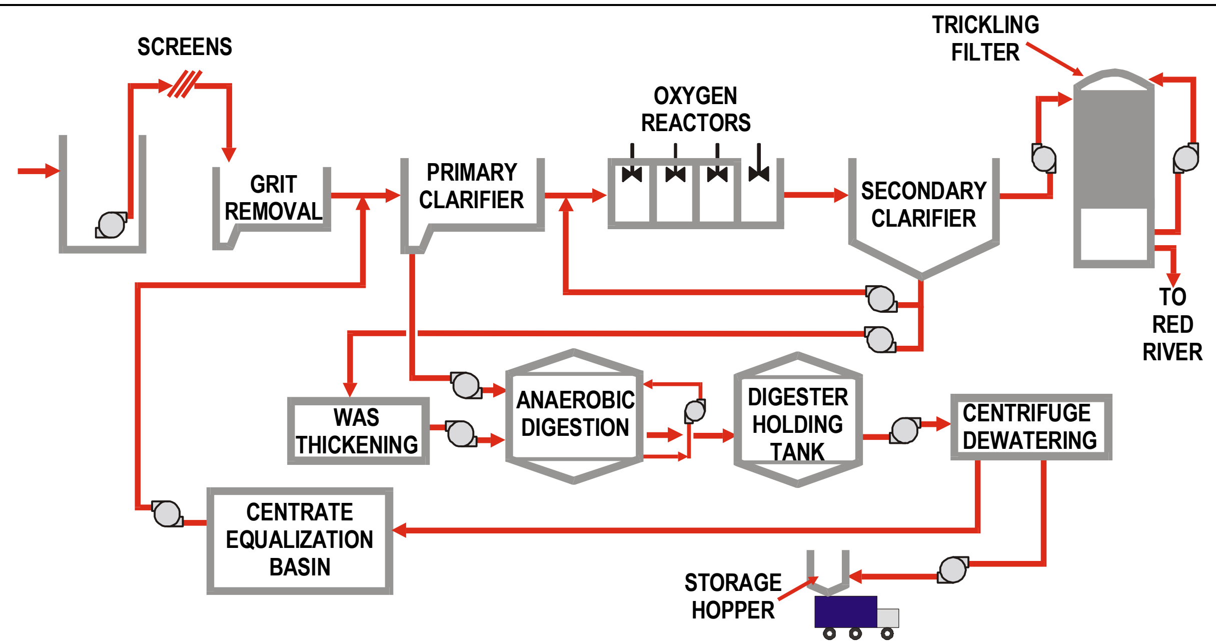
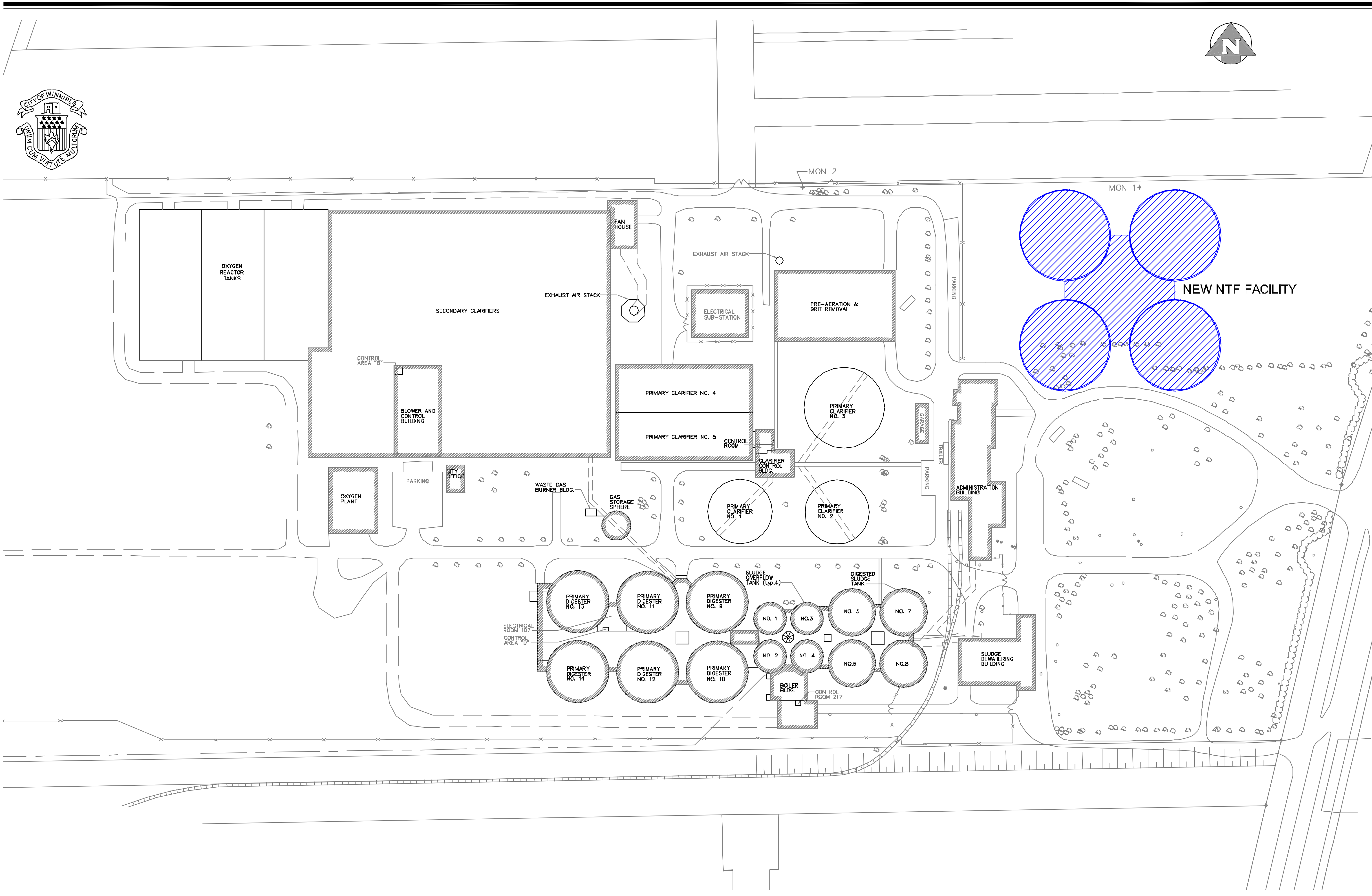


Figure NE-3.1: Second Stage Nitrifying Trickling Filters at the North End Water Pollution Control Centre



NEWPCC Second Stage NTF
Figure NE 3.2

NEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table NE-3.1: Second Stage Nitrifying Trickling Filters at the NEWPCC

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
AAF, ML/d	302	269
PDWF, ML/d	568	397
PWWF, ML/d	1060	1060
BOD_5 Load		
Average, kg/d (40 percent removal in PSTs)	59,800	32,184
Maximum, kg/d (45 percent removal in PSTs)	-	42,147
TSS Load, kg/d		
Average, kg/d (60 percent removal in PSTs)	56,400	25,972
Maximum, kg/d (65 percent removal in PSTs)	-	45,168
HPO Bioreactor		
Number of reactors	6	6
Total Bioreactor Volume, m^3	20,132	20,132
HRT at ADWF, h	2.23	2.23
Temperature, min-max, °C	11/22	11/22
SRT (winter), d	-	
SRT (summer), d	-	
MLSS, (at avg.), mg/L	-	
MLSS, (at max month), mg/L	-	
Secondary Clarifiers		
Number of units	10 Square 16 Rectangular	10 Square 16 Rectangular
Diameter, m	Sq - 20 x 20 Rect - 8.23 x 69.35	Sq – 20 x 20 Rect - 8.23 x 69.35
SWD, m	Sq – 4.65 Rect – 3.65	Sq – 4.65 Rect – 3.65
Total area, m^2	Sq - 2,000 Rect - 9,132	Sq - 2,000 Rect - 9,132
OFR @ PDWF, m/h	1.80	1.80
SLR @ PWWF, $kg/m^2/h$	11.38	11.38
Secondary Effluent		
Flow		
Average, ML/d		269
Maximum month, ML/d		418
BOD Load		
Average, kg/d		2,110
Maximum month, kg/d		3,165
TSS Load		
Average, kg/d		2,110
Maximum month, kg/d		3,165
TKN Load		
Average, kg/d		5,275
Maximum month, kg/d		6,858

NEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table NE-3.1: Single Stage Nitrification at the NEWPCC (cont'd.)

Parameter **Primary Effluent Flows & Loads**	Existing Plant	Upgraded Plant
Nitrifying Trickling Filter Pumps		
Number of Units		4
Capacity, L/s		2,780
Head, m		20
Power, kW		-
Nitrifying Trickling Filters		
Number of Units		4
Diameter, m		50.0
Media Depth, m		7.2
Media Density, m^2/m^3		135
Nitrifying Trickling Filter Fans		
Recirculation Fans		
Number		4
Capacity, m^3/s		40
Backpressure, Pa		750
Size, kW		-
Supply Fans		
Number		4
Capacity, m^3/s		4.5
Backpressure, Pa		750
Size, kW		
Exhaust Fans		
Number		4
Capacity, m^3/s		5.0
Backpressure, Pa		375
Size, kW		-

TECHNICAL CRITERIA

1. Reliability:	Nitrifying trickling filters (NTFs) have been used at numerous plants for secondary effluent nitrification. This process is relatively simple and has proven effective as long as suitable predator control is incorporated in the design. It is assumed that the pH of the secondary effluent would rise through secondary clarification and filter application due to CO_2 stripping that occurs in these processes. On the basis of this assumption, nitrifier growth rates would not be inhibited due to low pH.
2. Robustness:	This process is relatively robust. Attached growth processes inherently retain the autotrophic microorganism population as there is no dependence on solids liquid separation. Effluent ammonia spikes will be handled well within reasonable limits, generally plus or minus 50 percent of the average. Toxic shocks would cause failure.

NEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
3. Flexibility:	The process will be difficult to modify to meet changing effluent quality requirements. There are few process conditions that can be modified other than recycle rates. Once the process is established, changes should not be introduced except to correct process upsets.
4. Impact on Other Parts of the Plant:	The new NTFs and the associated pump station would be an add-on module to the existing North End plant and there will be few impacts on the remainder of the plant with this process.
5. Space Requirements:	Figure NE-3.2 shows how the new nitrifying trickling filters would be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be provided to handle unanticipated future increases in flows and loads. The secondary plant could be converted to biological phosphorus removal in the future by modifying the initial cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.
7. Constructability:	The construction of the new nitrifying trickling filters would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the NTF pumps and fans.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Nitrifying trickling filters are relatively simple to operate. Monitoring of performance is necessary and at regular periods, a filter has to be taken off-line and flooded to provide predator control. However, these operations are not complex and could be semi-automated (operator initiation, automatic sequencing).
2. Ease of Maintenance:	The trickling filter pumps, trickling filter mechanisms, and circulation fans will increase maintenance requirements. There will be no increase in the difficulty of maintenance. Trickling filter mechanisms have few maintenance requirements other than regular bearing greasing. Other equipment is similar to that already installed at the plant.
3. Operator Safety:	A trickling filter enclosure is a confined space and would require that the operators follow the requisite procedures when entering. However, entry into the enclosure is infrequently required. No other new safety concerns would arise in the secondary treatment process.
4. Operator Environment:	There will be no significant changes from the existing operations other than within the trickling filter enclosure. In this area, high humidity can be expected and some level of odours would be evident.

NEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is envisioned.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	In the location proposed on Figure NE-3.2, the NTFs would be a prominent feature on the site. The top of the trickling filter media would be about ~10 metres above ground and the top of the dome, about 5 metres above that point. These structures would be immediately evident from Main Street and would increase the visual impact of the plant. Architectural finishes would be selected that would be compatible with the existing buildings; however, the domes would be fibreglass or aluminum and would not be similar to other facilities at the NEWPCC.
4. Odours:	No odours are anticipated from the NTFs. Passing foul air through the NTFs may actually decrease the odour levels in the air and reduce off-site impacts.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the nitrifying trickling filters and associated pumping station. It is expected that these units will cost approximately \$97 million. If second stage BAFs were installed rather than the nitrifying trickling filters, the approximate cost would be about \$73 million.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the power requirements for the NTF pumps and fans. The incremental O&M costs will be approximately \$540,000 per year. This cost covers the additional power requirements, additional equipment maintenance, and some allowance for extra operator time. If BAFs were used rather than NTFs, the additional annual operating costs would be approximately \$840,000 per year.
3. Other Down-stream Economic Impacts:	The expansion will use a significant portion of the land available in the site.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**NORTH END WATER POLLUTION CONTROL CENTRE CEPT WITH RAS REAERATION**
STANDARD:	10 mg/L (Periodically)

PROCESS DESCRIPTION

In this option the NEWPCC will be upgraded to meet a periodic effluent NH_3 concentration of 10 mg/L (as N) in summer. A facility will be constructed to add chemicals to the primary influent flow. These chemicals will enhance BOD and TSS removal (Chemically Enhanced Primary Treatment – CEPT) so that less load will be transferred to the secondary system. The basis for this design is that at least 60 percent of the influent BOD and 85 percent of the influent TSS will be removed. The additional six HPO bioreactors will be constructed to increase the biomass under aeration and to maintain the solids loading rate on the existing final clarifiers at a level similar to existing conditions. Each HPO bioreactor module will be modified to provide for a reaeration zone in the first cell. An hydraulic retention time (HRT) of about 5.8 hours in the mixed liquor zones and about 3.4 hours in the RAS reaeration zones will result at average flow conditions. This sizing will allow the biological system to maintain a solids retention time (SRT) of 6.5 to 7.5 days during summer periods when nitrification may be required.

To improve the system pH, the last cell of each bioreactor will be vented with air. This arrangement will allow the pH to be increased to about 6.5 so that minimal nitrification inhibition occurs. The largest oxygen demand will occur in the first cell – the reaeration zone. To assist in maintaining a neutral pH, alkali addition will be required.

A process flow schematic of the proposed upgrade of the NEWPCC to CEPT with RAS reaeration is presented in Figure NE-4.1. The design criteria for the upgraded secondary treatment process are presented in Table NE-4.1 on the following page.

A layout of the NEWPCC after upgrading the secondary treatment process to CEPT with RAS reaeration nitrification is presented in Figure NE-4.2. The six new HPO reactor modules will be built to the south of the six existing bioreactor modules.

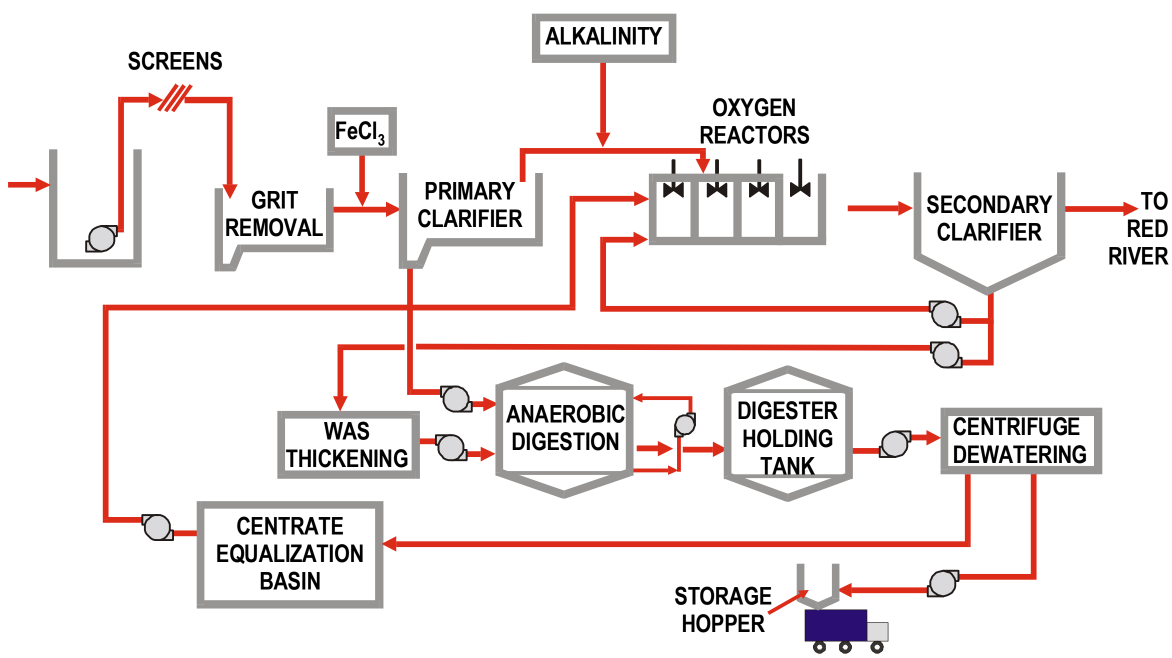
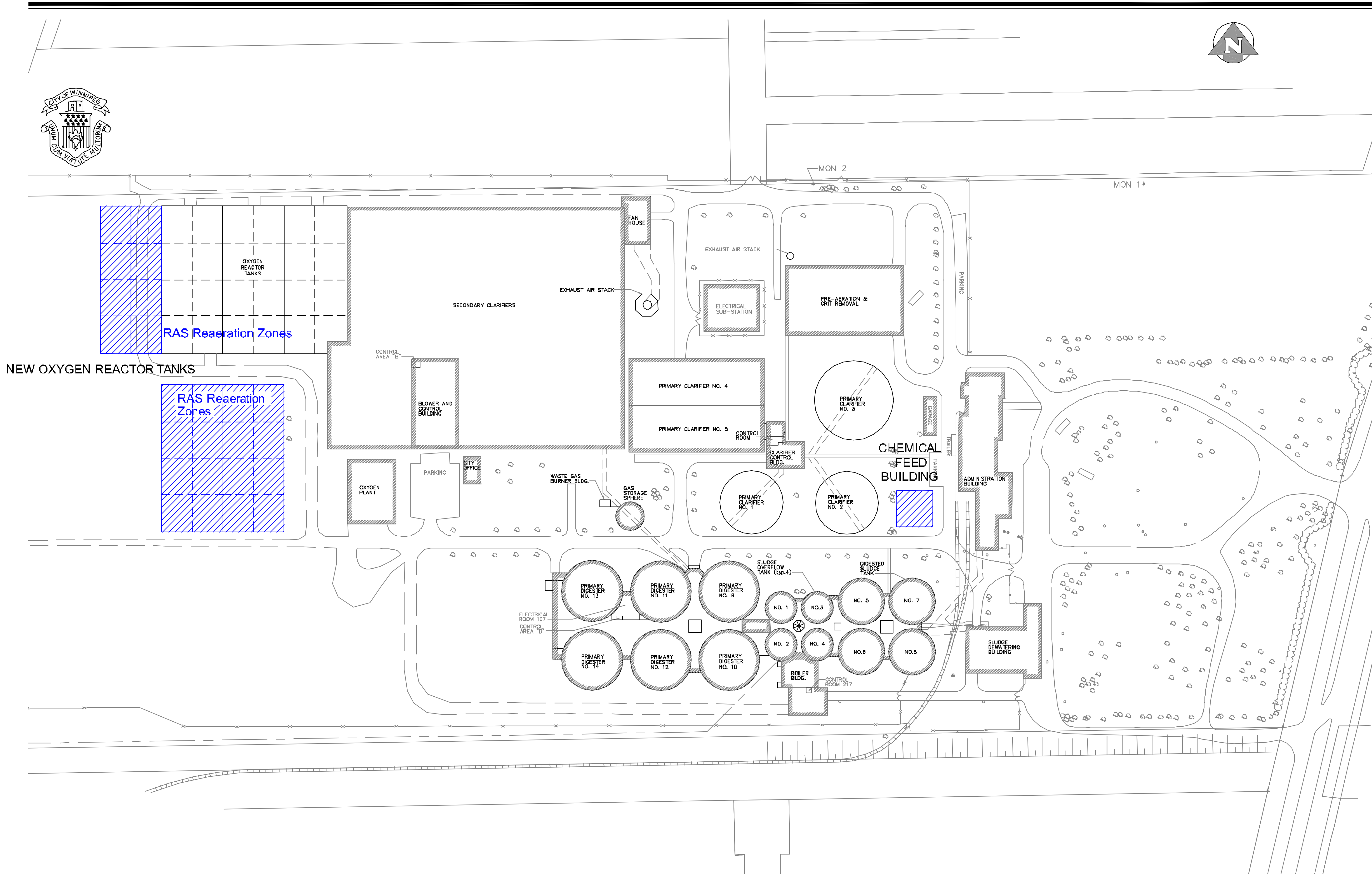


Figure NE-4.1: RAS Reaeration at the North End Water Pollution Control Centre



NEWPCC Periodic CEPT with RAS Reaeration
Figure NE 4.2

NEWPCC – CEPT with RAS Reaeration (Cont'd.)

PROCESS DESCRIPTION (CONT'D.)

Table NE-4.1: RAS Reaeration at the North End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
AAF, ML/d	302	211
PDWF, ML/d	568	397
PWWF, ML/d	1060	1060
BOD_5 Load		
Average, kg/d (60 percent removal in PSTs)	59,800	21,456
Maximum, kg/d (60 percent removal in PSTs)		30,652
TSS Load, kg/d		
Average, kg/d (85 percent removal in PSTs)	56,400	12,986
Maximum, kg/d (90 percent removal in PSTs)		12,905
HPO Bioreactor		
Number of reactors	6	12
Total Bioreactor Volume, m^3 - mixed liquor - RAS reaeration	30,132 0	45,200 15,066
HRT at ADWF, h - mixed liquor - RAS reaeration	2.23 0	5.8 3.4
Temperature, min-max, °C	11/22	11/22
SRT (winter), d	-	-
SRT (summer), d	-	6.5 to 7.5
MLSS, (at avg.), mg/L	-	
MLSS, (summer), mg/L	-	~2,500
Secondary Clarifiers		
Number of units	10 Square 16 Rectangular	10 Square 16 Rectangular
Diameter, m	Sq - 20 x 20 Rect - 8.23 x 69.35	Sq - 20 x 20 Rect - 8.23 x 69.35
SWD, m	Sq – 4.65 Rect – 3.65	Sq – 4.65 Rect – 3.65
Total area, m^2	Sq - 4,000 Rect - 9,132	Sq - 4,000 Rect - 9,132
OFR @ PDWF, m/h	1.80	1.80
SLR @ PDWF, $kg/m^2/h$	11.38	11.38

TECHNICAL CRITERIA

1. Reliability:	RAS Reaeration can effectively remove ammonia to about 5 mg/L in summertime. The key will be pH control through the venting of the last cell in each module. It is imperative that the pH be maintained above 6.5. The loss of alkalinity due to chemical addition may exacerbate this situation.
2. Robustness:	The robustness of this process depends upon the settleability of the secondary sludge. If the SVI can be maintained at 100 mL/g or below, the process will remain relatively stable. Any increases to or beyond that value may result in poor secondary clarifier performance.

NEWPCC – CEPT with RAS Reaeration (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
3. Flexibility:	The process is relatively flexible. Operational changes to oxygen supply rates, RAS rates, and the split of the primary effluent flow into the first two cells allow changes to be made to react to changing flows and loads. CEPT can be modulated to trim the secondary loads.
4. Impact on Other Parts of the Plant:	The existing HPOAS reactors and secondary clarifiers would have to be expanded to handle the higher HRT and SRT necessary for nitrification. However, the operating strategy and controls would remain similar to the current practice. When not operating in RAS reaeration mode, the flow routing configuration in the bioreactors would remain as it is now. The 55 tonne per day capacity of the existing cryogenic oxygen generating facility should accommodate the needs of the periodic CEPT and RAS reaeration process. The addition of CEPT would have a substantial impact upon primary clarifier operation. Significantly more sludge would be generated and there would be changes in its character.
5. Space Requirements:	Figure NE-4.2 shows that the additional HPO reactors can be accommodated within the existing NEWPCC site.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be provided to handle unanticipated increases in flows and loads. The secondary plant could be converted to biological phosphorus removal in the future by modifying the second cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream does not negate biological phosphorus removal. If CEPT were introduced, no further treatment would likely be required to remove sufficient phosphorus to meet a limit of 1.0 mg/L. It would be advisable to provide split chemical addition so that some could be added to the secondary treatment area should it become necessary to trim the final phosphorus concentration.
7. Constructability:	The construction of new HPO reactors would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Some modification and extension to the primary effluent distribution channels and mixed liquor collection channels would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the additional bioreactor mixers.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Reaeration would introduce a new level of complexity to the operation of the plant. SRT control would depend upon RAS and WAS rates. CEPT would further add to the complexity of the operation.

NEWPCC – CEPT with RAS Reaeration (Cont'd.)

OPERATIONAL CRITERIA (Cont'd.)	
2. Ease of Maintenance:	Additional mechanical mixers in the oxygenated zones will increase maintenance requirements. There will be no increase in the difficulty of maintenance. CEPT equipment is relatively simple; although the chemicals are hazardous and special procedures are required to work in the vicinity of this material.
3. Operator Safety:	There would be no additional safety concerns related to the expanded plant. The hazardous nature of chemicals used for CEPT adds to the care and caution that must be exercised.
4. Operator Environment:	There will be no significant changes from the existing operations. Fume management in the chemical area would obviate any potential problems in that area.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is envisioned for conventional RAS reaeration. Should CEPT be incorporated, traffic would increase marginally due to the bulk chemical deliveries.
2. Noise:	The new operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. The chemical storage and feed facility would be relatively small and would not be a high structure. Thus, no substantial visual impacts are envisioned.
5. Odours:	New reactors will be covered and no odours are anticipated. CEPT using ferric salts would likely reduce odour generation through the plant.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors and the chemical storage and metering equipment. It is expected that these units will cost approximately \$24 million. These costs are substantially lower than required for addition of nitrification for annual nitrification.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements and power requirements for the reactor mixers. The incremental O&M costs will be approximately \$250,000 per month, when CEPT is required. This cost covers chemical costs, the additional power requirements, additional equipment maintenance, and some allowance for extra operator time. It includes the additional costs associated with capacity expansion as well as nitrification.
3. Other Down-stream Economic Impacts:	The use of large areas of the site will reduce flexibility to handle further changes in plant service area or population.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**NORTH END WATER POLLUTION CONTROL CENTRE PERIODIC AMMONIA REMOVAL BY CHLORINATION**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option, the NEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) by breakpoint chlorination. Chlorine will be dosed following the secondary clarifiers at an average dose of about 150 mg/L. Sulphur dioxide or sodium bisulphite will be used to dechlorinate the effluent prior to discharge to the Red River. It is assumed that the historical ammonia removal rates will continue to be achieved by the secondary treatment process, and that chlorine will only be used to polish the effluent. Based on this approach, approximately 50 to 80 tonnes of chlorine will be required each day.

The upgraded facility will include a bulk rail car chlorine and tonne container sulphur dioxide receiving and storage areas, storage areas, evaporating/metering and control systems, a containment and scrubbing system, and rapid mix injection and dispersion chambers. Bulk chlorine will be delivered to the plant site by rail to minimize purchased chemical costs and to avoid multiple daily deliveries of tonne cylinders on trucks. A process flow schematic Figure NE-5.1. The design criteria for the process are presented in Table NE-5.1 on the following page.

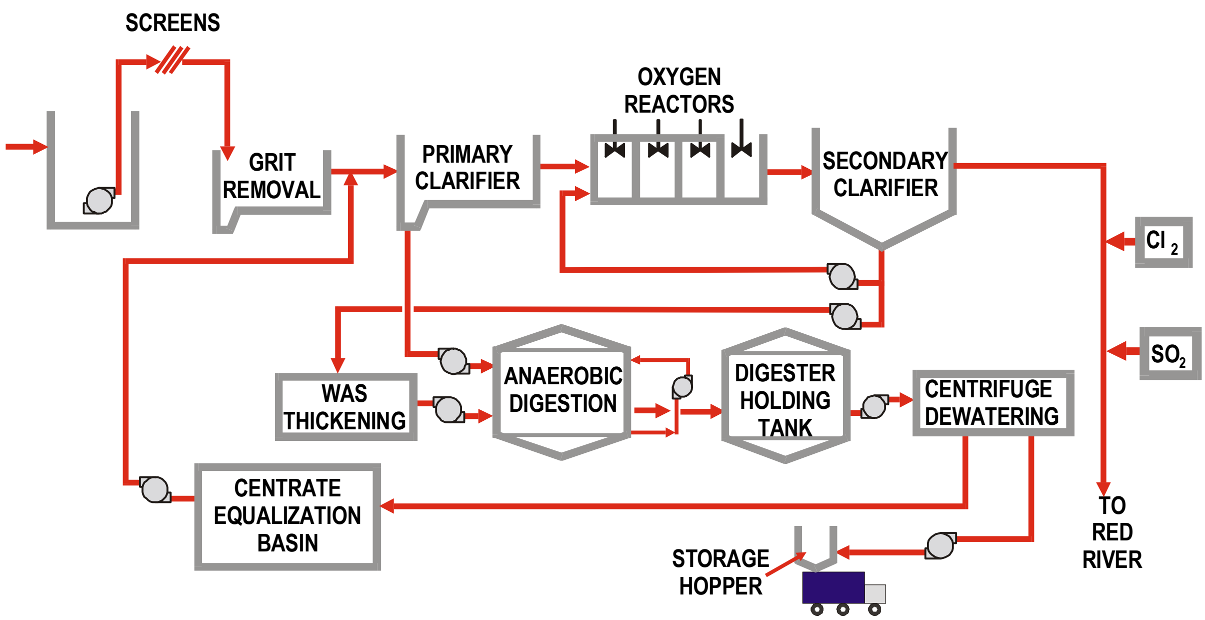


Figure NE-5.1: Process Flow Schematic – NEWPCC Breakpoint Chlorination for Ammonia Removal

NEWPCC – Periodic Ammonia Removal by Chlorination (Cont'd.)

PROCESS DESCRIPTION (CONT'D.)

Table NE-5.1: Periodic Chlorination at the North End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Upgraded Plant Design**
ADWF, ML/d	211
PDWF, ML/d	397
Secondary Effluent Ammonia , mg/L (assumed)	25
Chlorination Facility	
Chorine Dosage	
At ADWF, mg/L	250
At PDWF, mg/L	200
Chlorine Usage	
Average, kg/d	53,000
Peak, kg/d	79,400
Chlorine Storage	
Size of Rail Cars, kg	100,000
Evaporators	
Number	25
Capacity, kg/d	3,636
Chlorinators	
Number	25
Capacity, kg/d	3,636
Sulphur Dioxide Facility	
SO_2 Dosage	
Average, mg/L	5
Peak, mg/L	20
SO_2 Usage	
Average, kg/d	1,000
Peak, kg/d	7,000
SO_2 Storage	
Size of Containers, kg	910
Online Containers	3
Standby Containers	3
Reserve Containers	14
Total Spaces	20
Evaporators	
Number	3
Capacity, kg/d	3,636
Sulphonators	
Number	3
Capacity, kg/d	3,636

NEWPCC – Periodic Ammonia Removal by Chlorination (Cont'd.)

TECHNICAL CRITERIA	
1. Reliability:	Chlorination and dechlorination technology is well developed and has been widely applied for many decades. If periodic use of this technology is implemented, equipment will have to be serviced and tested on a regular basis to ensure safe operation. It is likely that for the amount of chlorine to be applied in this application, alkalinity will be required to maintain the pH of the effluent in a neutral range not only to comply with effluent discharge limits but also to minimize the risk of forming the toxic NCl_3 byproduct of the breakpoint reactions. This technology is specific for the ammonium ion and therefore must be operated at a pH of less than ~8 to prevent formation of ammonia gas in solution. Thus wastewater containing significant amounts of organic nitrogen must be given a sufficient amount of bacterial treatment to convert organic nitrogen to ammonium but not to nitrite or nitrate. Any nitrogen in the secondary effluent stream still in the Kjeldahl form will not be treated by this method.
2. Robustness:	Varying ammonia loads can be handled by adjusting the chlorine dosage accordingly. This would be done with an automatic control system including flow measurement and ammonia and chlorine sensing devices.
3. Flexibility:	Sufficient flexibility can be provided by configuring equipment for changing flows and loads.
4. Impact on Other Parts of the Plant:	There would be little impact on other parts of the plant.
5. Space Requirements:	Space requirements for breakpoint chlorination would be relatively modest. The most space would be required by the bulk chlorine and sulphur dioxide receiving, storage, evaporating and metering systems together with their related containment and scrubbing systems.
6. Expandability:	The process would be readily expandable by the addition of more chlorination equipment.
7. Constructability:	No particular impediments to construction are anticipated. Appropriate tie-ins to the existing effluent channels would be required when it is time to commission the rapid mixing and contact tank.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Normal operation would be automated and would generally require only periodic attention and monitoring by the operating staff. The most labour intensive operational requirements would be for changing from empty to full chlorine (or sulphur dioxide) containers.
2. Ease of Maintenance:	Maintenance would be relatively straightforward and typical of equipment maintenance requirements commonly found in many water/wastewater treatment facilities.

NEWPCC – Periodic Ammonia Removal by Chlorination (Cont'd.)

OPERATIONAL CRITERIA (Cont'd.)	
3. Operator Safety:	Because of the extremely hazardous nature of chlorine and sulphur dioxide, special training must be given to the plant operating and maintenance staff to minimize the risk of an incident and to deal properly with an incident should one occur.
4. Operator Environment:	The operator's environment would not be different to that at a typical water/wastewater treatment facility. The City already uses bulk chlorine at the NEWPCC so the operators should be accustomed to this process.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	There would be additional rail traffic for the delivery and removal of full and empty rail cars containing chlorine. In addition periodic deliveries of bulk caustic solution would be required. There would be a potential health concern over the danger associated with trucking chemicals.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The new building housing the chlorination, containment and scrubbing facilities would be apparent on each plant site. In addition, a new rail car siding(s) would be required at the NEWPCC.
4. Odours:	Some chlorine odour may be noticeable in the immediate vicinity of the chlorine dosing point; however, the odour would dissipate rapidly as one moves away from this point.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of chemical scrubbing facilities, chlorinators, and evaporators. It is expected that these units will cost approximately $15 million.
2. Operating and Maintenance Costs:	The incremental O&M costs will be approximately $1.2 million per month for chemical costs.
3. Other Down-stream Economic Impacts:	Upgrading the NEWPCC to ammonia removal by periodic chlorination will require a relatively modest portion of space.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT	SOUTH END WATER POLLUTION CONTROL CENTRE, SINGLE STAGE NITRIFICATION
STANDARD	2 mg/L

PROCESS DESCRIPTION

In this option, the SEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) in summer by modifying and expanding the HPO bioreactors to facilitate simultaneous carbonaceous removal and nitrification. The estimated total bioreactor volume of 26,000 m^3 will be required to provide a hydraulic retention time (HRT) of 7 hours to maintain a solids retention time (SRT) of 6.5 to 7.5 days during the summer months. A key element of this process is pH control in order to prevent nitrification inhibition. The last aerobic cell will be vented to allow CO_2 stripping to increase the mixed liquor pH by preventing CO_2 accumulation in the mixed liquor. In addition, some alkalinity addition to the primary effluent may be required to buffer pH depression resulting from the nitrification reaction.

The bioreactor will be operated at elevated MLSS concentrations. To handle these concentrations and the anticipated higher flows, one new secondary clarifier will be constructed (45.7 metres in diameter).

A process flow schematic of the proposed upgrade of the SEWPCC to single stage nitrification is presented in Figure SE-1.1. The design criteria for the upgraded secondary treatment process are presented in Table SE-1.1 on the following page.

A layout of the SEWPCC after upgrading the secondary treatment process to HPO single stage nitrification is presented in Figure SE-1.2. The 10 new HPO reactor modules will be built south of the existing 4 cell bioreactor modules. The new clarifier will be constructed on the northwest side of the existing secondary clarifiers.

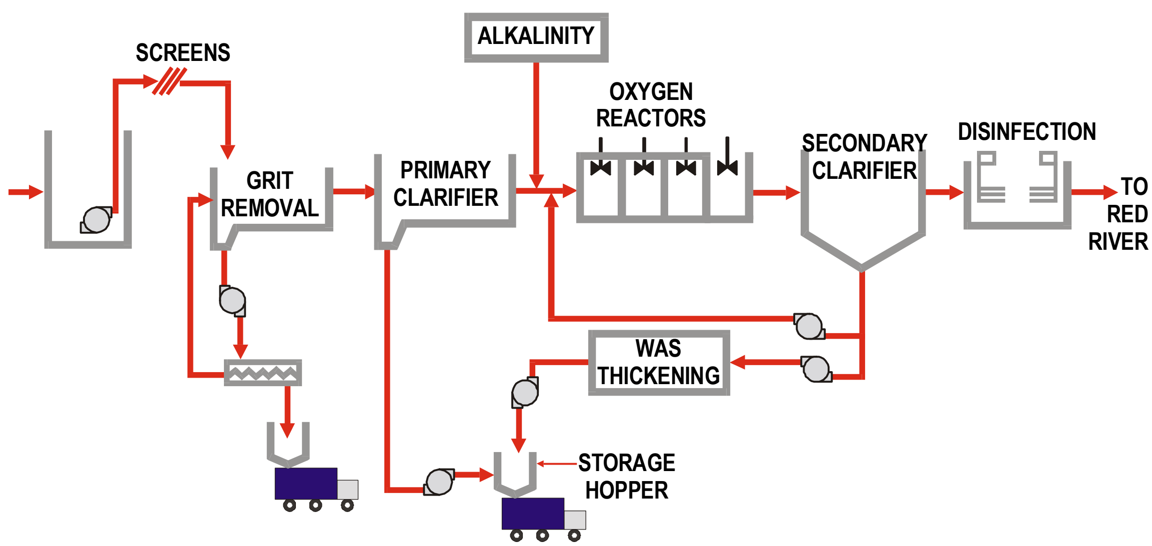
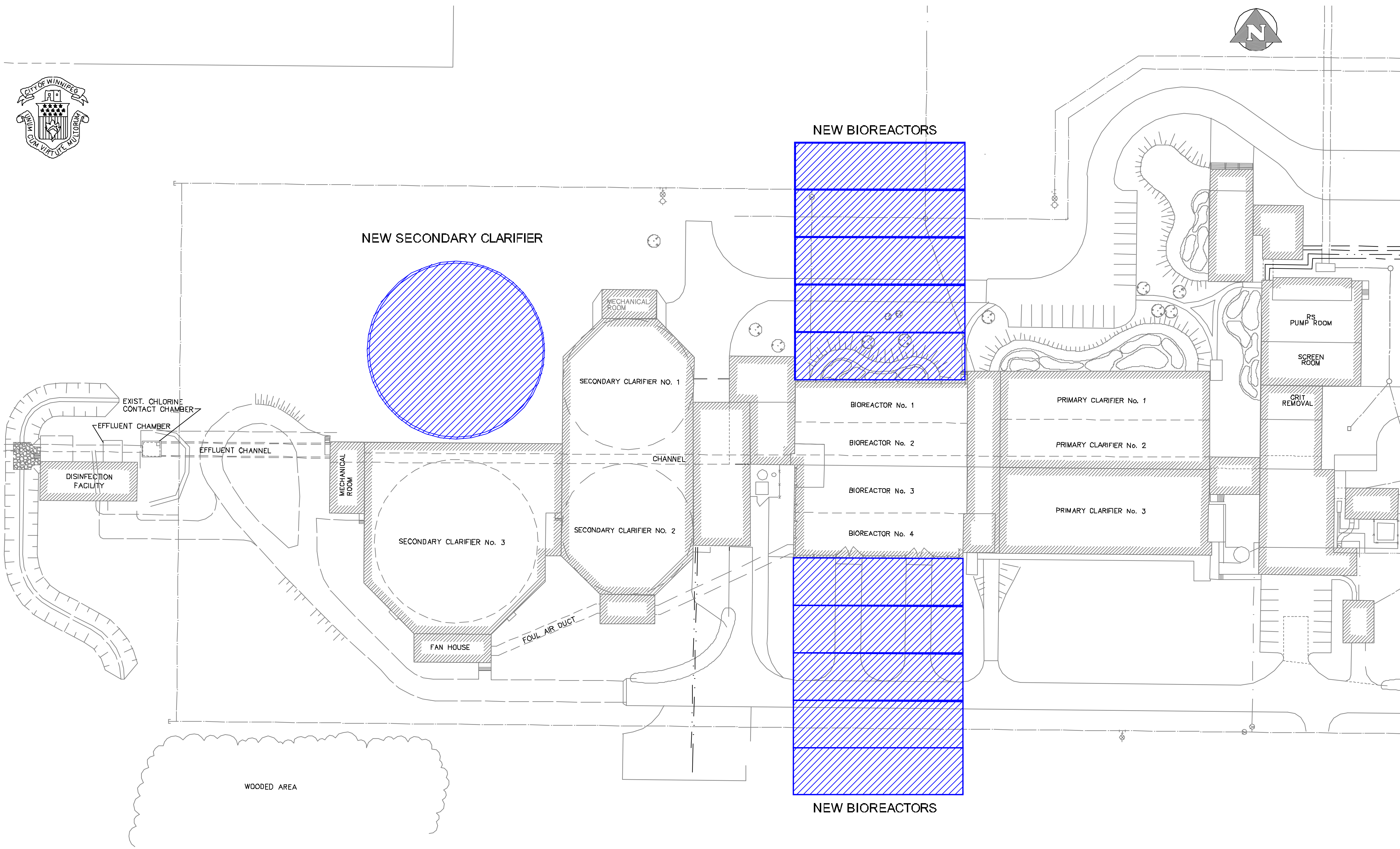


Figure SE-1.1: Process Flow Schematic – SEWPCC Single State Nitrification



SEWPCC Single Stage Nitrification
Figure SE 1.2

SEWPCC – Single Stage Nitrification (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table SE-1.1: Single Stage Nitrification at the South End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
ADWF, ML/d	58	88
PDWF, ML/d	100	150
PWWF, ML/d	174	264
BOD_5 Load		
Average, kg/d (47 percent removal in PSTs)		12,975
Maximum, kg/d (55 percent removal in PSTs)		20,540
TSS Load, kg/d (65 percent removal in PCs)		
Average, kg/d (75 percent removal in PSTs)		7,450
Maximum, kg/d (85 percent removal in PSTs)		8,940
HPO Bioreactor		
Number of reactors	4	14
Volume/reactor, m^3	1,620	1,620
HRT at ADWF, h	2.0	7.0
Temperature, min-max, °C	16	16
SRT (winder), d	-	--
SRT (summer), d		6.5 to 7.0
MLSS, (at avg.), mg/L		3,000
MLSS, (summer), mg/L		4,750
Secondary Clarifiers		
Number of units	3	
Diameter, m	2 @ 33.5; 1@ 45.7	2 @ 33.5; 2 @ 45.7
SWD, m	4.6	4.6
Total area, m^2	3,400	5,040
OFR @ PDWF, m/h	1.2	0.95
SLR @ PWWF, $kg/m^2/h$	6.25	13.4

TECHNICAL CRITERIA

1. Reliability:	The reliability of the process is largely dependent on maintaining the mixed liquor pH in the optimum range for nitrification, i.e., between 6.5 and 8.5. Maintaining the process pH in this range can be very tenuous because of the cumulative effects of increased CO_2 production from biological carbonaceous removal and alkalinity depletion from nitrification. As the CO_2 content in the gas phase increases, the pH concentration in the mixed liquor increases and the process pH is depressed. The pH depression normally found in HPO processes is exacerbated by the alkalinity destruction resulting from nitrification. At pH values below 6.5, the growth rate of the nitrifying organisms is inhibited. Positive pH control is required to keep the system stable and reliable.
2. Robustness:	Because of the sensitivity of nitrifiers and the potential for inhibition at pH values below 6.5, the process is more susceptible to upsets from flow and load variations than the air activated sludge process. The robustness of the process can be somewhat improved by increasing the bioreactor SRT.

SEWPCC – Single Stage Nitrification (Cont'd.)

TECHNICAL CRITERIA (cont'd.)	
2. Robustness: (cont'd.)	Co-thickening of primary sludge and WAS should be suspended. WAS will likely denitrify in the primary clarifiers affecting their performance and impacting the bioreactors. Co-thickening also results in reseeding of undesirable microorganisms to the bioreactor which should be avoided to ensure stability in nitrification mode.
3. Flexibility:	The process will be difficult to modify to meet changing effluent quality requirements as partial nitrification is unstable and poses many operating problems. Once the process is established, changes should not be introduced except to correct process upsets. Bringing basins on and off line will be complicated by the need for longer SRTs should the mixed liquor pH be low.
4. Impact on Other Parts of the Plant:	The addition of nitrification would require an expansion to the existing HPOAS reactors in order to increase the SRT to sustain nitrification. It is estimated that an additional 10 reactors, each with a volume of 1,620 m^3 will be required. The existing pressure swing adsorption unit has a capacity of 21 tonnes per day. Based on venting the last tank and provision of aeration in this cell, nitrification implementation at the SEWPCC would increase the average oxygen demand to approximately 15 tonnes per day, with peak demands of approximately 21 tonnes per day. This demand equals the capacity of the existing oxygen generation system. However, if denitrification was included in the process, oxygen savings up to 4 tonnes per day could be realized. An additional 45.7 m final clarifier is required to handle the anticipated increase in solids loading rate. Secondary sludge quantities will be reduced substantially due to the change in operation. Longer SRTs will result in a reduction of approximately 20 percent.
5. Space Requirements:	Figure SE-1.2 shows that the additional HPO reactors and secondary clarifier can be accommodated readily within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be required to handle year round nitrification and any future increases in flows and loads. The plant could be converted to biological phosphorus removal in the future by modifying the initial cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be mandatory to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.
7. Constructability:	The construction of new HPO reactors and secondary clarifier would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Some modification to the primary effluent distribution channels, mixed liquor collection channels, and flow splitting to the secondary clarifiers would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the additional PSA unit and bioreactor mixers.

SEWPCC – Single Stage Nitrification (Cont'd.)

OPERATIONAL CRITERIA	
1. Ease of Operation:	Because of the sensitivity of the HPO nitrification process to the mixed liquor pH, the process is more susceptible to process upsets resulting from changes to the incoming flows and loads. Additional monitoring and control parameters will be required to maintain plant stability (e.g. pH, alkalinity, tighter DO and SRT control).
2. Ease of Maintenance:	The additional PSA unit, mechanical mixers in the oxic zone, secondary clarifier, and chemical feed system will increase maintenance requirements. However, there will be no increase in the difficulty of maintenance.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process. However, if chemical addition is required for pH control in the bioreactor, this could result in some additional safety issues depending on the chemical used.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	A minor increase in traffic is expected to bring bulk chemicals to the plant if alkalinity addition is required. There will be a decrease in sludge hauling traffic.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. Architectural finishes would be compatible and thus would cause minimum impact.
4. Odours:	The new reactors will be covered and no odours are anticipated. Venting the last oxic cell to atmosphere is unlikely to result in the generation of offensive odours.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors, new secondary clarifiers, an additional PSA unit, and the chemical storage and feed facility. It is expected that these units will cost approximately $36 million. This option is the baseline and provides the benchmark against which other options will be measured.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements, power requirements for the reactor mixers, and chemical addition for pH adjustment. A small savings in O&M costs will be realized as a result of the reduced sludge production in the biological process. The incremental O&M costs will be approximately $540,000 per year. This cost includes the additional power requirements and some allowance for extra operator time. It includes additional costs for expansion and for nitrification.
3. Other Down-stream Economic Impacts:	The use of large areas of the site will reduce flexibility to handle further changes in plant service area or population. However the site is sufficiently large that this is not a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**SOUTH END WATER POLLUTION CONTROL CENTRE – HPO WITH RAS REAERATION**
STANDARD:	10 mg/L

PROCESS DESCRIPTION

In this option the SEWPCC will be upgraded to meet an effluent NH_3 concentration of 10 mg/L (as N) in summer. The HPO bioreactor will be expanded to facilitate carbonaceous removal at future flows and loads. Each bioreactor also will be modified to provide for a reaeration zone in the first cell of each bioreactor module. An estimated total bioreactor volume of 12,960 m^3 will be required to provide a hydraulic retention time (HRT) of about 3.6 hours at average flow conditions. This sizing will allow the biological system to maintain a solids retention time (SRT) of 6.5 to 7.5 days through the year.

To improve the system pH, the last cell of each bioreactor will be vented with air. This arrangement will allow the pH to be increased to about 6.5 so that minimal nitrification inhibition occurs. The largest oxygen demand will occur in the first cell – the reaeration zone.

The bioreactor will be operated at relatively high MLSS concentrations, ranging from 3,000 to 4,800 mg/L in the latter three cells and about 10,000 mg/L in the reaeration cell. To handle these concentrations and the anticipated higher flows, one new secondary clarifiers will be constructed, 45.7 metres in diameter. The need for only one clarifier is based on achieving SVIs below 100 mL/g. If the SVI is over this value, a second new clarifier would be required.

At the anticipated operating conditions, it will be impossible to achieve effluent ammonia concentrations below 2 mg/L on a consistent basis. To achieve less than 5 mg/L on a consistent basis, the total number of reactors would have to be increased to about 10 and the SRT would have to be increased to about 8 days. The influent would have to be distributed between the two initial cells – approximately 25 percent to the first cell and 75 percent to the second cell.

A process flow schematic of the proposed upgrade of the SEWPCC to HPO with RAS reaeration is presented in Figure SE-2.1. The design criteria for the upgraded secondary treatment process are presented in Table SE-2.1 on the following page.

A layout of the SEWPCC after upgrading the secondary treatment process to RAS reaeration nitrification is presented in Figure SE-2.2. The 4 new HPO reactor modules will be built south of the existing 4 cell bioreactor modules. The new clarifier(s) will be constructed on the northwest side of the existing secondary clarifiers.

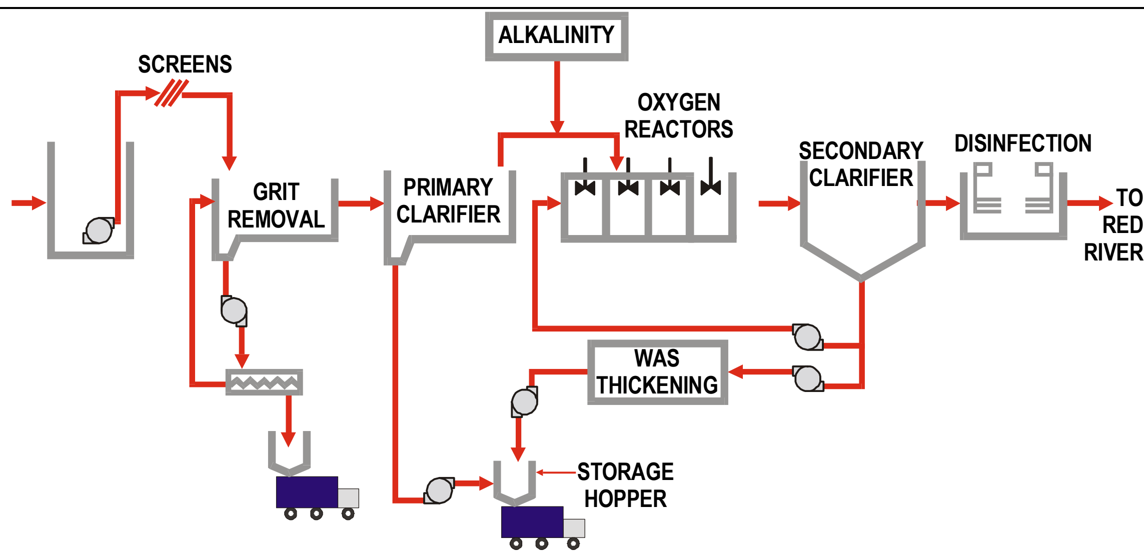
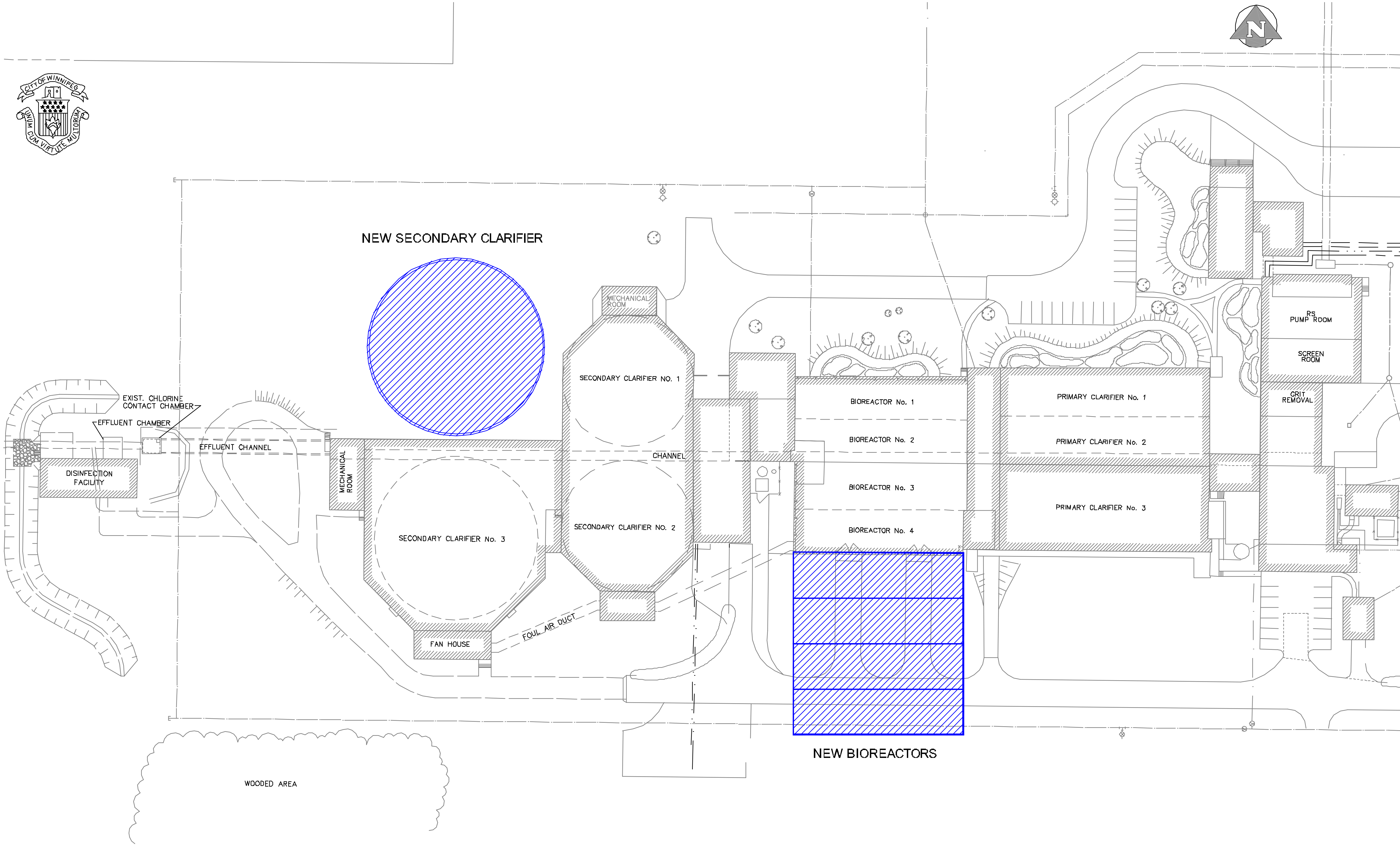


Figure SE-2.1: RAS Reaeration at the South End Water Pollution Control Centre



SEWPCC HPO with RAS Reaeration

Figure SE 2.2

SEWPCC – HPO with RAS Reaeration (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table SE-2.1: RAS Reaeration at the South End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
AAF, ML/d	58	88
PDWF, ML/d	100	150
PWWF, ML/d	174	264
BOD_5 Load		
Average, kg/d (47 percent removal in PSTs)		12,975
Maximum, kg/d (55 percent removal in PSTs)		20,540
TSS Load, kg/d (65 percent removal in PCs)		
Average, kg/d (75 percent removal in PSTs)		7,450
Maximum, kg/d (85 percent removal in PSTs)		8,940
HPO Bioreactor		
Number of reactors	4	8
Volume/reactor, ^{m3}	1,620	1,620
HRT at ADWF, h	2.0	3.6
Temperature, min-max, °C	16	16
SRT (winter), d	-	2.5
SRT (summer), d		6.5
MLSS, (at avg.), mg/L		3,000
MLSS, (at max month), mg/L		4,750
Secondary Clarifiers		
Number of units	3	4
Diameter, m	2 @ 33.5; 1@ 45.7	2 @ 33.5; 2 @ 45.7
SWD, m	4.6	4.6
Total area, m^2	3,400	5,040
OFR @ PDWF, m/h	1.2	1.24
SLR @ PDWF, $kg/m^2/h$	6.25	10.5

TECHNICAL CRITERIA

1. Reliability:	RAS Reaeration should effectively remove ammonia to about 5 mg/L. The key will be pH control through the venting of the last cell in each module. It is imperative that the pH be maintained above 6.5.
2. Robustness:	The robustness of this process depends upon the settleability of the secondary sludge. If the SVI can be maintained at 100 mL/g or below, the process will remain relatively stable. Any increases to or beyond that value will result in poor secondary clarifier performance.
3. Flexibility:	The process is relatively flexible. Operational changes to oxygen supply rates, RAS rates, and the split of the primary effluent flow into the first two cells allow changes to be made to react to changing flows and loads.

SEWPCC – HPO with RAS Reaeration (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
4. Impact on Other Parts of the Plant:	The existing HPOAS reactors and secondary clarifiers would have to be expanded to handle projected increases in flow and to provide the necessary hydraulic retention time for nitrification. However, the operating strategy and controls would remain similar to the current practice. When not operating, flow routing would remain as it is now. Accordingly, there are few impacts on the remainder of the plant with this process.
5. Space Requirements:	Figure SE-2.2 shows that the additional HPO reactors and secondary clarifiers can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be provided to handle the operational needs during the winter and future increases in flows and loads. The secondary plant could be converted to biological phosphorus removal in the future by modifying the second cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.
7. Constructability:	The construction of new HPO reactors and secondary clarifiers would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Some modification to the primary effluent distribution channels, mixed liquor collection channels, and flow splitting to the secondary clarifiers would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the additional bioreactor mixers.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Reaeration would introduce a new level of complexity to the operation of the plant. SRT control would depend upon RAS and WAS rates.
2. Ease of Maintenance:	Additional PSA capacity, mechanical mixers in the oxidized zone, and the secondary clarifier(s) will increase maintenance requirements. There will be no increase in the difficulty of maintenance.
3. Operator Safety:	There would be no additional safety concerns related to the expanded plant.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is envisioned for conventional RAS reaeration.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. The secondary clarifier(s) would be enclosed in a manner similar to the existing units. No substantial visual impacts are envisioned.

SEWPCC – HPO with RAS Reaeration (Cont'd.)

ENVIRONMENTAL AND AESTHETIC CRITERIA (Cont'd.)	
4. Odours:	New reactors will be covered and no odours are anticipated.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors and new secondary clarifiers, and additional or expanded PSA unit. It is expected that these units will cost approximately \$21 million.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements and power requirements for the reactor mixers. The incremental O&M costs will be approximately \$250,000 per year. This cost covers the additional power requirements, additional equipment maintenance, and some allowance for extra operator time. It includes the additional costs associated with capacity expansion as well as nitrification.
3. Other Down-stream Economic Impacts:	The use of large areas of the site will reduce flexibility to handle further changes in plant service area or population. However the site is sufficiently large that this is not a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**SOUTH END WATER POLLUTION CONTROL CENTRE - SECOND STAGE NITRIFYING TRICKLING FILTERS**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option the SEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) in summer. The HPO bioreactor will be expanded to facilitate carbonaceous removal at future flows and loads. An estimated total bioreactor volume of 9,720 m^3 will be required to provide a hydraulic retention time (HRT) of about 2.6 hours at average flow conditions. This sizing will allow the biological system to maintain a solids retention time (SRT) of 1.75 to 2.5 days through the year.

The bioreactor will be operated at MLSS concentrations that are similar to the present conditions, ranging from 2,00 to 3,500 mg/L. To handle these concentrations and the anticipated higher flows, one new secondary clarifier will be constructed, 45.7 metres in diameter.

The secondary effluent will be intercepted prior to effluent disinfection and pumped to three new nitrifying trickling filters. Each filter will be 27.5 metres in diameter with 6.0 metres of high density media (135 m^2/m^3). The filters have been sized to remove ammonia at a rate of 0.165 $kg/m^3/d$. The filters would be designed to be flooded regularly to control biomass predators (worms, fly larvae, and snails). Flooding would entail filling the filter with water every week and leaving it for an 8 to 12 hour period. The nitrifying trickling filter system would be designed with effluent recycle to ensure that wetting rates are maintained at relatively high levels. Higher wetting rates enhance the efficiency of this process.

The NTFs would be covered for environmental protection and fans would be provided to circulate air through the media. The recirculation rate would be approximately 12 m^3/s to ensure a face velocity of approximately 1.2 m/min. At this face velocity, good distribution is assured. In addition to recirculation fans, air supply fans will be provided to ensure that the oxygen content of the recirculated air does not decrease below about 19 percent (by weight). To ensure that this level of oxygen depletion is not exceeded, a continual air supply of 1.35 m^3/s per filter will be provided. This air supply will be drawn from the interior of the existing buildings. Exhaust fans will draw 1.5 m^3/s from each filter and return it to the foul air system for dispersal through the plant stack. Extracting air at a rate that is 10 percent higher than the supply rate will ensure that the enclosure is maintained under a slight negative pressure at all times.

A process flow schematic of the proposed upgrade of the SEWPCC to second stage nitrifying trickling filter nitrification is presented in Figure SE-3.1. The design criteria for the upgraded secondary treatment process are presented in Table SE-3.1 on the following page.

A layout of the SEWPCC after upgrading the secondary treatment process to second stage nitrifying trickling filters is presented in Figure SE-3.2. The 2 new HPO reactor modules will be built south of the existing 4 cell bioreactor modules. The new clarifiers will be constructed on the northwest side of the existing secondary clarifiers. The three new nitrifying trickling filters will be constructed southwest of the secondary clarifier area, adjacent to the UV disinfection facility.

SEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

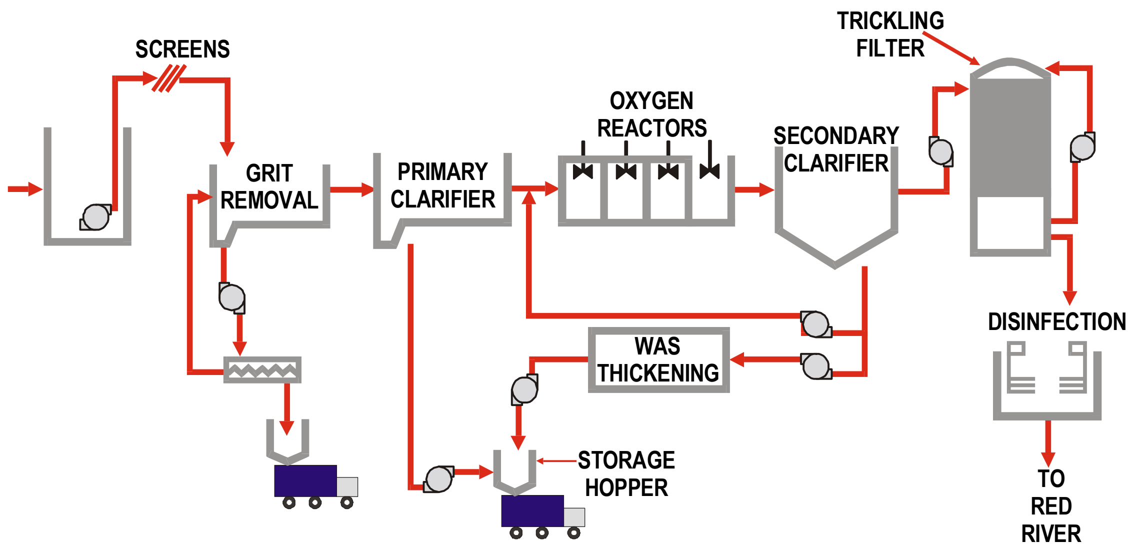
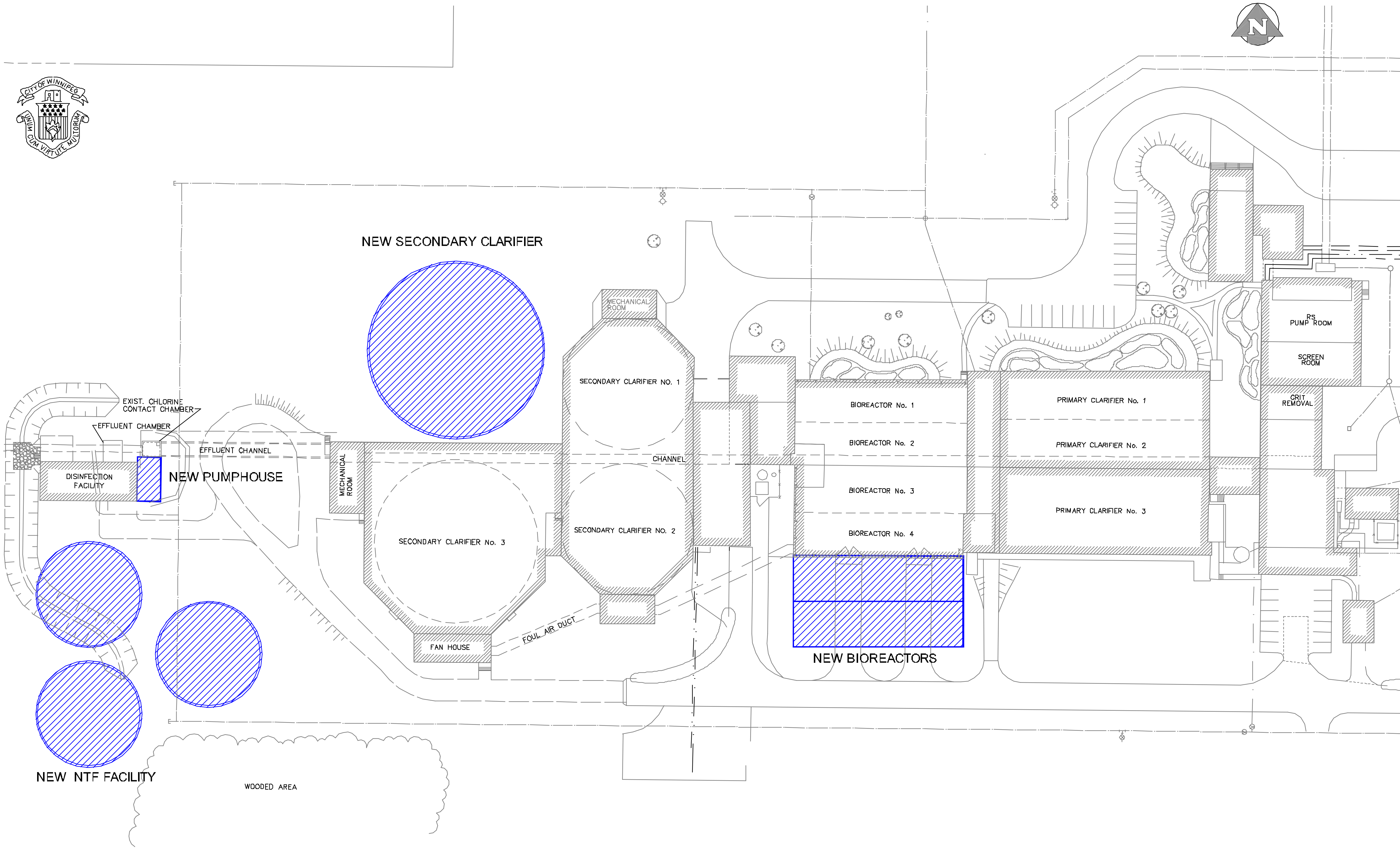


Figure SE-3.1: Second Stage Nitrifying Trickling Filters at the South End Water Pollution Control Centre

Table SE-3.1: Second Stage Nitrifying Trickling Filters at the SEWPCC

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
AAF, ML/d	58	88
PDWF, ML/d	100	150
PWWF, ML/d	174	264
BOD_5 Load		
Average, kg/d (47 percent removal in PSTs)		12,975
Maximum, kg/d (55 percent removal in PSTs)		20,540
TSS Load, kg/d (65 percent removal in PCs)		
Average, kg/d (75 percent removal in PSTs)		7,450
Maximum, kg/d (85 percent removal in PSTs)		8,940
HPO Bioreactor		
Number of reactors	4	6
Volume/reactor, m^3	1,620	1,620
HRT at ADWF, h	2.0	2.65
Temperature, min-max, °C	16	16
SRT (winter), d	-	2.5
SRT (summer), d		2.5
MLSS, (at avg.), mg/L		2,000
MLSS, (at max month), mg/L		3,200
Secondary Clarifiers		
Number of units	3	4
Diameter, m	2 @ 33.5; 1@ 45.7	2 @ 33.5; 2 @ 45.7
SWD, m	4.6	4.6



SEWPCC Second Stage NTF
Figure SE 3.2

SEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table SE-3.1: Single Stage Nitrification at the SEWPCC (cont'd.)

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
Secondary Clarifiers (cont'd.)		
Total area, m^2	3,400	5,040
OFR @ PDWF, m/h	1.2	1.24
SLR @ PWWF, $kg/m^2/h$	6.25	6.5
Secondary Effluent		
Flow		
Average, ML/d		88
Maximum month, ML/d		97.5
BOD Load		
Average, kg/d		880
Maximum month, kg/d		1,465
TSS Load		
Average, kg/d		880
Maximum month, kg/d		1,465
TKN Load		
Average, kg/d		1,670
Maximum month, kg/d		2,145
Nitrifying Trickling Filter Pumps		
Number of Units		3
Capacity, L/s		870
Head, m		15
Power, kW		200
Nitrifying Trickling Filters		
Number of Units		3
Diameter, m		27.5
Media Depth, m		6.0
Media Density, m^2/m^3		135
Nitrifying Trickling Filter Fans		
Recirculation Fans		
Number		3
Capacity, m^3/s		12.0
Backpressure, Pa		750
Size, kW		22.5
Supply Fans		
Number		3
Capacity, m^3/s		1.35
Backpressure, Pa		750
Size, kW		2.5
Exhaust Fans		
Number		3
Capacity, m^3/s		1.5
Backpressure, Pa		375
Size, kW		1.5

SEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

TECHNICAL CRITERIA	
1. Reliability:	Nitrifying trickling filters (NTFs) have been used at numerous plants for secondary effluent nitrification. This process is relatively simple and has proven effective as long as a suitable predator control is incorporated in the design. It is assumed that the pH of the secondary effluent would rise through secondary clarification and filter application due to CO_2 stripping that occurs in these processes. On the basis of this assumption, nitrifier growth rates would not be inhibited due to low pH.
2. Robustness:	This process is relatively robust. Attached growth processes inherently retain the autotrophic microorganism population as there is no dependence on solids liquid separation. Effluent ammonia spikes will be handled well within reasonable limits, generally plus or minus 50 percent of the average. Toxic shocks would cause failure.
3. Flexibility:	The process will be difficult to modify to meet changing effluent quality requirements. There are few process conditions that can be modified other than recycle rates. Once the process is established, changes should not be introduced except to correct process upsets.
4. Impact on Other Parts of the Plant:	The existing HPOAS reactors and secondary clarifiers would have to be expanded to handle projected increases in flow. However, the operating strategy and controls would remain the same as current practice. The new NTFs and the associated pump station would be inserted in the process between the secondary clarifiers and UV disinfection. When not operating, flow routing would remain as it is now. Accordingly, there are few impacts on the remainder of the plant with this process.
5. Space Requirements:	Figure SE-3.2 shows that the additional HPO reactors, secondary clarifiers, and nitrifying trickling filters can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be provided to handle the operational needs during the winter and future increases in flows and loads. The secondary plant could be converted to biological phosphorus removal in the future by modifying the initial cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal.
7. Constructability:	The construction of new HPO reactors, secondary clarifiers, and nitrifying trickling filters would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Some modification to the primary effluent distribution channels, mixed liquor collection channels, and flow splitting to the secondary clarifiers would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the additional PSA units, bioreactor mixers, and NTF pumps.

SEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

OPERATIONAL CRITERIA	
1. Ease of Operation:	Nitrifying trickling filters are relatively simple to operate. Monitoring of performance is necessary and at regular periods, a filter has to be taken off-line and flooded to provide predator control. However, these operations are not complex and could be semi-automated (operator initiation, automatic sequencing).
2. Ease of Maintenance:	Additional PSA capacity, mechanical mixers in the oxidized zone, the secondary clarifier, trickling filter pumps, nitrifying trickling filter mechanisms, and circulation fans will increase maintenance requirements. There will be no increase in the difficulty of maintenance. Trickling filter mechanisms have few maintenance requirements other than regular bearing greasing. Other equipment is similar to that already installed at the plant.
3. Operator Safety:	A trickling filter enclosure is a confined space and would require that the operators follow the requisite procedures when entering. However, entry into the enclosure is infrequently required. No other new safety concerns would arise in the secondary treatment process.
4. Operator Environment:	There will be no significant changes from the existing operations other than within the trickling filter enclosure. In this area, high humidity can be expected and some level of odours would be evident.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is envisioned.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. The top of the trickling filter media would be about 8.5 metres above ground and the top of the dome, about 5 metres above that point. These structures would be immediately evident from the highway and would increase the visual impact of the plant. Architectural finishes would be selected that would be compatible with the existing buildings; however, the domes would be fibreglass or aluminum and would not be similar to other facilities at the SEWPCC.
4. Odours:	New reactors will be covered and no odours are anticipated. Passing foul air through the NTFs may actually decrease the odour levels in the air and reduce off-site impacts.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors, new secondary clarifiers, additional or expanded PSA unit, and the nitrifying trickling filters and pump station. It is expected that these units will cost approximately \$42 million. If a second stage BAF was installed rather than the nitrifying trickling filters, the approximate cost would be about \$35 million.

SEWPCC – Second Stage Nitrifying Trickling Filters (Cont'd.)

COST CRITERIA (Cont'd.)	
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements, power requirements for the reactor mixers and TF pumps and fans. The incremental O&M costs will be approximately $185,000 per year. This cost covers the additional power requirements, additional equipment maintenance, and some allowance for extra operator time. It includes the additional costs associated with capacity expansion as well as nitrification. If BAF were used rather than NTFs, the additional annual operating costs would be approximately $240,000 per year.
3. Other Down-stream Economic Impacts:	The use of large areas of the site will reduce flexibility to handle further changes in plant service area or population. However the site is sufficiently large that this is not a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**SOUTH END WATER POLLUTION CONTROL CENTRE CEPT WITH RAS REAERATION**
STANDARD:	10 mg/L

PROCESS DESCRIPTION

In this option the SEWPCC will be upgraded to meet a periodic effluent NH_3 concentration of 10 mg/L (as N) in summer. A facility will be constructed to add chemicals to the primary influent flow. These chemicals will enhance BOD and TSS removal (Chemically Enhanced Primary Treatment – CEPT) so that less load will be transferred to the secondary system. The basis for this design is that at least 60 percent of the influent BOD and 85 percent of the influent TSS were removed. This removal would likely require about 35 mg/L of ferric chloride or 90 mg/L of alum to achieve. The HPO bioreactor will be expanded to facilitate carbonaceous removal at future flows and loads. Each also will be modified to provide for a reaeration zone in the first cell of each bioreactor module. An estimated total bioreactor volume of 9,720 m^3 will be required to provide a hydraulic retention time (HRT) of about 2.6 hours at average flow conditions. This sizing will allow the biological system to maintain a solids retention time (SRT) of 6.5 to 7.5 days during periods when nitrification is required.

To improve the system pH, the last cell of each bioreactor will be vented with air. This arrangement will allow the pH to be increased to about 6.5 so that minimal nitrification inhibition occurs. The largest oxygen demand will occur in the first cell – the reaeration zone.

The bioreactor will be operated at relatively high MLSS concentrations, ranging from 3,000 to 4,000 mg/L in the latter three cells and about 10,000 mg/L in the reaeration cell. To handle these concentrations and the anticipated higher flows, one new secondary clarifier will be constructed, 45.7 metres in diameter. The need for only one secondary clarifier is based on achieving SVIs below 100 mL/g. If the SVI is over this value, a second new clarifier would be required.

At the anticipated operating conditions, it will be impossible to achieve effluent ammonia concentrations below 2 mg/L on a consistent basis. To achieve less than 5 mg/L on a consistent basis, the total number of reactors would have to be increased to about 8 and the SRT would have to be increased to about 8 days. The influent would have to be distributed between the two initial cells – approximately 25 percent to the first cell and 75 percent to the second cell.

A process flow schematic of the proposed upgrade of the SEWPCC to CEPT with RAS reaeration is presented in Figure SE-4.1. The design criteria for the upgraded secondary treatment process are presented in Table SE-4.1 on the following page.

A layout of the SEWPCC after upgrading the secondary treatment process to CEPT with RAS reaeration nitrification is presented in Figure SE-4.2. The 2 new HPO reactor modules will be built south of the existing 4 cell bioreactor modules. The new clarifier(s) will be constructed on the northwest side of the existing secondary clarifiers.

SEWPCC – CEPT with RAS Reaeration (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

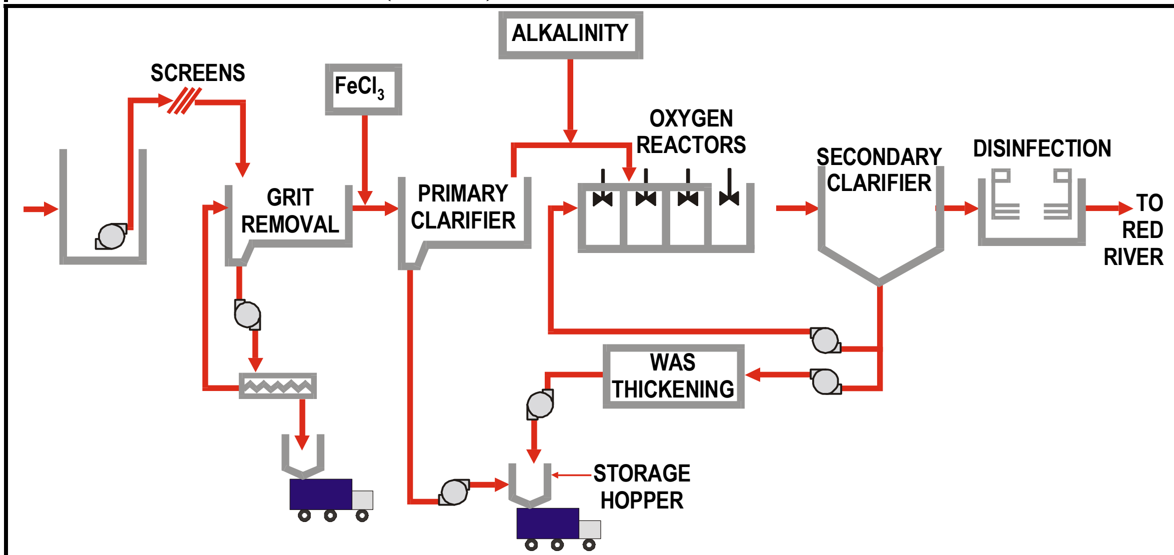
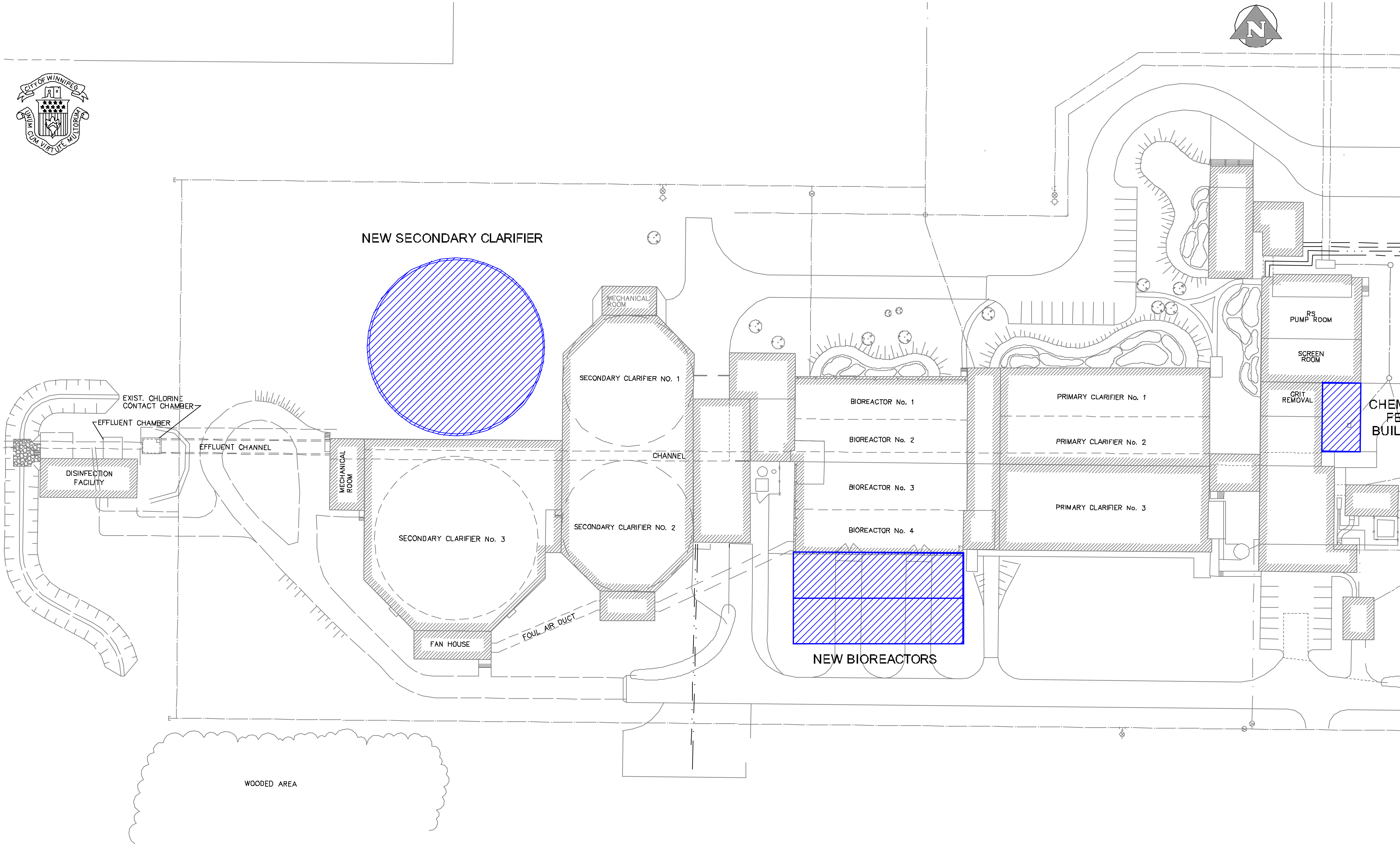


Figure SE-4.1: RAS Reaeration at the South End Water Pollution Control Centre

Table SE-4.1: RAS Reaeration at the South End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant**	**Upgraded Plant**
AAF, ML/d	58	88
PDWF, ML/d	100	150
PWWF, ML/d	174	264
BOD_5 Load		
Average, kg/d (60 percent removal in PSTs)		9,700
Maximum, kg/d (65 percent removal in PSTs)		17,100
TSS Load, kg/d		
Average, kg/d (85 percent removal in PSTs)		4,320
Maximum, kg/d (90 percent removal in PSTs)		5,960
HPO Bioreactor		
Number of reactors	4	6
Volume/reactor, ^{m3}	1,620	1,620
HRT at ADWF, h	2.0	2.6
Temperature, min-max, °C	16	16
SRT (winter), d	-	2.5
SRT (summer), d		6.5
MLSS, (at avg.), mg/L		3,000
MLSS, (at max month), mg/L		4,750
Secondary Clarifiers		
Number of units	3	4
Diameter, m	2 @ 33.5; 1@ 45.7	2 @ 33.5; 2 @ 45.7
SWD, m	4.6	4.6
Total area, m^2	3,400	5,040
OFR @ PDWF, m/h	1.2	1.24
SLR @ PDWF, $kg/m^2/h$	6.25	10.5



SEWPCC CEPT with RAS Reaeration

Figure SE 4.2

SEWPCC – CEPT with RAS Reaeration (Cont'd.)

TECHNICAL CRITERIA	
1. Reliability:	RAS Reaeration should effectively remove ammonia to about 5 mg/L. The key will be pH control through the venting of the last cell in each module. It is imperative that the pH be maintained above 6.5. The loss of alkalinity due to chemical addition may exacerbate this situation.
2. Robustness:	The robustness of this process depends upon the settleability of the secondary sludge. If the SVI can be maintained at 100 mL/g or below, the process will remain relatively stable. Any increases to or beyond that value may result in poor secondary clarifier performance.
3. Flexibility:	The process is relatively flexible. Operational changes to oxygen supply rates, RAS rates, and the split of the primary effluent flow into the first two cells allow changes to be made to react to changing flows and loads. CEPT can be modulated to trim the secondary loads.
4. Impact on Other Parts of the Plant:	The existing HPOAS reactors and secondary clarifiers would have to be expanded to handle projected increases in flow and to provide the necessary hydraulic retention time for nitrification. However, the operating strategy and controls would remain similar to the current practice. When not operating, flow routing would remain as it is now. Accordingly, there are few impacts on the remainder of the plant with this process. The addition of CEPT would have a substantial impact upon primary clarifier operation. Significantly more sludge would be generated and there would be changes in its character.
5. Space Requirements:	Figure SE-4.1 shows that the additional HPO reactors and secondary clarifiers can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be provided to handle the operational needs during the winter and future increases in flows and loads. The secondary plant could be converted to biological phosphorus removal in the future by modifying the second cell in each module to provide pre-anoxic, anaerobic, and anoxic zones. Likely, no further changes would be required to the bioreactor; however, primary sludge fermenters would be required and separate secondary sludge thickening would be needed to ensure phosphorus release in the sludge treatment stream did not negate biological phosphorus removal. If CEPT was introduced, no further treatment would likely be required to remove sufficient phosphorus to meet a limit of 1.0 mg/L. It would be advisable to provide split chemical addition so that some could be added to the secondary treatment area should it become necessary to trim the final phosphorus concentration.
7. Constructability:	The construction of new HPO reactors and secondary clarifiers would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Some modification to the primary effluent distribution channels, mixed liquor collection channels, and flow splitting to the secondary clarifiers would be required. Requirements for the new structures are not extraordinary. However, full concrete decks with insulation and covers would be required. The existing electrical service may require upgrading to provide capacity for the additional PSA units and bioreactor mixers.

SEWPCC – CEPT with RAS Reaeration (Cont'd.)

OPERATIONAL CRITERIA	
1. Ease of Operation:	Reaeration would introduce a new level of complexity to the operation of the plant. SRT control would depend upon RAS and WAS rates. CEPT would further add to the complexity of the operation.
2. Ease of Maintenance:	Additional PSA capacity, mechanical mixers in the oxidized zone, and the secondary clarifier(s) will increase maintenance requirements. There will be no increase in the difficulty of maintenance. CEPT equipment is relatively simple; although the chemicals are hazardous and special procedures are required to work in the vicinity of this material.
3. Operator Safety:	There would be no additional safety concerns related to the expanded plant. The hazardous nature of chemicals used for CEPT adds to the care and caution that must be exercised.
4. Operator Environment:	There will be no significant changes from the existing operations. Fume management in the chemical area would obviate any potential problems in that area.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is envisioned for conventional RAS reaeration. Should CEPT be incorporated, traffic would increase marginally due to the chemical deliveries.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. The secondary clarifier(s) would be enclosed in a manner similar to the existing units. The chemical storage and feed facility would be relatively small and would not be a high structure. Thus, no substantial visual impacts are envisioned.
4. Odours:	New reactors will be covered and no odours are anticipated. CEPT using ferric salts would likely reduce odour generation through the plant.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the new HPO reactors and new secondary clarifiers, and an additional or expanded PSA unit. The expected capital cost of these units is $13 million.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements and power requirements for the reactor mixers. The incremental O&M costs will be approximately $75,000 per month, when CEPT is required. This cost covers chemical costs, the additional power requirements, additional equipment maintenance, and some allowance for extra operator time. It includes the additional costs associated with capacity expansion as well as nitrification.
3. Other Down-stream Economic Impacts:	The use of large areas of the site will reduce flexibility to handle further changes in plant service area or population. However the site is sufficiently large that this is not a major concern.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**SOUTH END WATER POLLUTION CONTROL CENTRE, PERIODIC AMMONIA REMOVAL USING BREAKPOINT CHLORINATION**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option, the SEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) by breakpoint chlorination. Chlorine will be dosed following the secondary clarifiers at an average dose of about 200 mg/L. Sulfur dioxide or sodium bisulphate will be used to dechlorinate the effluent prior to discharge to the Assiniboine River. It is assumed that the historical ammonia removal rates will continue to be achieved by the secondary treatment process, and that chlorine will only be used to polish the effluent. Based on this philosophy approximately 17,500 kg of chlorine will be required each day.

The upgraded facility will include a bulk chlorine and sulphur dioxide receiving area, storage, evaporating/metering and control system, a containment and scrubbing system, and rapid mix injection and dispersion chambers. A rail spur will be extended to the plant to provide for bulk chlorine deliveries. A process flow schematic Figure SE-5.1. The design criteria for the process are presented in Table SE-5.1 on the following page.

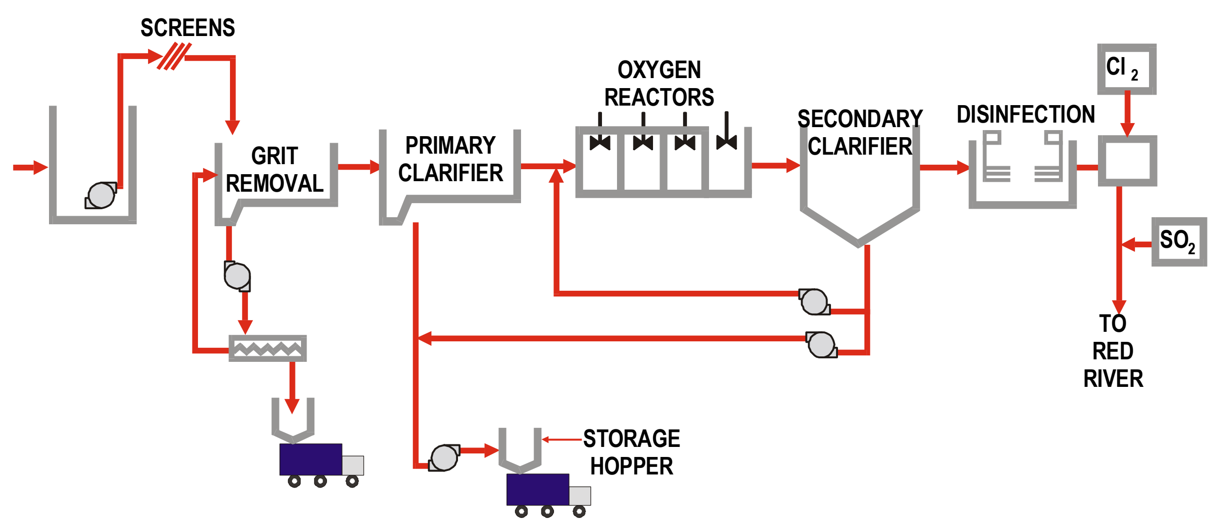


Figure SE-5.1: Process Flow Schematic – SEWPCC Breakpoint Chlorination

Table SE-5.1: Single Stage Nitrification at the SEWPCC

Parameter **Primary Effluent Flows & Loads**	**Upgraded Plant Design**
ADWF, ML/d	88
PDWF, ML/d	150
Secondary Effluent Ammonia , mg/L (assumed)	20
Chlorination Facility	
Chorine Dosage	
At ADWF, mg/L	200
At PDWF, mg/L	200
Chlorine Usage	
Average, kg/d	17,500
Peak, kg/d	30,000

SEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

PROCESS DESCRIPTION (CONT'D.)

Table SE-5.1: Single Stage Nitrification at the SEWPCC (Cont'd.)

Parameter **Primary Effluent Flows & Loads**	**Upgraded Plant Design**
Chlorine Storage	
Size of Containers, kg	90,000
Evaporators	
Number	8
Capacity, kg/d	8,000
Chlorinators	
Number	8
Capacity, kg/d	8,000
Sulphur Dioxide Facility	
SO_2 Dosage	
Average, mg/L	2
Peak, mg/L	5
SO_2 Usage	
Average, kg/d	175
Peak, kg/d	750
SO_2 Storage	
Size of Containers, kg	910
Online Containers	1
Standby Containers	1
Reserve Containers	3
Total Spaces	5
Evaporators	
Number	2
Capacity, kg/d	2000
Sulphonators	
Number	2
Capacity, kg/d	2000

TECHNICAL CRITERIA

1. Reliability:	Chlorination and dechlorination technology is well developed and has been widely applied for many decades. If periodic use of this technology is implemented, equipment will have to be serviced and tested on a regular basis to ensure safe operation.
2. Robustness:	Varying ammonia loads can be handled by adjusting the chlorine dosage accordingly. This would be done with an automatic control system including flow measurement and ammonia and chlorine sensing devices.
3. Flexibility:	Sufficient flexibility can be provided by configuring equipment for changing flows and loads.
4. Impact on Other Parts of the Plant:	There would be little impact on other parts of the plant.

SEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

TECHNICAL CRITERIA	
5. Space Requirements:	Space requirements for breakpoint chlorination would be relatively modest. The most space would be required by the bulk chlorine and sulphur dioxide receiving, storage, evaporating and metering systems together with their related containment and scrubbing systems.
6. Expandability:	The process would be readily expandable by the addition of more chlorination equipment.
7. Constructability:	No particular impediments to construction are anticipated.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Normal operation would be automated and would generally require only periodic attention and monitoring by the operating staff. The most labour intensive operational requirements would be for changing from empty to full chlorine and sulphur dioxide containers.
2. Ease of Maintenance:	Maintenance would be more difficult due to the intermittent and hazardous nature of the chlorine and sulphur dioxide used in this process. Most chlorination systems require overhaul prior to being placed back into service after any period out of service.
3. Operator Safety:	Because of the extremely hazardous nature of chlorine and sulphur dioxide, special training must be given to the plant operating and maintenance staff to minimize the risk of an incident and to deal properly with an incident should one occur.
4. Operator Environment:	The operator's environment would not be different to that at a typical water/wastewater treatment facility. The City uses bulk chlorine at the NEWPCC so the operators should be accustomed to this process.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	There would be rail traffic but no other additional traffic to the site. Rail cars would deliver and remove full and empty bulk tank cars containing chlorine and sulphur dioxide. In addition periodic deliveries of bulk caustic solution would be required. There would be a potential health concern over the danger associated with shipment of these chemicals.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The new building housing the chlorination, containment and scrubbing facilities would be apparent on each plant site. In addition, a new rail car siding(s) would be required.
4. Odours:	Some chlorine odour may be noticeable in the immediate vicinity of the chlorine dosing point; however, the odour would dissipate rapidly as one moves away from this point.

SEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of chemical scrubbing facilities, chlorinators, and evaporators. It is expected that these units will cost approximately $15 million.
2. Operating and Maintenance Costs:	The incremental O&M costs will be approximately $280,000 per month for chemical costs when breakpoint chlorination is used.
3. Other Down-stream Economic Impacts:	Upgrading the SEWPCC to periodic ammonia removal using breakpoint chlorination will require only a small portion of space.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**WEST END WATER POLLUTION CONTROL CENTRE, SINGLE STAGE NITRIFICATION**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option, the WEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) in summer by modifying the existing air activated sludge bioreactors to facilitate simultaneous carbonaceous removal and nitrification. The existing total bioreactor volume of 10,250 m^3 is sufficient to maintain a solids retention time (SRT) of 10 days during the summer months. A key element of this process configuration is to provide an anoxic zone to recover alkalinity and reduce oxygen requirements. The anoxic zones will be constructed within the existing tankage.

The bioreactor will be operated at elevated MLSS concentrations. To handle these higher concentrations, one new secondary clarifier will be constructed, measuring 30 metres in diameter.

A process flow schematic of the proposed upgrade of the WEWPCC to single stage nitrification is presented in Figure WE-1.1. The design criteria for the upgraded secondary treatment process are presented in Table WE-1.1 on the following page.

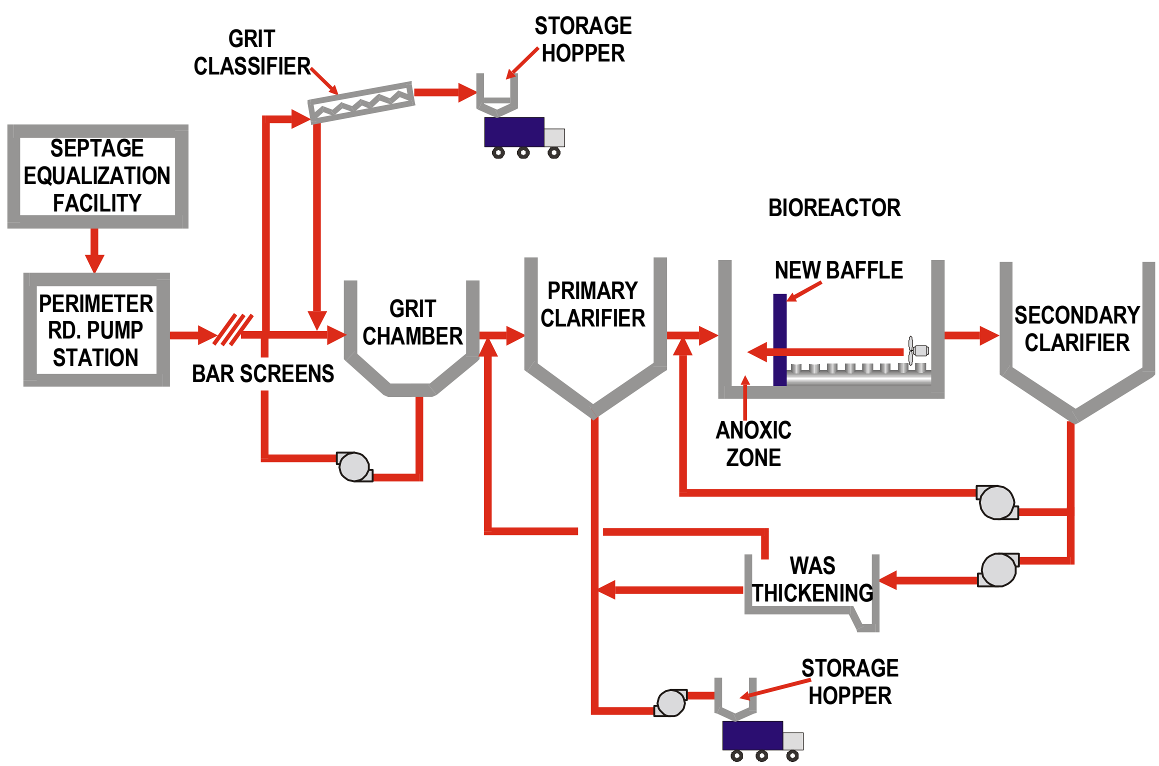


Figure WE-1.1: Process Flow Schematic – WEWPCC Single Stage Nitrification

WEWPCC – Single Stage Nitrification (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table WE-1.1: Single Stage Nitrification at the West End Water Pollution Control Centre

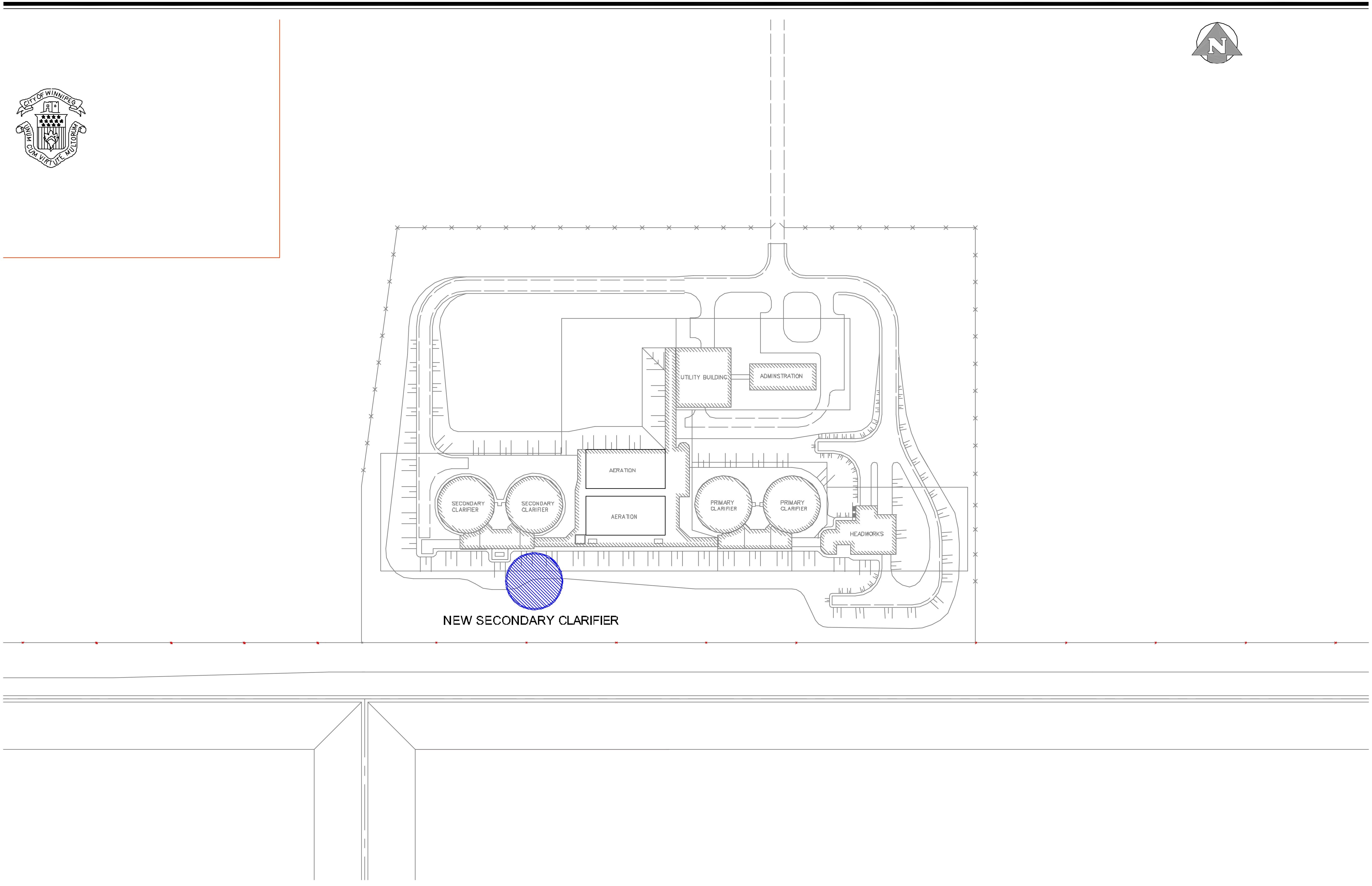
Parameter **Primary Effluent Flows & Loads**	**Existing Plant Rating**	**Upgraded Plant Design**
ADWF, ML/d	32	29.6
PDWF, ML/d	44	52.9
PWWF, ML/d	112	112
BOD_5 Load		
Average, kg/d (assumed 40 percent removal in PSTs)	4672	3618
Maximum, kg/d (assumed 40 percent removal in PSTs)	5888	5010
TSS Load		
Average, kg/d (assumed 60 percent removal in PSTs)	2300	3044
Maximum, kg/d (assumed 60 percent removal in PSTs)	3040	5088
Air Activated Sludge Bioreactors		
Number of reactors	2	2
Volume/reactor, m^3	5,125	5,125
HRT at ADWF, h	7.7	8.3
Temperature, min-max, °C	10 to 20	18
SRT (winter), d	5 to 6	10
SRT (summer), d	3 to 4	10
MLSS, (at avg.), mg/L		
MLSS, (summer), mg/L	1620	3000
Secondary Clarifiers		
Number of units	2	3
Diameter, m	30	30
SWD, m	4.0	4.0
Total area, m^2	1413	2119
OFR @ PDWF, m/h	1.58	1.1
SLR @ PWWF, $kg/m^2/h$	4.80	5.8

TECHNICAL CRITERIA

1. Reliability:	The reliability of the process is largely dependent on maintaining the necessary SRT to achieve nitrification. The existing tankage is capable of maintaining an SRT of 10 days, which is sufficient to reduce the effluent ammonia to below 2 mg/L during the summer months. By providing an anoxic zone in the activated sludge reactors, alkalinity will be recovered, and will eliminate the need for costly chemical addition.
2. Robustness:	Because of the sensitivity of nitrifiers and the potential for inhibition due to shock loads, discharges such as septage should be equalized before being discharged to the facility. Also, co-thickening of primary sludge and WAS should be suspended. WAS will likely denitrify in the primary clarifiers affecting their performance and impacting the bioreactors. Co-thickening also results in reseeding of undesirable microorganisms to the bioreactor which should be avoided to ensure stability in nitrification mode. With the forgoing in place, if the appropriate measures are taken to ensure that the system is operating at the necessary SRT, then this system can consistently produce effluent meeting the license limits.

WEWPCC – Single Stage Nitrification (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
3. Flexibility:	The operation of this system will be very similar to the existing plant. The process will offer some flexibility, as there are two parallel trains that will allow processes to be taken out of service during winter for maintenance. Once summer nitrification is established, changes should not be introduced except to correct process upsets.
4. Impact on Other Parts of the Plant:	The addition of nitrification would require: • Modifications to the existing bioreactor • One new 30 metre diameter clarifier • A septage equalization facility • Separate thickening of primary and waste activated sludge. The anoxic zone will help to control the growth of filamentous organisms and improve the settleability characteristics of the sludge. Operating at the higher SRT required for nitrification will reduce secondary sludge production by approximately 10 to 20 percent. Separate WAS thickening is recommended to ensure stable operation in nitrification mode.
5. Space Requirements:	Figure WE-1.2 shows that the additional secondary clarifier can be accommodated within the existing site limits.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be required for year-round nitrification and to accommodate any future increases in flows and loads. The plant could be converted to biological phosphorus removal in the future by modifying the bioreactors to include a pre-anoxic and anaerobic zone. It is likely that some additional reactor volume and a fermenter would be required for phosphorus and nitrogen removal.
7. Constructability:	The construction of anoxic zones, and upgrading the aeration system would be carried out in one basin at a time. This can be readily accommodated as currently only one basin is in use. The construction of the third clarifier would mostly be external to the existing plant, and would not cause a major disruption of normal plant operations. Requirements for the new structures are not extraordinary.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Because of the sensitivity of the nitrification process, the process is more susceptible to process upsets resulting from changes to the incoming flows and loads. Additional monitoring and control parameters will be required to maintain plant stability (e.g. pH, alkalinity, tighter DO, and SRT control).
2. Ease of Maintenance:	The addition of mechanical mixers in the anoxic zone, and an additional clarifier will increase maintenance requirements. However, there will be no increase in the difficulty of maintenance.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process.



WEWPCC Single Stage Nitrification
Figure WE 1.2

WEWPCC – Single Stage Nitrification (Cont'd.)

OPERATIONAL CRITERIA (Cont'd.)	
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	The traffic due to sludge hauling will be reduced.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The third clarifier would be covered in a similar manner to the existing clarifiers. Architectural finishes would be compatible and thus would cause minimum impact.
4. Odours:	No increase in odours is anticipated.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of anoxic cells in the existing bioreactors, a new aeration system, a new clarifier, a septage equalization facility and a separate WAS thickening facility. It is expected that these units will cost approximately $9 million. This option is the baseline and provides the benchmark against which other options will be measured.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements and power requirements for the reactor mixers. A minor savings in O&M costs will be realized as a result of the reduced sludge production in the biological process. The incremental O&M costs will be approximately $36,000 per year. This cost includes the additional power requirements and some allowance for extra operator time.
3. Other Down-stream Economic Impacts:	Upgrading the WEWPCC to nitrification will require only a small portion of space (e.g. that required for a third clarifier). This will allow greater flexibility in upgrading options in the future.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**WEST END WATER POLLUTION CONTROL CENTRE, STEP FEED CONFIGURATION**
STANDARD:	5 mg/L

PROCESS DESCRIPTION

In this option, the WEWPCC will be upgraded to meet an effluent NH_3 concentration of 5 mg/L (as N) in summer by modifying the existing bioreactors to a step feed configuration. The existing total bioreactor volume of 10,250 m^3 is sufficient to maintain a solids retention time (SRT) of 10 days during the summer months. A key element of this configuration is that due to the step feed arrangement, the solids loading rate will be maintained to a satisfactory level for the existing clarifiers. Channels will be constructed in each bioreactor to provide a three-pass configuration, with influent being discharged into each pass. A small anoxic zone will be constructed at the beginning of each pass to provide sufficient denitrification to recover alkalinity and oxygen.

The bioreactor will be operated at an MLSS concentration of approximately 2300 mg/L. At these concentrations, it is expected that the existing clarifiers will perform adequately.

A process flow schematic of the proposed upgrade of the WEWPCC to step feed is presented in Figure WE-2.1. The design criteria for the upgraded secondary treatment process are presented in Table WE-2.1 on the following page.

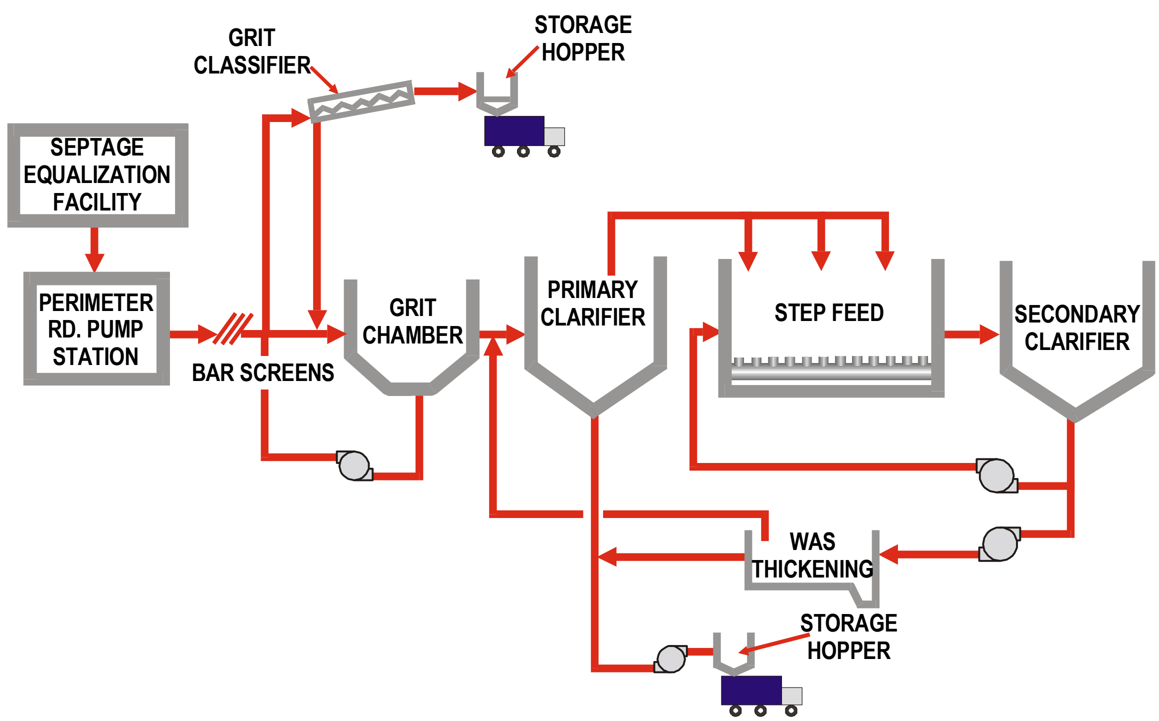


Figure WE-2.1: Process Flow Schematic – WEWPCC Step Feed

WEWPCC – Step Feed Configuration (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table WE-2.1: Step Feed Nitrification at the West End Water Pollution Control Centre

Parameter **Primary Effluent Flows & Loads**	**Existing Plant Rating**	**Upgraded Plant Design**
ADWF, ML/d	32	29.6
PDWF, ML/d	44	52.9
PWWF, ML/d	112	112
BOD_5 Load		
Average, kg/d (assumed 40 percent removal in PSTs)	4672	3618
Maximum, kg/d (assumed 40 percent removal in PSTs)	5888	5010
TSS Load		
Average, kg/d (assumed 60 percent removal in PSTs)	2300	3044
Maximum, kg/d (assumed 60 percent removal in PSTs)	3040	5088
Air Activated Sludge Bioreactors		
Number of reactors	2	2
Volume/reactor, m^3	5,125	5,125
HRT at ADWF, h	7.7	8.3
Temperature, min-max, °C	10 to 20	18
SRT (winder), d	5 to 6	10
SRT (summer), d	3 to 4	10
MLSS, (at avg.), mg/L		
MLSS, (summer), mg/L	1620	2300
Secondary Clarifiers		
Number of units	2	2
Diameter, m	30	30
SWD, m	4.0	4.0
Total area, m^2	1413	2119
OFR @ PDWF, m/h	1.58	1.6
SLR @ PWWF, $kg/m^2/h$	4.80	5.8

TECHNICAL CRITERIA

1. Reliability:	Step feed is a common arrangement for larger, conventional activated sludge facilities. The configuration is primarily used to increase the rated capacity of existing plants without increasing existing tankage. The existing tankage is capable of maintaining an SRT of 10 days, which is sufficient to reduce the effluent ammonia to below 2 mg/L during the summer months. By providing an anoxic zone in the activated sludge reactors, alkalinity will be recovered, and will eliminate the need for costly chemical addition.
2. Robustness:	The step feed system is less susceptible to plant upsets from flow and load variations. The impacts from these variations are minimized by distributing the primary effluent to various points through the length of the bioreactor. Oxygen requirements are also equalized throughout the basin, minimizing the risks of low dissolved oxygen concentrations in the reactors. The step feed configuration is affected by temperature to a greater degree than the single stage configuration, and as a result, ammonia bleed through may occur at the colder temperatures.

WEWPCC – Step Feed Configuration (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
2. Robustness (cont'd.)	Because of the sensitivity of nitrifiers and the potential for inhibition due to shock loads, discharges such as septage should be equalized before being discharged to the facility. Also, co-thickening of primary sludge and WAS should be suspended. WAS will likely denitrify in the primary clarifiers affecting their performance and impacting the bioreactors. Co-thickening also results in reseeding of undesirable microorganisms to the bioreactor which should be avoided to ensure stability in nitrification mode. With the forgoing in place, if the appropriate measures are taken to ensure that the system is operating at the necessary SRT, then this system can consistently produce effluent meeting the license limits.
3. Flexibility:	This system offers a higher degree of flexibility than conventional activated sludge processes. The distribution of primary effluent throughout the step feed basin can be varied seasonally and tailored to provide optimized results.
4. Impact on Other Parts of the Plant:	The addition of nitrification would require: • Modifications to the existing bioreactor • A septage equalization facility • Separate thickening of primary and waste activated sludge. The anoxic zone will help to control the growth of filamentous organisms and improve the settleability characteristics of the sludge. Operating at the higher SRT required for nitrification will reduce secondary sludge production by approximately 10 to 20 percent. Separate WAS thickening is recommended to ensure stable operation in nitrification mode.
5. Space Requirements:	No additional space is needed.
6. Expandability:	The design shown handles summer flows and loads predicted until 2041. New parallel treatment trains would be required for year-round nitrification and to accommodate any future increases in flows and loads. The plant could be converted to biological phosphorus removal in the future by modifying the bioreactors to include a pre-anoxic and anaerobic zone. It is likely that some additional reactor volume and a fermenter would be required for phosphorus and nitrogen removal.
7. Constructability:	Structural modifications would be required within the existing bioreactors, as would upgrading the aeration system. This can be readily accommodated as currently only one basin is in use.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Nitrification is more sensitive than carbonaceous treatment. Additional monitoring will be required to assess plant stability (e.g. pH, alkalinity, tighter DO, and SRT control). Primary effluent flow splits to the various stages are critical and may involve greater operator attention to achieve process optimization.

WEWPCC – Step Feed Configuration (Cont'd.)

OPERATIONAL CRITERIA (Cont'd.)	
2. Ease of Maintenance:	Additional mixers would increase maintenance requirements but do not change the difficulty of maintenance.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	Sludge hauling traffic will be reduced.
2. Noise:	New operating equipment is similar to existing equipment. There will be no significant increase in noise.
3. Visual:	There would be no significant visual impact.
4. Odours:	No increase in odours is anticipated.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of channels in the existing bioreactors, a new aeration system, a septage equalization facility, and a separate WAS thickening facility. It is expected that these units will cost approximately $7 million.
2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen requirements and power requirements for the reactor mixers. A minor savings in O&M costs will be realized as a result of the reduced sludge production in the biological process. The incremental O&M costs will be approximately $36,000 per year. This cost includes the additional power requirements and some allowance for extra operator time.
3. Other Down-stream Economic Impacts:	Upgrading the WEWPCC to step feed nitrification will not require any additional space. This will allow greater flexibility in upgrading options in the future, although the site is relatively unconstrained to begin with.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**WEST END WATER POLLUTION CONTROL CENTRE, LAGOON NITRIFICATION**
STANDARD:	15 mg/L

PROCESS DESCRIPTION

In this option, the existing WEWPCC lagoons will be used to reduce the effluent ammonia from the plant. Other studies conducted on nitrification in lagoons have indicated that parameters such as retention time, nitrifier growth rate, temperature, pH, dissolved oxygen concentration, and ammonia concentration all have a strong influence on achieving nitrification.

A review of ammonia removal through the WEWPCC lagoons in summer months during 1995 through 1998 is shown below in Figure WE-3.1. The secondary plant effluent quality is also shown to allow a determination of the ammonia reduction through the lagoons alone. From this, it is observed that the secondary plant has been providing ammonia reductions over various periods. The lagoons themselves are providing only some of the overall reduction observed.

The data indicates that generally the ammonia level in the lagoon discharge drops to below 10 mg/L in late April or early May, and remains below 10 mg/L until October for many months of this period. However, in some months, the average ammonia concentration is above 10 mg/L. Daily ammonia concentrations higher than this have been recorded. Since 1995, the average and maximum ammonia concentrations in the lagoon discharge for the summer months have been as follows:

- April – avg. 11.3 mg/L, max. 25.5 ,g/L
- May - avg. 2.7 mg/L, max. 6.5 mg/L
- June - avg. 5.6 mg/L, max. 6.5 mg/L
- July – avg. 6.2 mg/L, max 20.5 mg/L
- August - avg. 5.4 mg/L, max. 17.5 mg/L
- September - avg. 6.7 mg/L, max 21.5 mg/L
- October - avg. 9.0 mg/L, max 19.5 mg/L

It may be possible to mitigate somewhat the effect of the ammonia peaks by distributing the effluent into the lagoons through a diffuser to prevent short-circuiting. However, due to these high ammonia peaks, any acute toxicity criteria (daily values) that are placed on the effluent may be exceeded.

Based on the foregoing, it is assumed that the lagoons could be used to polish the effluent from the existing plant to achieve an ammonia standard of about 15 mg/L (monthly average) on a reliable basis.

The lagoons should also be considered as a low cost, polishing step downstream of the other nitrification processes under consideration.

WEWPCC – Lagoon Nitrification (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

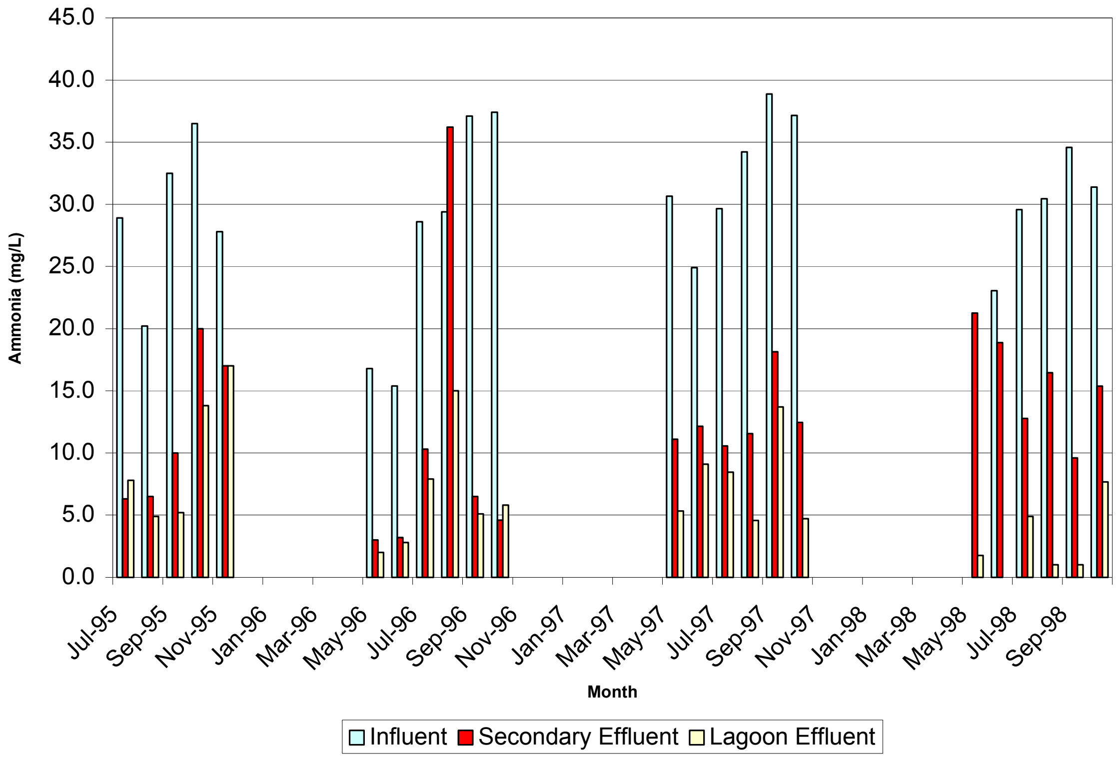


Figure WE-3.1: Ammonia Concentration in Lagoon Effluent (monthly average)

TECHNICAL CRITERIA

1. Reliability:	The WEWPCC lagoons have proven over the past four years that an effluent ammonia limit of 15 mg/L can be achieved during the summer months, based on monthly averages. Peaks over 20 mg/L have been measured so any standard involving daily compliance will not be achievable. The peaks may be the result of wet weather by-pass flow, sludge in the bottom of the lagoons mixing due to wind effects, fermentation of sludge, or algae in effluent. In the long term, sludge accumulation in the lagoons may cause the effluent ammonia concentration to increase. Lagoons of similar size in Regina and Brandon have shown very little ammonia reduction in summer months, likely due to the negative impact of the sludge at the bottom of the cells. Based on the performance of the WEWPCC lagoons and other lagoons of similar size, lagoon technology should only be considered if a low to moderate level of ammonia control is required and is based on monthly average values.
2. Robustness:	Lagoons can not generally operate under adverse and fluctuating conditions. Temperature changes result in density gradients, and may result in "turn over" increasing the effluent ammonia concentration.

WEWPCC – Lagoon Nitrification (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
3. Flexibility:	Lagoons are simple to operate, however, they offer little flexibility in operation. It may be possible to configure the lagoons to allow by-passing of certain cells, which would provide added flexibility during cleaning, or to optimize operation.
4. Impact on Other Parts of the Plant:	Wet weather flows are by-passed following the primary clarifiers, directly to the lagoons. The ammonia concentration in the by-pass can take as long as 40 days before it is passed through the lagoons to the River. This complicates the ability to monitor compliance of a standard based on dry weather flows. Depending on the volume of by-pass, one of the smaller cells might be utilized to store by-pass flows until winter, when no ammonia limits are required.
5. Space Requirements:	No additional space is needed.
6. Expandability:	If an ammonia limit below 15 mg/L (monthly average) is imposed, then additional treatment would be needed upstream of the lagoons at the mechanical plant. The lagoons would act only to polish the effluent before discharge to the Assiniboine River. If total nitrogen limits are imposed (e.g. denitrification), then the lagoons may be used to help reduce the nitrate concentration before discharge to the river. The lagoons can also be used for chemical phosphorus removal if in the future if it is implemented. This would be accomplished by dosing ferric chloride following the secondary clarifiers, and precipitating out phosphorus in the lagoons. Lagoon nitrification would not impact the expansion of the mechanical plant to biological phosphorus removal if implemented in the future.
7. Constructability:	There would be little impact on the existing structures or operation at the treatment facility.
OPERATIONAL CRITERIA	
1. Ease of Operation:	There would be no change in the operation of the treatment facility.
2. Ease of Maintenance:	There would be little change in the present maintenance requirements.
3. Operator Safety:	No new safety concerns would arise.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	No change in traffic is expected.
2. Noise:	No change in noise is expected.
3. Visual:	There would be no significant visual impact.
4. Odours:	No increase in the current level of odours is anticipated.

WEWPCC – Lagoon Nitrification (Cont'd.)

COST CRITERIA	
1. Capital Cost:	The major capital cost item is the installation of a diffuser system to distribute secondary effluent across the first lagoon cell. It is expected that this item will cost approximately $1 million.
2. Operating and Maintenance Costs:	There will no significant increase in O & M costs.
3. Other Down-stream Economic Impacts:	Utilizing the WEWPCC lagoons for nitrification may require desludging of the lagoons in the future at a significant cost.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**WEST END WATER POLLUTION CONTROL CENTRE, PERIODIC AMMONIA REMOVAL USING CEPT/SINGLE STAGE NITRIFICATION**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

Chemically enhanced primary treatment (CEPT) involves the addition of metal salts prior to the primary clarifier to improve performance. For existing activated sludge facilities that require additional tankage, CEPT can be used to remove a higher percentage of inorganic and organic material in the primary clarifiers. This lowers the load to the downstream activated sludge reactors, and minimizes the tankage required to achieve nitrification. Previous analysis of the WEWPCC indicated that with the addition of one secondary clarifier, the existing reactor volumes are adequate to achieve summer nitrification to the year 2041. By using CEPT, the load to the activated sludge reactors would be reduced by approximately 20 percent. Based on this load reduction, a 10-day SRT could be maintained at a mixed liquor concentration of 2,400 mg/L. At the reduced secondary clarifier loading rate, the existing secondary clarifiers would be sufficient.

A new building would be constructed at the plant to accommodate the new chemical dosing station. If ferric chloride is used, it is estimated that approximately 900 kg/d would be required. To allow for 30 days of storage a 2.4 metre diameter tank, 4 metres high would be required. All associated metering pumps and ancillaries would be contained within the new building.

Ferric chloride addition would reduce the wastewater alkalinity by approximately 28 mg/L. To ensure that sufficient alkalinity remains available for nitrification, an anoxic zone would be constructed in the activated sludge reactors (as outlined in the single stage nitrification option). This would recover alkalinity and reduce oxygen costs.

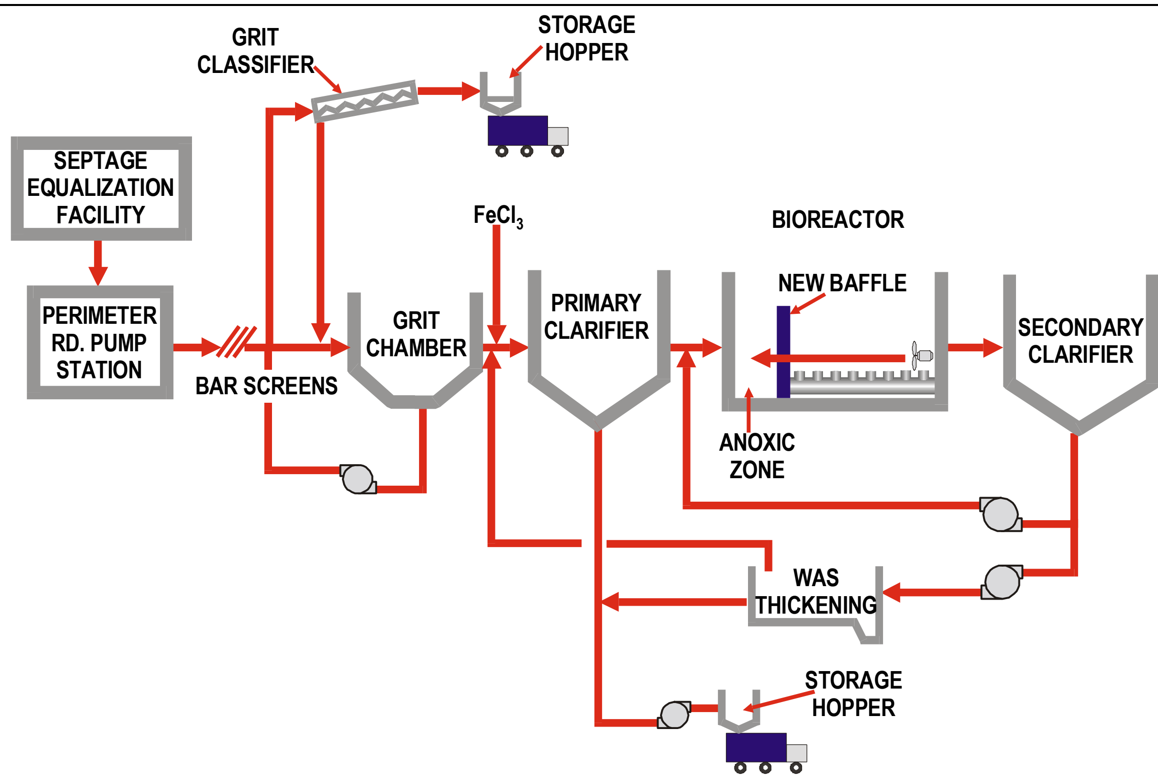


Figure WE-4.1: Process Flow Schematic – WEWPCC CEPT/Single Stage Nitrification

WEWPCC – Periodic Ammonia Removal Using CEPT/Single Stage Nitrification (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table WE-4.1: CEPT with Single Stage Nitrification at the WEWPCC

Parameter	Existing Plant Rating	Upgraded Plant Design
Ferric Chloride Dose, mg/L		30
Ferric Chloride Usage		900
Ferric Chloride Storage, m^3		20
Primary Effluent Flows & Loads		
ADWF, ML/d	32	29.6
PDWF, ML/d	44	52.9
PWWF, ML/d	112	112
BOD_5 Load		
Average, kg/d	4672	2412*
Maximum, kg/d	5888	3340*
TSS Load		
Average, kg/d	2300	1522*
Maximum, kg/d	3040	2544*
Air Activated Sludge Bioreactors		
Number of reactors	2	2
Volume/reactor, m^3	5,125	5,125
HRT at ADWF, h	7.7	8.3
Temperature, min-max, °C	10 to 20	18
SRT (winter), d	5 to 6	10
SRT (summer), d	3 to 4	10
MLSS, (at avg.), mg/L		
MLSS, (summer), mg/L	1620	2400
Secondary Clarifiers		
Number of units	2	2
Diameter, m	30	30
SWD, m	4.0	4.0
Total area, m^2	1413	1413
OFR @ PDWF, m/h	1.6	1.6
SLR @ PWWF, $kg/m^2/h$	4.80	5.8

* Note: Assumed 60 percent removal of BOD, and 80 percent removal of TSS

TECHNICAL CRITERIA

1. Reliability:	CEPT followed by activated sludge treatment is a well-developed technology and has been used in wastewater treatment for many years. The reliability of the overall process is similar to that of single stage nitrification. The existing tankage is capable of maintaining an SRT of 10 days, which is sufficient to reduce the effluent ammonia to below 2 mg/L during the summer months. By providing an anoxic zone in the activated sludge reactors, alkalinity will be recovered, and will reduce chemical costs.

WEWPCC – Periodic Ammonia Removal Using CEPT/Single Stage Nitrification (Cont'd.)

TECHNICAL CRITERIA (Cont'd.)	
2. Robustness:	Because of the sensitivity of nitrifiers and the potential for inhibition due to shock loads, discharges such as septage should be equalized before being discharged to the facility. Also, co-thickening of primary sludge and WAS should be suspended. WAS will likely denitrify in the primary clarifiers affecting their performance and impacting the bioreactors. Co-thickening also results in reseeding of undesirable microorganisms to the bioreactor which should be avoided to ensure stability in nitrification mode. With the forgoing in place, if the appropriate measures are taken to ensure that the system is operating at the necessary SRT, then this system can consistently produce effluent meeting the license limits.
3. Flexibility:	The chemical feed system will be designed to ensure that sufficient flexibility is provided to allow operation under changing flow and load conditions. The operation of activated sludge system will be very similar to the existing plant. The process will offer some flexibility, as there are two parallel trains that will allow processes to be taken out of service during winter for maintenance. Once summer nitrification is established, changes should not be introduced except to correct process upsets.
4. Impact on Other Parts of the Plant:	The addition of nitrification would require: • construction of a new building • chemical storage tank, and dosing equipment • modifications to the existing bioreactor • upgrading the aeration system • a septage equalization facility • separate thickening of primary and waste activated sludge. CEPT will increase primary sludge generation by approximately 80 percent. Operating at the higher SRT required for nitrification, combined with the reduced loading to the secondary process will reduce secondary sludge production by approximately 20 to 25 percent. The anoxic zone will help to control the growth of filamentous organisms and improve the settleability characteristics of the sludge. Separate WAS thickening is recommended to ensure stable operation in nitrification mode.
5. Space Requirements:	Space requirements for a new building would be relatively modest. The building would have to be sized to accommodate a 2.4 m diameter tank with all the related components necessary to dose chemical into the primary clarifiers.
6. Expandability:	New parallel treatment trains would be required for year-round nitrification and to accommodate any future increases in flows and loads. Dosing ferric chloride prior to the primary clarifiers will remove phosphorus to less than 1 mg/L by precipitation as $FePO_4$. Therefore, this alternative will provide both ammonia and phosphorous removal prior to discharge to the Assiniboine River.
7. Constructability:	No particular impediments to construction are anticipated.

WEWPCC – Periodic Ammonia Removal Using CEPT/Single Stage Nitrification (Cont'd.)

OPERATIONAL CRITERIA	
1. Ease of Operation:	Normal operation would be entirely automated and would generally require only periodic attention and monitoring by the operating staff.
2. Ease of Maintenance:	Maintenance would be relatively straightforward and typical of equipment maintenance requirements commonly found in many water/wastewater treatment facilities.
3. Operator Safety:	Because of the nature of ferric chloride, special training must be given to the plant operating and maintenance staff to minimize the risk of an incident and to deal properly with an incident should one occur.
4. Operator Environment:	The operator's environment would be little different to that at a typical water/ wastewater treatment facility.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	There would be additional traffic for the delivery of truckloads of ferric chloride.
2. Noise:	New operating equipment is similar to existing equipment. There will be no significant increase in noise.
3. Visual:	The new building housing the chemical dosing equipment would be apparent.
4. Odours:	Due to the addition of ferric chloride, it is expected that odours would be reduced.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of chemical storage building, construction of anoxic cells in the existing bioreactors, a septage equalization facility and a separate WAS thickening facility. It is expected that these units will cost approximately $6 million.
2. Operating and Maintenance Costs:	The incremental O&M costs will be primary due to chemical costs associated with metal salt addition, and increased sludge hauling costs. It is expected that the increased O&M cost will be approximately $30,000 per month when the CEPT system is operating.
3. Other Down-stream Economic Impacts:	Upgrading the WEWPCC to nitrification will require only a small portion of space.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	**WEST END WATER POLLUTION CONTROL CENTRE, PERIODIC AMMONIA REMOVAL USING BREAKPOINT CHLORINATION**
STANDARD:	2 mg/L

PROCESS DESCRIPTION

In this option, the WEWPCC will be upgraded to meet an effluent NH_3 concentration of 2 mg/L (as N) on a periodic basis by breakpoint chlorination. Chlorine will be dosed following the secondary clarifiers at an average dose of about 150 mg/L. Sulfur dioxide or sodium bisulphate will be used to dechlorinate the effluent prior to discharge to the Assiniboine River. It is assumed that the historical ammonia removal rates will continue to be achieved by the secondary treatment process, and that chlorine will only be used to polish the effluent. Based on this philosophy approximately 5000 kg of chlorine will be required each day.

The upgraded facility will include a bulk chlorine and sulphur dioxide receiving area, storage, evaporating/metering and control system, a containment and scrubbing system, and rapid mix injection and dispersion chambers. Bulk chlorine will be trucked to the plant site to avoid the high capital cost of a rail spur. A process flow schematic Figure WE-5.1. The design criteria for the process are presented in Table WE-5.1 on the following page.

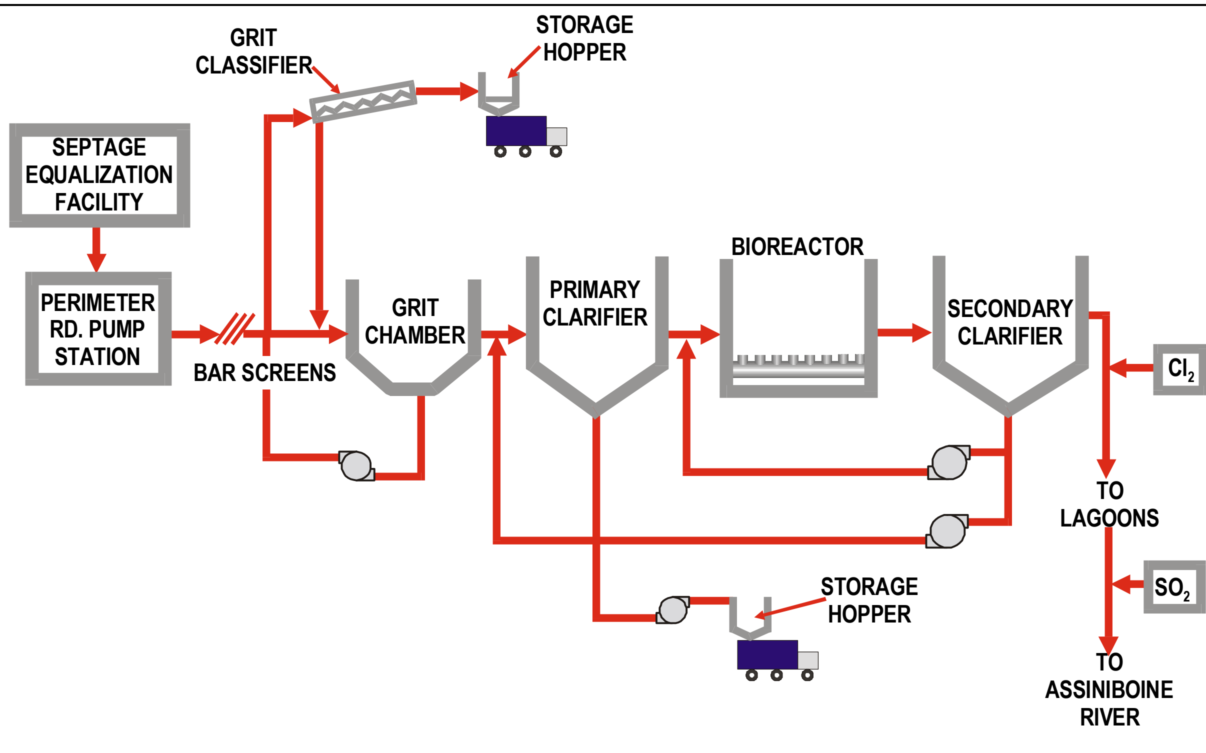


Figure WE-5.1: Process Flow Schematic – WEWPCC Breakpoint Chlorination

WEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table WE-5.1: Ammonia Reduction by Chlorination at the WEWPCC

Parameter **Primary Effluent Flows & Loads**	**Upgraded Plant Design**
ADWF, ML/d	29.6
PDWF, ML/d	52.9
Secondary Effluent Ammonia , mg/L (assumed)	15
Chlorination Facility	
Chorine Dosage	
At ADWF, mg/L	150
At PDWF, mg/L	150
Chlorine Usage	
Average, kg/d	4,440
Peak, kg/d	7,935
Chlorine Storage	
Size of Containers, kg	910
Evaporators	
Number	5
Capacity, kg/d	2000
Chlorinators	
Number	5
Capacity, kg/d	2000
Sulphur Dioxide Facility	
SO_2 Dosage	
Average, mg/L	2
Peak, mg/L	60
SO_2 Usage	
Average, kg/d	60
Peak, kg/d	3000
SO_2 Storage	
Size of Containers, kg	910
Online Containers	1
Standby Containers	1
Reserve Containers	3
Total Spaces	5
Evaporators	
Number	2
Capacity, kg/d	2000
Sulphonators	
Number	2
Capacity, kg/d	2000

TECHNICAL CRITERIA

1. Reliability:	Chlorination and dechlorination technology is well developed and has been widely applied for many decades. If periodic use of this technology is implemented, equipment will have to be serviced and tested on a regular basis to ensure safe operation.

WEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

TECHNICAL CRITERIA	
2. Robustness:	Varying ammonia loads can be handled by adjusting the chlorine dosage accordingly. This would be done with an automatic control system including flow measurement and ammonia and chlorine sensing devices.
3. Flexibility:	Sufficient flexibility can be provided by configuring equipment for changing flows and loads.
4. Impact on Other Parts of the Plant:	There would be little impact on other parts of the plant.
5. Space Requirements:	Space requirements for breakpoint chlorination would be relatively modest. The most space would be required by the bulk chlorine and sulphur dioxide receiving, storage, evaporating and metering systems together with their related containment and scrubbing systems.
6. Expandability:	The process would be readily expandable by the addition of more chlorination equipment.
7. Constructability:	No particular impediments to construction are anticipated.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Normal operation would be automated and would generally require only periodic attention and monitoring by the operating staff. The most labour intensive operational requirements would be for changing from empty to full chlorine and sulphur dioxide containers.
2. Ease of Maintenance:	Maintenance would be relatively straightforward and typical of equipment maintenance requirements commonly found in many water/wastewater treatment facilities.
3. Operator Safety:	Because of the extremely hazardous nature of chlorine and sulphur dioxide, special training must be given to the plant operating and maintenance staff to minimize the risk of an incident and to deal properly with an incident should one occur.
4. Operator Environment:	The operator's environment would not be different to that at a typical water/ wastewater treatment facility. The City uses bulk chlorine at the NEWPCC so the operators should be accustomed to this process.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	There would be additional traffic for the delivery and removal of full and empty cylinders containing chlorine and sulphur dioxide. In addition periodic deliveries of bulk caustic solution would be required. There would be a potential health concern over the danger associated with trucking chemicals.
2. Noise:	New operating equipment is similar to existing equipment. There will be no significant increase in noise.
3. Visual:	The new building housing the chlorination, containment and scrubbing facilities would be apparent on the plant site. In addition, a new rail car siding(s) would be required.

WEWPCC – Periodic Ammonia Removal Using Breakpoint Chlorination (Cont'd.)

ENVIRONMENTAL AND AESTHETIC CRITERIA (Cont'd.)	
4. Odours:	Some chlorine odour may be noticeable in the immediate vicinity of the chlorine dosing point; however, the odour would dissipate rapidly as one moves away from this point.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the construction of chemical scrubbing facilities, chlorinators, and evaporators. It is expected that these units will cost approximately $4 million.
2. Operating and Maintenance Costs:	The incremental O&M costs will be approximately $80,000 per month for chemical costs when breakpoint chlorination is being used.
3. Other Down-stream Economic Impacts:	Upgrading the WEWPCC to add breakpoint chlorination will require only a small portion of space.

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	NORTH END WATER POLLUTION CONTROL CENTRE CENTRATE TREATMENT – BIOLOGICAL OXIDATION
STANDARD:	<20 mg/L

PROCESS DESCRIPTION

In this option, the ammonia in the centrate would be biologically oxidized to nitrate and the nitrified centrate would be added to the primary effluent of the mainstream treatment process. This would result in a reduction in the nitrogen load on the mainstream treatment process by about 20 percent, along with a somewhat greater reduction in the final effluent ammonia concentration. The result could be an annual average ammonia concentration in the treated effluent of less than 20 mg/L.

Two biological treatment systems would be constructed, each designed for half of the centrate flow. The bioreactors could be designed as HPO units to utilize the excess oxygen generating capacity at the North End plant. A supplemental alkali addition will be required to maintain the pH in the range of 7.0 to 8.0 for favourable nitrification. The bioreactor will be covered and fitted with an odour control system. A common mixed liquor channel will be provided so that if one bioreactor is out of service for maintenance, both clarifiers can still be used. Therefore if the system is being operated at an unusually high SRT to compensate for the out-of-service bioreactor, the solids loading rates on the clarifiers will still be reasonable.

As the centrate is relatively warm (30 to 34°C), the growth rate of the nitrifying organisms will be favourable. It is anticipated that the system can operate satisfactorily at an SRT of ~10 days. However, because the incoming ammonia concentration in the centrate is very high, there is a risk of ammonia toxicity in the system. To counteract this risk, each bioreactor will be designed as a completely mixed vessel and therefore ideally, the ammonia concentration at any point in the bioreactor will be the same as the effluent concentration from the bioreactor.

A process flow schematic of the proposed centrate biological treatment system at the NEWPCC is presented in Figure NEC-1.1. A layout of the NEWPCC after installation of the centrate biological treatment system is presented in Figure NEC-1.2. The new centrate biological treatment system would be constructed to the west of the anaerobic digestion complex.

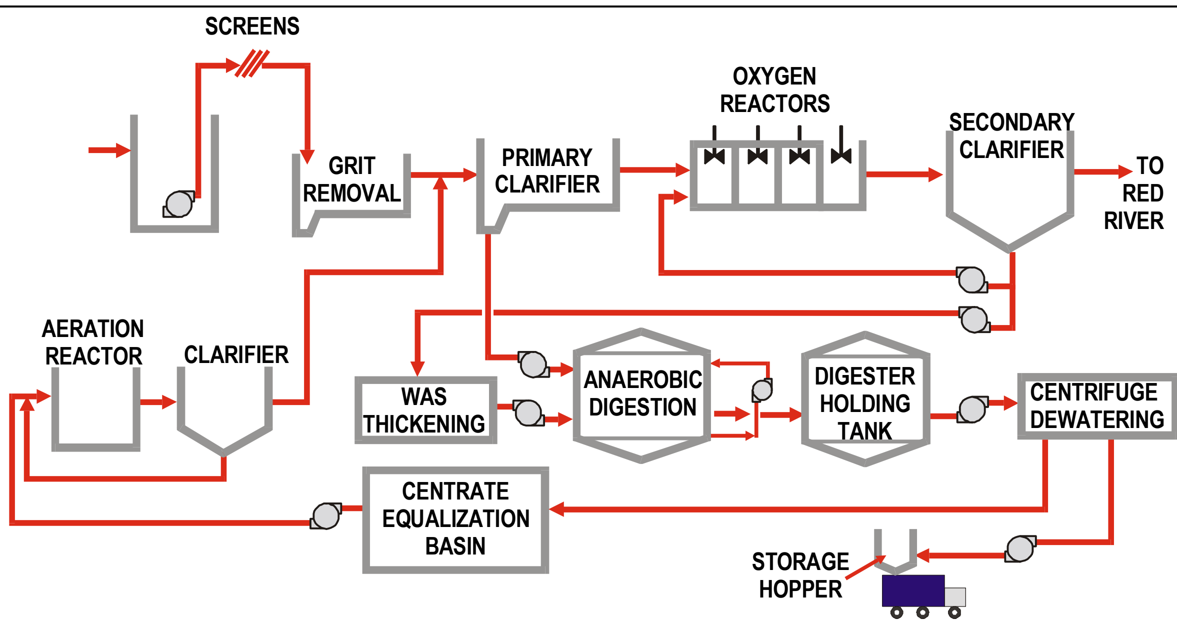
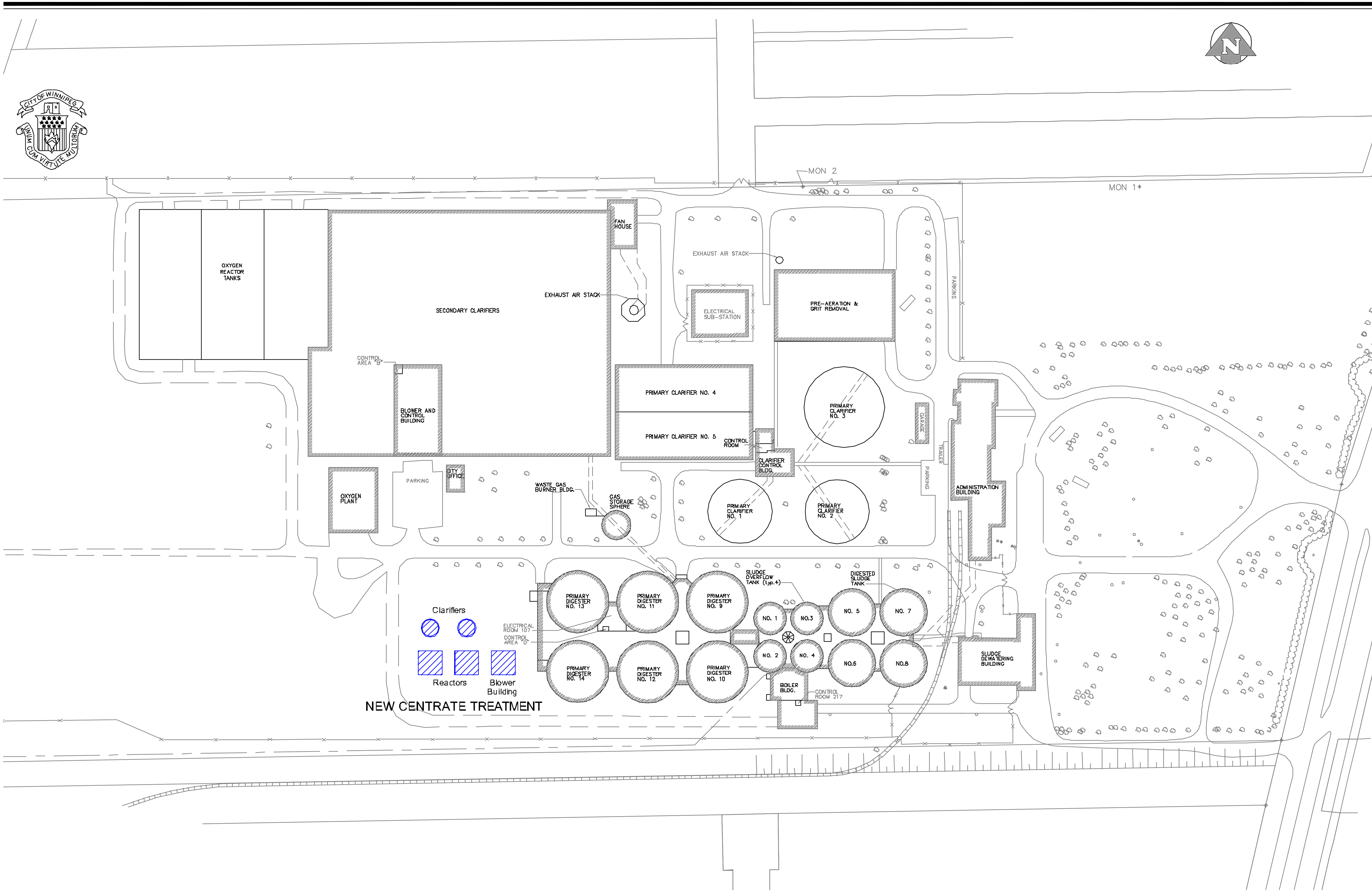


Figure NEC-1.1: Centrate Biological Treatment System at the North End Water Pollution Control Centre



NEWPCC Centrate Treatment-Biox Unit

Figure NE CEN-1.2

NEWPCC Centrate Treatment – Biological Oxidation (Cont'd.)

PROCESS DESCRIPTION (Cont'd.)

Table NEC-1.1: Centrate Biological Treatment System at the NEWPCC

Parameter **Centrate Flows & Loads**	**Existing System**	**New System**
ADWF, ML/d	1.78	1.78
PDWF, ML/d	2.07	2.07*
PWWF, ML/d	2.07	2.07
COD Load		
Two days per week - Average, kg/d	-	520
Five days per week - Maximum, kg/d	-	1040
TKN Load		
Two days per week - Average, kg/d	-	725
Five days per week - Maximum, kg/d	-	1450
Bioreactor		
Number of reactors	None	2
Volume/reactor, m^3	-	1,000
HRT at PDWF, h	-	24
Temperature, min-max, °C	30/35	16
SRT (winder), d		10
SRT (summer), d		10
MLSS, (at avg.), mg/L		2,600
MLSS, (summer), mg/L		2,600
Secondary Clarifiers		
Number of units	None	2
Diameter, m	-	10.0
SWD, m	-	5.0
Total area, m^2	-	157
OFR @ PDWF, m/h	-	2.1
SLR @ PWWF, $kg/m^2/h$	-	2.1

Note: * Not including wash water that is presently being used for control struvite buildup in the centrifuges.

NEWPCC Centrate Treatment – Biological Oxidation (Cont'd.)

TECHNICAL CRITERIA	
1. Reliability:	The reliability of the process is largely dependent on maintaining the mixed liquor pH in the optimum range for nitrification, i.e. between 6.5 and 8.5. If HPO technology is used, maintaining the process pH in this range can be very tenuous because of the cumulative effects of increased CO_2 production from biological carbonaceous removal and alkalinity depletion from nitrification. As the CO_2 content in the gas phase increases, the pH concentration in the mixed liquor increases and the process pH is depressed. The pH depression normally found in HPO processes is exacerbated by the alkalinity destruction resulting from nitrification. At pH values below 6.5, the growth rate of the nitrifying organisms is inhibited. Positive pH control is required to keep the system stable and reliable. If air activated sludge technology is used, there likely still will be insufficient alkalinity to buffer the acid byproduct of the nitrification reactions.
TECHNICAL CRITERIA (Cont'd.)	
2. Robustness:	The completely mixed configuration of the bioreactors will contribute to the robustness of the process. Nevertheless, because of the sensitivity of nitrifiers and the potential for inhibition at pH values below 6.5, the process is more susceptible to upsets from flow and load variations than the air activated sludge process. The robustness of the process can be somewhat improved by increasing the bioreactor SRT.
3. Flexibility:	The process is relatively flexible in that the main control parameters will be the SRT and, to some extent, the RAS pumping rate. In addition, the system will be provided with the ability to operate either one or both bioreactors with either one or both clarifiers. Regardless, this flexibility will have a limited impact on the ability of the mainstream treatment process to achieve the desired ammonia limit because for the most part, the final secondary effluent ammonia concentration will be very much dependent on the incoming TKN loading to the North End plant.
4. Impact on Other Parts of the Plant:	If the bioreactors are designed as HPO units, the main impact will be the added demand of approximately 7 tonnes per day on the cryogenic oxygen production facility at the North End plant. As the nominal production capacity of the cryogenic system is ~55 tonnes per day and the current demand is ~33 tonnes per day, this is not expected to require a capacity increase for the cryogenic plant. A second significant impact on other parts of the plant will be the intended reduction in nitrogen loading on the secondary treatment process. Another beneficial impact could be the continuous seeding of the mainstream treatment train with nitrifying organisms wasted from the centrate biological treatment unit. If tighter permit limits are imposed, this may help the NE plant comply with such limits with a somewhat lesser need for mainstream bioreactor tankage.
5. Space Requirements:	Figure NEC-1.2 shows that the centrate treatment system can be accommodated within the existing site limits.

NEWPCC Centrate Treatment – Biological Oxidation (Cont'd.)

6. Expandability:	The design shown handles centrate flows predicted until 2041. Additional centrate treatment units could be constructed to handle future unanticipated increases in flows and loads. The beneficial impact of continuous seeding of the mainstream treatment train by nitrifying organisms in the WAS from the centrate biox unit has been noted above. This could help reduce the amount of mainstream treatment bioreactor tankage required to meet possible tighter permit limits in the future.
7. Constructability:	Construction can occur without hampering the ongoing operation of the plant. A brief minor interruption will occur when the tie-in of the new centrate pumping station is made.
OPERATIONAL CRITERIA	
1. Ease of Operation:	Because of the sensitivity of the nitrification process to the mixed liquor pH, the process is more susceptible to process upsets resulting from changes to the incoming flows and loads. Careful monitoring and control will be required to maintain plant stability.
OPERATIONAL CRITERIA	
2. Ease of Maintenance:	The addition of a centrate biological treatment unit will increase maintenance requirements at the North End plant; however, there will be no increase in the difficulty of maintenance as the technology would be similar to what is already in the secondary section of the plant.
3. Operator Safety:	No new safety concerns would arise in the secondary treatment process. However, if chemical addition is required for pH control in the bioreactor, this could result in some additional safety issues.
4. Operator Environment:	There will be no significant changes from the existing operations.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	A minor increase in traffic is expected to bring bulk chemicals to the plant if alkalinity addition is required.
2. Noise:	New operating equipment is similar to existing equipment. The will be no significant increase in noise.
3. Visual:	The HPO reactors are underground and covered similar to existing tanks. Architectural finishes would be compatible and thus would cause minimum impact.
4. Odours:	The new reactors will be covered and the exhaust gases subject to odour control measures.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include a centrate pumping system, the two new bioreactors and secondary clarifiers and related pumping, instrumentation and controls, and the chemical storage and feed facility. It is expected that these units will cost approximately $10 million.

NEWPCC Centrate Treatment – Biological Oxidation (Cont'd.)

2. Operating and Maintenance Costs:	Additional O&M costs are associated with the increase in oxygen (or air) requirements, power requirements for the reactor mixers (if required), centrate and RAS pumping systems, and chemical addition for pH adjustment. The incremental O&M costs will be approximately $700,000 per year. This cost also includes an allowance for extra operator time.
3. Other Down-stream Economic Impacts:	

Note: All cost information is very preliminary and is intended to indicate the approximate relative difference in cost between alternatives to allow selection of the alternatives to examine in more detail in the Conceptual Design stage. These estimates are not intended to represent the final costs of any of the alternatives.

PLANT:	NORTH END WATER POLLUTION CONTROL CENTRE – CENTRATE TREATMENT – AMMONIA STRIPPING & RECOVERY
STANDARD:	<20 mg/L NH_3-N

PROCESS DESCRIPTION

In this option, the ammonia in the centrate would be stripped from solution and recovered as ammonium sulphate solution for possible sale and use as a fertilizer. This would result in a reduction in the nitrogen load on the mainstream treatment process by about 20 percent, along with a somewhat greater reduction in the final effluent ammonia concentration. The result could be an annual average ammonia concentration in the treated effluent of less than 20 mg/L.

A closed loop system consisting of a counter-current trickle-flow packed tower and an absorption column would be used for ammonia stripping and absorption respectively. The stripping step would be conducted under alkaline conditions and the absorption step would be conducted under acidic conditions. It is proposed that three (3) separate closed-loop stripper/absorber units be installed, each one capable of dealing with one-half of the maximum month centrate flow. In this fashion, a 50 percent back-up capacity will be provided. The dimensions of each stripping section would be approximately 3.5 m diameter by 8 m high. The dimensions of each absorption section would be approximately 2.5 m diameter by 5 m high. The units would be fabricated from FRP. Air flow in each tower would be counter-current at about 0.5 m^3/s.

The centrate feedstock would be pre-treated with lime and/or caustic to raise the pH to the ~10.5 to ~11.0 range. This will precipitate solids that will be settled as part of the pre-treatment step and the elevated pH will permit the ammonia to be readily stripped from solution in the stripping tower. The settled solids could be added to the digested sludge feed to the centrifuges.

A process flow schematic of the proposed centrate treatment system at the NEWPCC is presented in Figure NEC-2.1. A layout of the NEWPCC after installation of the centrate stripping/absorption system is presented in Figure NEC-2.2. The new centrate treatment system would be constructed to the west of the anaerobic digester complex and would be housed inside a building.

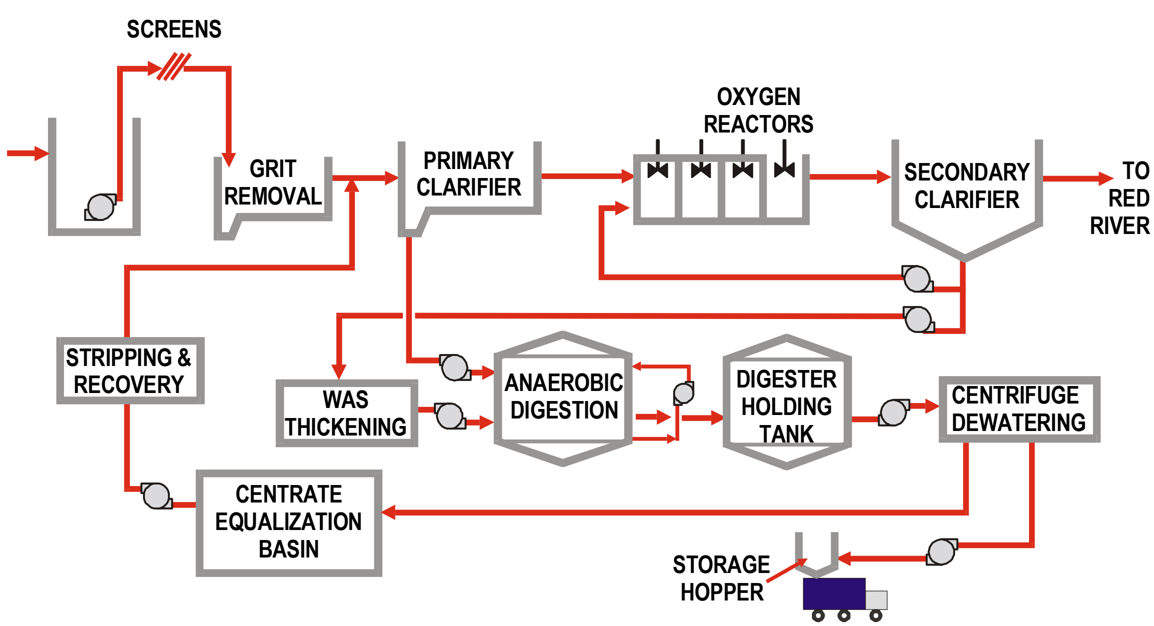
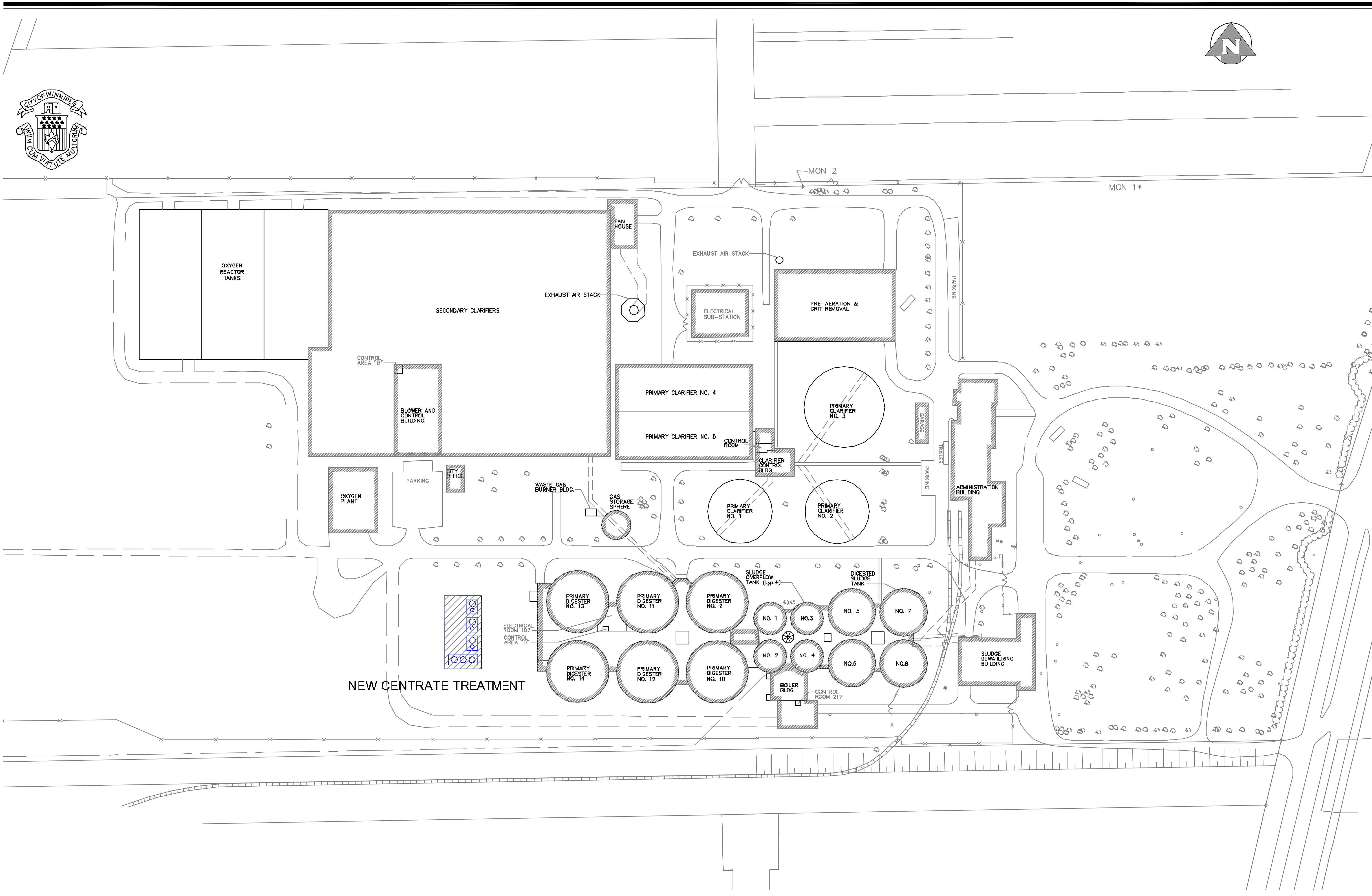


Figure NEC-2.1: Centrate Treatment – Ammonia Stripping & Recovery at the NEWPCC



NEWPCC Centrate Treatment - Ammonia Stripping & Recovery

Figure NE CEN-2.2

NEWPCC Centrate Treatment – Ammonia Stripping & Recovery (Cont'd.)

TECHNICAL CRITERIA	
1. Reliability:	Because of the closed loop configuration of the system, the scaling and freezing problems that have plagued mainstream ammonia stripping systems should not occur for this sidestream system. Care must be taken to minimize air leakage into the closed-loop system, otherwise scaling will become a significant problem. The stripping/absorption technology is relatively simple and has been applied in numerous applications in the chemical processing industries.
2. Robustness:	The process can withstand moderated fluctuations in ammonia loadings with adjustments to the alkali and acid dosages and/or the counter-current gas flow rate.
3. Flexibility:	The process is relatively simple and straightforward to operate. A limited amount of flexibility is available for the operator in that the chemical dosages and the airflow rate can be adjusted. Regardless, this flexibility will have a limited impact on the ability of the mainstream treatment process to achieve the desired ammonia limit because for the most part, the final secondary effluent ammonia concentration will be very much dependent on the incoming TKN loading to the North End plant.
4. Impact on Other Parts of the Plant:	The main impact on other parts of the plant will be the intended reduction in nitrogen loading on the secondary treatment process. A second possible benefit could be an improvement in sludge dewaterability in the centrifuges due to the addition of the lime-treated solids from the centrate pre-treatment system.
5. Space Requirements:	Figure NEC-2.2 shows that the centrate treatment system can be accommodated within the existing site limits.
6. Expandability:	The design shown handles centrate flows predicted until 2041. Additional stripping/absorption units could be constructed to handle future unanticipated increases in flows and loads.
7. Constructability:	Construction can occur without hampering the ongoing operation of the plant. A brief minor interruption will occur when the tie-in of the new centrate pumping station is made.
OPERATIONAL CRITERIA	
1. Ease of Operation:	This would be new and unfamiliar technology to the operating staff; however it should be a relatively straightforward process to operate. With the appropriate training, the operators could acquire the additional skills that they would need to operate it effectively.
2. Ease of Maintenance:	Additional maintenance work will be required to service the pumps and fans, although this type of equipment would be familiar to the plant's maintenance staff. Periodically, the tower packing will require inspection. It may be necessary to add slimicides to the liquid phase in order to minimize biological growths in the packing that could impair the efficiency of the process. As noted previously, it will be necessary to minimize air leakage into the closed-loop system, otherwise a difficult scaling condition could arise that, if allowed to continue for a prolonged period, could lead to a very difficult maintenance problem.

NEWPCC Centrate Treatment – Ammonia Stripping & Recovery (Cont'd.)

OPERATIONAL CRITERIA	
3. Operator Safety:	Elevated platforms would be required to access the top of the stripping and absorption columns. Appropriate access stairways and hand railings can be provided to minimize any safety risks. Proper training for the operators will be required for the handling of the bulk alkali and acid chemicals.
4. Operator Environment:	Under normal operation, no particular adverse conditions should occur in the operators' environment.
ENVIRONMENTAL AND AESTHETIC CRITERIA	
1. Traffic:	There would be periodic bulk tanker truck receipts of acid and alkali, as well as deliveries of ammonium sulphate solution product.
2. Noise:	The major source of noise from the system would be the fan noise and this would be contained within the building.
3. Visual:	A building would be constructed to house the stripping/absorption units and related equipment. The building would be approximately 12 m high and would be compatible with the other buildings on the site.
4. Odours:	The closed-loop design of the system will minimize the risk of odour emissions. There may be some odour associated with the ammonium sulphate product; however this would be contained and managed as appropriate.
COST CRITERIA	
1. Capital Cost:	Major capital cost items include the three stripping/absorption units and associated fans, a centrate pumping station, bulk acid and alkali receiving, storage and metering systems, and the ammonium sulphate solution storage and load-out facilities. It is expected that the building and equipment will cost approximately $10 million.
2. Operating and Maintenance Costs:	O&M costs will be associated with chemical purchases and power for the fans. In addition, there will be a part-time need for operator attention to the system.
3. Other Down-stream Economic Impacts:	