WINNIPEG SEWAGE TREATMENT PROGRAM

SOUTH END PLANT

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PROCESS SELECTION REPORT

Final	FINAL AFTER VALIDATION OF EXECUTIVE SUMMARY	12/07/11	ASI	NWA
B7	ISSUANCE AFTER ADDITIONAL ANALYSIS	05/05/11	ASI	NWA
B6	ISSUE FOR PRESENTATION - **PROGRAM CONFIDENTIAL**	17/01/11	ASI	NWA
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Rev	NATURE OF REVISION	DATE	MADE	APPROVED

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EXECUTIVE SUMMARY

The Winnipeg Sewage Treatment Program (WSTP, the "Program") is a non-traditional infrastructure delivery model that focuses on extensive collaboration and shared risks and responsibilities for the improvement and operation of the three wastewater treatment plants owned and operated by the City of Winnipeg (CoW). Among which is the South End Water Pollution Control Centre (SEWPCC) which treats wastewater from the City's south side.

In March 2006, the Manitoba Conservation Centre (the Regulator), issued a new licence with respect to operation of SEWPCC which imposes new effluent limits on both nitrogen and phosphorus and should become effective on Dec. 31st 2012. Consequently the City has to face the need for expansion and upgrade of the plant. For that purpose, it implemented the SEWPCC expansion and upgrade project (the "Project"). Initiated with the involvement of a local consultancy consortium led by Stantec, the Project has come under the scope of the Program.

Objective

The objective of this report is to conclude the Process Selection stage of the SEWPCC expansion and upgrade project selecting, on the basis of best whole life cost (NPV of Capex and Opex over 30 years) and technical evaluation, a preferred process technology from a review of the possible technologies that would meet the project's objectives. The selected treatment process will be the basis for subsequent design, construction and commissioning activities to achieve the Regulatory requirements.

Key Assumptions

The basic assumptions for the Project have been reviewed and updated by the Program, the two main areas for review were:

1) *Influent Characterization*,
   Influent quality data for SEWPCC was reviewed and updated to take account of all data available to date. Defining accurately the current quality of influent and providing a projection for a twenty year design life of the treatment process taking the operation to year 2031. The two critical design assumptions with respect to influent are:
   - 2031 SEWPCC catchment area population: 250,000 inhabitants and
   - No change in per capita flows and loads at 2031 compared to current conditions

2) *Effluent Requirements*.
   Designing the Project to achieve a strict compliance with the proposed license conditions (specifically never to exceed) would result in over sizing the plant for normal operating conditions. This over sizing would incur a significantly higher capital and operating cost for little additional benefit to the environment and create challenging design and operating conditions under normal operation as the plant has to be designed to operate under this wide range of flow conditions. The Regulator is well aware of the City's concerns on the issue and is considering the arguments. Meanwhile, Process Selection is progressing under the compliance assumptions adopted by the city Council on February 14, 2011 which were used to generate the project budget, specifically the never to exceed constraint for BOD and TSS is replaced by a 30day rolling average. It is however anticipated that the cost premium for never to exceed would be similar for each option and is therefore not a factor in selection of the preferred process option. The city council agreed at the same Council meeting that chemical reduction of phosphorus can be considered an allowable process.

		DESIGN ASSUMPTIONS			
TSS	on effluent	30-day rolling average	<25 *	mg/l	24 h effluent composite sample
$CBOD_5$	on effluent	30-day rolling average	<25	mg/l	24 h effluent composite sample
TN	on effluent	30-day rolling average	<15	mg/l	24 h effluent composite sample
TP	on effluent	30-day rolling average	<1	mg/l	24 h effluent composite sample

Options Selection

Process selection was completed through a combination of new expertise brought to the Program by Veolia Co and building on the results of engineering studies commissioned by the City prior to the involvement of the Program in the Project. Four process options were shortlisted for further study, two of which are based on previous work done by Stantec and two on expertise and experience brought to the Program by Veolia Co. An Expert Advisory Panel (EAP) engaged independently by the City and composed of recognized world class wastewater treatment specialists subsequently validated these options and narrowed the shortlist to the following three options:

1. Option 2, based on IFAS technology and bioP removal,
2. Option 3, based on a combined Activated Sludge / Biological Aerated Filters technology with bioP removal and
3. Option 4, based on Biological Aerated Filters technology with partially bioP removal.

A preliminary construction and operation risk and opportunity matrix was prepared for each option based on the experience of the team as captured during the process selection workshop and evaluation of the options.

Option Evaluation

The three options were subjected to an evaluation process based on the following principles:

- Definition of 21 comparison criteria in three technical categories (process, constructability and operation) and one financial category;
- Weighting of the criteria by the Program's Management Team;
- Scoring of the three options by technical teams from the Program with respect to process, constructability and operation categories;
- Validation of the financial assessment of the three options by an external cost estimator (Hanscomb);
- Conversion of the financial assessment of each option to a financial score;

A summary of the technical and financial scoring is shown below together with the forecast whole life cost of each option.

	Global scores	%
Option 2	849	94%
Option 3	812	89%
Option 4	907	100%

		OPTION 2	OPTION 3	OPTION 4
TOTAL CAPEX PROJECT VALUE	uc	223,757,425.00	235,202,916.00	176,563,276.00
TOTAL OPEX PROJECT VALUE (average 2010 - 2031)	uc	2,082,340.00	2,046,468.00	3,057,737.00
WHOLE LIFE COST (Construction + 30 year operation NPV with 6% discount rate)	uc	234,311,677.00	243,435,624.00	215,322,052.00

(CAPEX values include contingencies for construction change orders and OPEX includes the sludge hauling to NEWPCC)

The following table highlights the main differences between the Option 2 and 4 which received the two best global scoring.

Category	Description	Comments	Ranking Option 2	Ranking Option 4
Construction	**Construction duration**	The interference with the existing plant and the quantity of concrete makes the option 2 significantly more complex to build.	-	+
Environmental	**Impact of Construction and Commissioning on wastewater treatment.**	Reuse of existing plant facilities in option 2 would generate important disruption for the operation of the plant during construction and commissioning phase.	-	+
	Phosphorus recovery	Only 60% of the phosphorus will be recoverable in option 4 as the chemically bounded phosphorus will not be recoverable. Option 4 allows for later implementation of process recovery system if required.	+	-
Process	**Hydraulic Profile and flood impact mitigation**	The hydraulic profile can be adapted to flood level requirements as the solution includes an intermediate pumping station;	-	+
	Opportunity to build and operate with only Nitrification and a provision for de-nitrification later	Option 4 can allow for a future expansion with de-nitrification or the operational flexibility to run the plant without the de-nitrification. The Option 2 does not have that flexibility	-	+
	Sludge Production	Sludge production is much higher for the Option 4 as a consequence of the use of chemicals	+	-

Sludge treatment costs are excluded from the project scope as this will be part of a separate citywide study to produce a bio-solids strategy. All options produce a treatable sludge as evaluated in the selection criteria. Nonetheless, sludge treatment costs are considered relevant costs in process selection for SEWPCC because the three options generate significantly different amounts of sludge. Practical options for sludge treatment with respect to SEWPCC were analysed, with the assumption that the unit cost of sludge treatment is similar for each option.

The inclusion of sludge treatment costs into the scope of the option selection for SEWPCC will have the effect of reducing the gap between the whole life NPV calculations for the options but will not change the ranking as presented below.

A1 - Pelletization		GLOBAL SCORING
Option 2		859.31
Option 4		**913.05**

A2 - Thermal oxidation		GLOBAL SCORING
Option 2		857.08
Option 4		**918.81**

A3 - Composting		GLOBAL SCORING
Option 2		855.63
Option 4		**920.27**

A4 - Landfilling		GLOBAL SCORING
Option 2		857.21
Option 4		**910.81**

A5 - Land application		GLOBAL SCORING
Option 2		855.90
Option 4		**909.13**

Of the three options, option 4 was first assessed as having the largest carbon footprint due to chemical requirements of the treatment process and sludge transport. It was subsequently acknowledged that the carbon footprint calculation had to take into account the emissions from secondary treatment. The process in option 2 mainly oxidises carbon in the secondaries with consequential CO2 release whilst option 4 mostly captures it in the primary sludge. Once combined with sludge treatment options involving cogeneration, option 4 results in a lower overall carbon footprint due to potential displacement of fossil fuel carbon sources.

The real cost impact of the carbon footprint has been taken in to account in the financial evaluation, whereas the non-financial element of the environmental impact of emissions is not taken into account due to the zero weighting of the criteria. A sensitivity analysis on the evaluation criteria indicates that if it were included in the weighting it would not change the order of technical preference. In addition, some leads of improvement in respect to option 4's carbon footprint have been identified. Among them the most important are i) the recourse to "green" coagulant in primary treatment, ii) the recourse to reused exogenous source of carbon for post denitrification and the potential for technical innovations which is expected to be more important for a recent technology like BAF than for activated sludges.

Recommendations

This report considers that process Option 4 (Biological Aeration Filter) represents the best technical and economic solution to meet the project objectives and recommends that Option 4 is approved to be taken forward for design and implementation.

INTRODUCTION

The City of Winnipeg (COW) owns and operates the South End Water Pollution Control Centre (SEWPCC) which treats wastewater from the City's south side.

In March 2006, the Manitoba Conservation Centre (the Regulator), issued a new licence with respect to operation of SEWPCC. The requirements of the license impose new effluent limits on both nitrogen and phosphorus and should become effective on Dec. 31st 2012.

To address the new license, the City hired a project team to conduct a study and prepare a Preliminary Design Report (PDR) and a Conceptual Design Report (CDR) with respect to Upgrade/Expansion of SEWPCC. This study was conducted by a consultancy consortium leaded by Stantec and took place between 2005 and 2009.

In 2010, the City began implementing The Winnipeg Sewage Treatment Program (WSTP, the "Program") The Program is a non-traditional infrastructure delivery model that focuses on extensive collaboration and shared risks and responsibilities for the improvement and operation of the City's three wastewater treatment plants. The SEWPCC upgrade became part of the Program scope at this point, with the Program now comprising CoW and VW North America (Veolia Co).

In order to take advantage of the significant amount of work completed over the last 5 years on the SEWPCC upgrading/expansion project, a specific methodology has been implemented by the Program. In addition to capitalizing on the existing work, this methodology is aligned to the development of the Program and will be further developed for the delivery of other capital projects the in the Program, (SEWPCC, NEWPCC, bio solids, etc …). The project methodology follows the following three main steps:

- **STEP 1**: Process selection
- **STEP 2**: Target cost estimation for the selected process option
- **STEP 3**: Project delivery

This report concerns STEP 1 as applied to SEWPCC upgrade / expansion project.

PART I - PROCESS SELECTION METHODOLOGY

I. GENERAL

At the start of any construction project, the first step is usually a brainstorm session to identify all technical options available to reach the project's final goal. Following this, a comparison process is done to select the solution which fits the best to the project and the engineering process can then move forward with design and delivery of this preferred option. The Program has based its project methodology on this concept and named this step the "**process selection step**".

II. THE DIFFERENT STAGES OF THE "PROCESS SELECTION STEP"

Prior to involvement of the Program, a consultancy was engaged to identify, evaluate and recommend the possible process options available for the SEWPCC upgrading/expansion project, leading to the selection of two preferred solutions.

The Program has built on this work by:

i) Reviewing the previous reports to update or upgrade the results to fit the new 2010 constraints;
ii) Developing other solutions to insure a comprehensive process of selection from current wastewater treatment technology and
iii) Applying a project specific comparison procedure on the options in order to identify the best solution

In summary the different steps of the process selection are as follows:

- **STEP 1:** Existing information collection and basic assumptions definition
- **STEP 2:** Development of the Program's own solutions
- **STEP 3:** Comparison tool definition
- **STEP 4:** Process option selection

II.1 EXISTING INFORMATION COLLECTION AND BASIC ASSUMPTIONS DEFINITION

The first action by the Program was a detailed inventory of all the existing information about the SEWPCC project. The goal of which was not to create a data base of the existing information but to identify the information which can **i)** contribute to the basic assumptions which will define the basis of design (for example inlet characterization and outlet requirements) and/or **ii)** be directly applicable for the further development of the Project. The Projects' inventory methodology has been adapted accordingly and focuses on the following sources of information:

- Stantec's PDR and CDR,
- CoW operating records (raw data database, performance records, …),
- SEWPCC tours,
- CoW's Water and Waste Department interviews,
- Regulator's license and correspondence.

The basic assumptions definition is detailed in the Part II hereof and the process options retained from Stantec's previous work are described in Part III. Best efforts have been made to ensure that the inventory of asset information has been as comprehensive as possible however process selection is constrained by the accuracy and completeness of this information.

Note: Information regarding the existing SEWPCC facility (mainly drawings) has been collected for the purpose of the asset conditions assessment which will take place later during the target cost estimation step.

II.2 DEVELOPMENT OF THE PROGRAM'S OWN SOLUTIONS

Based on the inventory of available information for SEWPCC collated by the Program, the Program developed its own process options with the aim of identifying further solutions which could be of interest to the Project beyond those evaluated by the previous consultant. This step brings added value from the Program by integrating technology and worldwide expertise from the in house parties to the Program.

The development of new process solutions is based on the following:

- Analysis of the project's input and output constraints (sewage characteristics and treatment performance requirements).
- Upgrade / update / improvement of the existing process solutions
- In-house feed back / benchmark from similar projects in similar conditions
- Integration of in-house technologies
- Integration of new reliable technologies (technological follow-up)

The Program first identified **four (4)** solutions (stage 1 as described below), developing an additional more extensive pre-selection process (stage 2) to narrow the number of pre-selected options to **three (3)**. This process improved efficiency and economy by reducing the number of options subject to a detailed process evaluation.

- Stage 1: the process selection work done previously by Stantec, and validated by the CoW, has been an important part of the process selection step. Consequently two of the four pre-selected solutions are largely inspired by Stantec's work (as documented in the CDR), with the remaining two options being new solutions developed by the Program.
- Stage 2: the 4 pre-selected options were then reviewed by an Expert Advisory Panel (EAP) hired by the Program which took place during a **review workshop,** the aims to of which were to:
    - Check and validate the design assumptions
    - Pre-select the **three (3)** final best options from the four (4) previously selected and
    - Propose final adjustments, if any, to these 3 finally pre-selected options

The guidelines for the review workshop are attached to the present report Appendix 1: Review workshop guideline, for information.

II.3 COMPARISON TOOL DEFINITION

After the review workshop, the surviving three pre-selected process options were subjected to a technical and financial evaluation process. In order to complete an objective evaluation of the options the Program defined what "best for project" meant by defining evaluation criteria and scored each option regarding this definition. Prior to completing the scoring exercise, the criteria were weighted by the Program Management Team. The comparison process can be summarized as follows:

- Step 1: identification of the comparison criteria
- Step 2: weighting of the criteria
- Step 3: scoring of the pre-selected options

Details of the comparison steps are described in Part IV of this report.

II.4 PROCESS OPTION SELECTION

By completing the robust process selection and evaluation processes described, the Program was able to select a single preferred option on a "best for project basis".
Note: for the purpose of this report, and waiting for the Program to be formally implemented, the "best for project" term has been defined as implying the lowest Whole Life Cost and best technical evaluation.
This option will be recommended to be taken forward for further development and implementation to allow the city to meet the new license requirements.

The selection process has provided a robust audit trail for the selection and recommendation of the preferred process option for SEWPCC. Final decision on the preferred option shall be subject to the governance requirements of the Program which require submission of the preferred option by the Program Management Team to the Leadership Team for recommendation to the Director. It is noted that the Management Team are not bound to make the selection of the preferred option on the result of the scoring and weighting matrix alone and may take other business criteria into account.

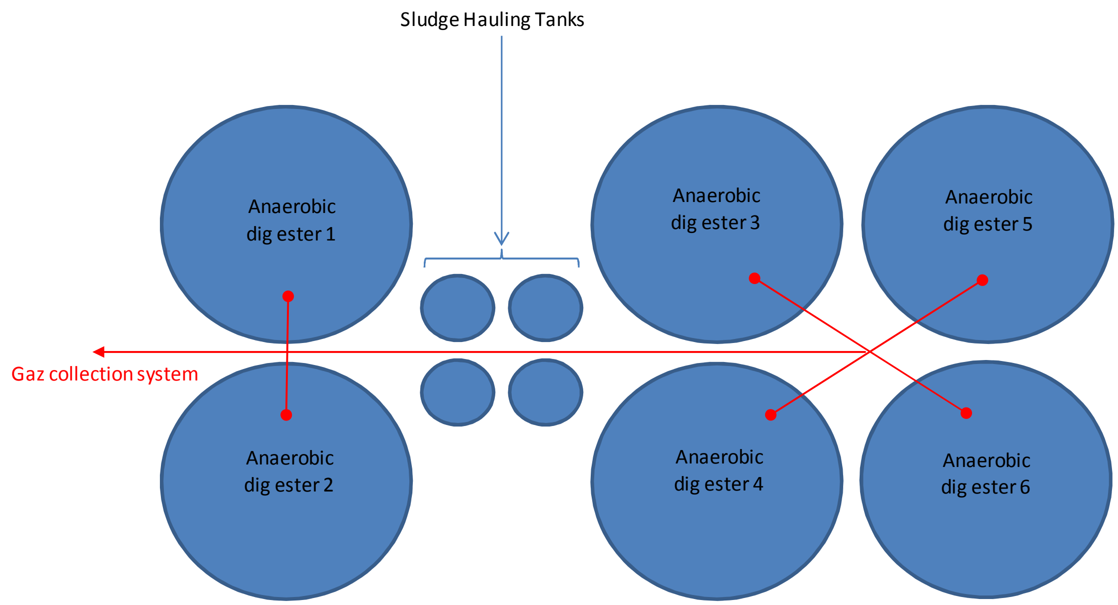
III. SIGNIFICANT PENDING ISSUES

The SEWPCC upgrade / expansion project is one component of the Winnipeg Sewage Treatment Program. Some of the issues which impact the Project are of a City wide nature that requires an integrated approach with other activities of the Program and the City. Such issues must be assessed to identify the extent to which they can impact the Project and assess if they could block progress of process selection for the Project.

The Project has looked at the City wide issues and identified Sludge Management, Septage Management, and Leachate Management as being significant. These are discussed below.

III.1 THE SLUDGE ISSUE

Currently, all the sludge produced in SEWPCC, WEWPCC and NEWPCC is treated at a centralised sludge centre at NEWPCC. The centralised sludge treatment process is shown below.



Note: Due to maintenance issues, sludge is currently being treated through five out the six existing digesters.

The sludge treatment system at NEWPCC is the subject of a separate City wide project which will be developed as part of a review of sludge strategy for the City, the Biosolids Management Plan. The link between process selection for the Project and this plan is **theoretically** reciprocal; process selection for SEWPCC may impact the Biosolids Management Plan which may in turn impact process selection for SEWPCC.

In practice, the reality of this reciprocity link resides in the significance of difference in sludge production between the pre-selected process options. The closer the quantity and quality of sludge production are between the options, the less significant the link will be.

Consequently the issue of how sludge will be treated beyond SEWPCC will have to be assessed in the process selection in order to ascertain: **i)** if options for sludge treatment might change the results of the process selection process for SEWPCC and **ii)** if the process selection for SEWPCC might compromise any Biosolids Management options. These issues are addressed in this report under Part V, chapter IV. PROCESS OPTION SELECTION.

III.2 THE SEPTAGE AND LEACHATE ISSUES

Change in the raw water characterization as a result of the receipt of Septage or Leachate at SEWPCC will impact on the design of treatment processes downstream their discharge point into the system. All options considered will be subject to the same enhanced design consequence due to septage and leachate with a similar relative increase in CAPEX and OPEX whatever the process technology implemented.

The decision on whether to accept septage and / or leachate at SEWPCC will need to be considered before starting the detailed design but will not impact the selection of a preferred option.

PART II – PROJECT'S ASSUMPTIONS DEFINITION

The starting point of the process selection is definition of the basic assumptions. They are crucial to correctly developing the Program's own process solutions and to analysing the validity of Stantec's former options in regard to the new project's context. As in any sewage treatment project, these assumptions deal with the quantity and quality of flows entering and leaving the plant:

- Inlet assumption: sewage characterization
- Outlet assumption: license requirements

I. SEWAGE CHARACTERIZATION

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On the basis of the data collected from Stantec's work, the Program analyzed Stantec's methodology and results in order to determine what needed to be updated or improved with regard to the inlet assumptions. The methodology used by the Program was as follows:

- Step 1: gain an understanding of the previous characterization
- Step 2: leads of improvement of the methodology (if any)
- Step 3: take account and integrate new data available following the publishing of the Stantec report

The results of this procedure as applied to the inlet characterization of SEWPCC are presented here below.

I.1 BACKGROUND

In preparing the PDR, Stantec evaluated historical flows and loads (1993 through 2005) to define baseline conditions prior to establishing future flows and loads. In 2009 Stantec followed up the PDR with the CDR. Flows and loads used in preparing mass balances in the CDR (Section 6.7) are noted as established in the PDR. Veolia's first review of influent flows and loads in the CDR mass balance noted some discrepancies when compared to the projected design values in PDR, particularly with respect to suspended solids. In addition, historical data used to project future flows in the PDR dates back to 1993 when water demand as well as SEWPCC base flows were higher than those in later years of the data range (2002-2005) considered in the PDR (Figures 4.18 through 4.21). Further more, from discussions with the City, it is noted that influent sampling modifications at SEWPCC were fully implemented in July 2005. Historical data (1990's through early 2000's) used in the PDR and CDR were from influent samples collected from the grit basin influent channel following screening. The sampling location was then changed to a pump discharge header. Therefore for some years influent samples were only collected from one of the four influent pump discharge headers. When one of the other three pumps was operating, the influent was not sampled. By July 2005 installation of individual samplers on all four influent pump discharge headers was completed. Therefore, from discussion with the City it is confirmed that data collected before July 2005 and used by Stantec can not be considered as fully reliable.

Thus, to confirm and project future flows and loads, the Program analyzed the most recent historical data (January 2005 through April 2010).

Note: an initial analysis for Year 2005, with the first six months included, did not reveal a significant difference in the annual averages when compared to the averages without the first six months. Therefore, all 12 months in 2005 were included in this analysis.

I.2 BASE LINE CALCULATION

I.2.1 EXISTING WASTEWATER FLOWS AND LOADS

The analysis of the existing data from January 2005 through April 2010 conducted by the Program resulted in the annual SEWPCC influent characteristics summarized in Table 1below.

		Flow (ML)	Temp (°C)	pH (s.u.)	TSS (mg/L)	BOD (mg/L)	TKN (mg/L)	NH3-N (mg/L)	Ortho P (mg/L)	Tot. P (mg/L)
AVERAGE	2005	68.99	14.98		183.32	222.97	37.98			6.14
AVERAGE	2006	58.92	16.68		178.50	226.26	42.85	26.33	4.03	6.56
AVERAGE	2007	58.51	15.36		195.07	247.29	41.41	28.14	4.25	6.58
AVERAGE	2008	58.25	15.06		186.59	218.42	42.53		4.70	7.21
AVERAGE	2009	64.76	14.20		201.22	217.69	44.90		4.26	6.91
AVERAGE	2010	53.58	12.85		230.76	258.48	51.67		4.50	7.43
ANNUAL AVERAGE	**2005-2010**	**60.50**	**14.85**		**195.91**	**231.85**	**43.56**	**27.24**	**4.35**	**6.80**
MAXIMUM DAY	2005	272.10	21.60	8.21	469.00	392.00	53.00			9.01
MAXIMUM DAY	2006	278.50	19.50	8.18	420.00	449.00	65.00	36.00	6.01	16.40
MAXIMUM DAY	2007	168.60	19.00	8.11	536.00	475.00	85.00	37.00	6.11	13.20
MAXIMUM DAY	2008	163.00	18.90	8.65	414.00	439.00	88.00		25.10	17.40
MAXIMUM DAY	2009	216.40	18.20	8.44	768.00	626.00	82.00		19.10	15.10
MAXIMUM DAY	2010	93.96	14.20	8.25	380.00	365.00	68.00		6.34	9.90
MAXIMUM DAY	**2005-2010**	**278.50**	**21.60**	**8.65**	**768.00**	**626.00**	**88.00**	**37.00**	**25.10**	**17.40**
MINIMUM DAY	2005	46.10	8.70	7.02	20.00	50.00	8.00			1.51
MINIMUM DAY	2006	41.20	10.90	7.20	60.00	50.00	15.00	8.70	1.76	2.37
MINIMUM DAY	2007	40.20	9.60	6.07	64.00	50.00	14.00	9.00	0.87	2.80
MINIMUM DAY	2008	37.80	9.70	7.38	46.00	50.00	14.00		1.37	2.80
MINIMUM DAY	2009	41.95	8.20	7.00	32.00	50.00	20.00		1.25	2.40
MINIMUM DAY	2010	42.05	8.20	7.22	132.00	148.00	30.00		2.53	4.50
MINIMUM DAY	**2005-2010**	**37.80**	**8.20**	**6.07**	**20.00**	**50.00**	**8.00**	**8.70**	**0.87**	**1.51**
STD. DEV.	2005	30.05	2.48	0.18	60.05	62.50	9.84			1.51
STD. DEV.	2006	22.98	2.00	0.16	44.86	51.08	8.16	6.13	0.95	1.54
STD. DEV.	2007	18.00	2.40	0.16	60.29	59.08	10.48	5.43	1.04	1.63
STD. DEV.	2008	15.79	1.81	0.14	58.05	45.64	8.56		1.42	1.60
STD. DEV.	2009	24.21	2.26	0.17	71.11	72.36	9.85		1.66	1.87
STD. DEV.	2010	10.83	1.15	0.16	45.81	45.78	7.91		0.82	1.24

Table 1: SEWPCC Influent Wastewater Characteristics Summary (2005 January through 2010 April)

Table 2 summarizes the mass loads during the same period. For each year, the annual average along with the maximum day value and the minimum day value are shown. Standard deviations for each parameter during the respective years are shown at the bottom of the tables. The overall average is the average of the annual averages while the overall maximum day and minimum day values noted are the maximum or minimum values during the period, i.e., they are not an average of the yearly maximum or minimum values.

		TSS (Kgs/day)	BOD (Kgs/day)	TKN (Kgs/day)	NH3-N (Kgs/day)	Ortho P (Kgs/day)	Tot. P (Kgs/day)
AVERAGE	2005	11,209.28	13,103.06	2,228.93			361.23
AVERAGE	2006	10,303.12	12,556.21	2,410.32	1,494.51	231.14	367.08
AVERAGE	2007	11,092.91	13,736.66	2,294.89	1,551.86	236.53	366.33
AVERAGE	2008	10,704.88	12,251.94	2,379.29		265.11	405.54
AVERAGE	2009	12,717.07	12,933.90	2,730.48		252.15	415.43
AVERAGE	2010	12,274.13	13,572.21	2,720.78		236.15	390.74
ANNUAL AVERAGE	**2005-2010**	**11,383.57**	**13,025.67**	**2,460.78**	**1,523.19**	**244.22**	**384.39**
MAXIMUM DAY	2005	27,785.80	32,826.20	3,108.90			502.37
MAXIMUM DAY	2006	50,130.00	23,617.40	4,647.50	1,778.40	294.49	995.48
MAXIMUM DAY	2007	29,185.60	27,634.10	4,576.00	1,802.93	358.07	755.04
MAXIMUM DAY	2008	44,940.00	29,357.40	4,444.00		1,465.84	878.70
MAXIMUM DAY	2009	86,688.00	33,196.00	4,725.00		2,070.09	808.40
MAXIMUM DAY	2010	23,963.35	21,144.14	3,637.98		331.33	607.89
MAXIMUM DAY	**2005-2010**	**86,688.00**	**33,196.00**	**4,725.00**	**1,802.93**	**2,070.09**	**995.48**
MINIMUM DAY	2005	5,050.00	5,265.00	904.00			248.71
MINIMUM DAY	2006	3,686.40	3,085.00	859.20	1,185.60	166.50	177.75
MINIMUM DAY	2007	3,545.60	7,430.00	1,212.50	986.00	83.43	184.30
MINIMUM DAY	2008	2,779.20	4,470.00	1,486.80		77.95	223.02
MINIMUM DAY	2009	1,812.48	3,603.50	1,806.26		126.32	270.86
MINIMUM DAY	2010	7,393.94	8,080.20	2,136.16		195.21	306.89
MINIMUM DAY	**2005-2010**	**1,812.48**	**3,085.00**	**859.20**	**986.00**	**77.95**	**177.75**
STD. DEV.	2005	3,843.86	3,156.70	314.60			44.70
STD. DEV.	2006	4,257.19	2,124.99	402.15	135.09	26.00	71.39
STD. DEV.	2007	3,717.21	2,469.85	390.87	161.51	36.98	66.34
STD. DEV.	2008	4,248.88	2,301.34	325.30		89.28	77.79
STD. DEV.	2009	6,350.51	3,435.26	443.16		104.64	71.09
STD. DEV.	2010	2,913.21	1,767.59	240.69		26.53	43.73

Table 2: SEWPCC Influent Waste Loads Summary (2005 January through 2010 April)

Some obvious outliers (reflective of data entry issues) were deleted before calculating the annual averages. Annual plots for each parameter revealed some very high or extremely low values in the data set. To determine if these values were outliers, the entire data set (January 1, 2005 through April 30, 2010) was grouped together and each parameter ranked to determine probabilities. Probability plots were then used to verify if the extreme values were actual outliers. Barring one day, March 10, 2009, all apparent extreme values were either due to flow or were part of a group. Both TSS and BOD concentrations on March 10, 2009 were much higher than those on adjacent (previous or next) days, i.e., March 9th or March 11th. Influent flow (46.68 MLD) on this day was lower than annual average, i.e., there were no wet weather related flows on this or previous day (March 9th flow 59 MLD). Although concentrations for both TSS and BOD on March 10th 2009 were the highest in the data set, calculated mass loads were not the highest.

A data set consisting of daily data falling approximately within three standard deviations (SD) was analyzed as an additional check for outliers. For each parameter, data that had a probability of less than 0.2% or greater than 99.8% was deleted. In most instances deleting either flow or concentration eliminated related mass load probabilities also. For mass loads that were not eliminated, the respective concentrations were deleted. Average values for the respective parameters in this data set were calculated and compared to the original averages, i.e., before deletion of the data beyond three SD. Table 3 summarizes the data set averages before and after deletion and the percent difference compared to before deletion.

	Flow (ML)	Temp (°C)	TSS (mg/L)	BOD (mg/L)	TKN (mg/L)	TP (mg/L)
2005-2010 AVERAGE (Before Eliminating Data Outside 3 SD)	60.50	14.85	195.91	231.85	43.56	6.80
2005-2010 AVERAGE (After Eliminating Data Outside 3 SD)	61.07	15.15	192.16	229.28	43.26	6.82
Percent Difference	**0.94%**	**1.96%**	**-1.92%**	**-1.11%**	**-0.68%**	**0.18%**

	TSS Load (Kgs/day)	BOD Load (Kgs/day)	TKN Load (Kgs/day)	TP Load (Kgs/day)
2005-2010 AVERAGE (Before Eliminating Data Outside 3 SD)	11,383.57	13,025.67	2,460.78	384.39
2005-2010 AVERAGE (After Eliminating Data Outside 3 SD)	11,186.53	12,912.87	2,453.55	386.64
Percent Difference	**-1.73%**	**-0.87%**	**-0.29%**	**0.59%**

Table 3: Comparison of Period Average (2005 January to 2010 April) Before and After Elimination of Data Outside of Three Standard Deviations

From Table 3 it is noted the differences in averages are minor, less than +/- 2%. Consequently the Program decided to retain all data in subsequent analysis. This adds to conservativeness in design.

Table 4 and Table 5 summarize the seasonal influent characteristics and mass loads respectively for the same time period. For each year, the seasonal averages are also summarized in the respective tables.

		Flow (ML)	Temp (°C)	TSS (mg/L)	BOD (mg/L)	TKN (mg/L)	NH3-N (mg/L)	Ortho P (mg/L)	Tot. P (mg/L)
AVERAGE	2005 FALL	56.15	16.44	204.52	241.00	40.51			6.72
AVERAGE	2006 FALL	52.62	17.63	177.04	244.92	45.19	29.00	4.33	7.03
AVERAGE	2007 FALL	52.94	17.62	196.54	256.11	40.59		4.73	6.35
AVERAGE	2008 FALL	62.28	16.83	167.10	204.80	38.64		4.67	6.71
AVERAGE	2009 FALL	55.32	16.93	201.32	238.04	49.20		4.56	7.36
AVERAGE	2010 FALL								
FALL AVERAGE		**55.86**	**17.09**	**189.30**	**236.97**	**42.83**	**29.00**	**4.57**	**6.83**
AVERAGE	2005 SPRING	77.36	13.27	214.18	207.67	35.00			5.43
AVERAGE	2006 SPRING	80.28	14.41	170.95	171.11	35.78	21.95	3.59	5.05
AVERAGE	2007 SPRING	68.06	12.73	188.04	225.71	38.64	26.31	3.84	6.13
AVERAGE	2008 SPRING	55.73	13.00	190.52	219.33	46.25		4.78	7.92
AVERAGE	2009 SPRING	81.25	11.41	213.88	187.21	42.05		3.60	6.27
AVERAGE	2010 SPRING	61.58	12.13	217.80	232.03	46.42		4.08	6.73
SPRING AVERAGE		**70.71**	**12.83**	**199.23**	**207.18**	**40.69**	**24.13**	**3.98**	**6.26**
AVERAGE	2005 SUMMER	91.65	16.98	145.81	171.29	28.42			4.66
AVERAGE	2006 SUMMER	55.02	17.77	176.18	217.80	41.60	25.77	3.96	6.65
AVERAGE	2007 SUMMER	65.88	16.97	172.14	214.73	36.13		3.60	5.83
AVERAGE	2008 SUMMER	66.95	16.19	188.60	202.63	38.21		4.16	6.44
AVERAGE	2009 SUMMER	74.10	15.32	180.76	187.80	37.49		3.65	5.69
AVERAGE	2010 SUMMER								
SUMMER AVERAGE		**70.72**	**16.64**	**172.70**	**198.85**	**36.37**	**25.77**	**3.84**	**5.85**
AVERAGE	2005 WINTER	50.45	13.18	183.37	254.82	44.87			6.99
AVERAGE	2006 WINTER	48.85	14.12	191.46	271.94	49.75	31.85	4.62	7.50
AVERAGE	2007 WINTER	46.72	13.83	223.89	293.07	50.36	31.39	5.00	8.02
AVERAGE	2008 WINTER	47.96	14.29	200.12	246.62	47.01		5.20	7.77
AVERAGE	2009 WINTER	47.72	13.95	208.21	258.99	51.18		5.25	8.34
AVERAGE	2010 WINTER	45.44	13.74	244.93	286.89	57.41		4.96	8.19
WINTER AVERAGE		**47.86**	**13.85**	**208.66**	**268.72**	**50.09**	**31.62**	**5.00**	**7.80**

Table 4: SEWPCC Seasonal Influent Wastewater characteristics Summary (2005 January through 2010 April)

		TSS (Kgs/day)	BOD (Kgs/day)	TKN (Kgs/day)	NH3-N (Kgs/day)	Ortho P (Kgs/day)	Tot. P (Kgs/day)
AVERAGE	2005 FALL	11,479.10	13,383.05	2,247.81			372.58
AVERAGE	2006 FALL	9,314.65	12,864.73	2,372.11	1,566.38	233.48	368.72
AVERAGE	2007 FALL	10,390.67	13,407.28	2,133.34		248.58	334.14
AVERAGE	2008 FALL	10,302.39	12,487.37	2,362.74		283.51	411.67
AVERAGE	2009 FALL	11,072.65	13,023.20	2,681.72		248.05	401.69
AVERAGE	2010 FALL						
FALL AVERAGE		**10,511.89**	**13,033.12**	**2,359.54**	**1,566.38**	**253.40**	**377.76**
AVERAGE	2005 SPRING	14,895.89	14,110.45	2,347.43			364.40
AVERAGE	2006 SPRING	12,804.21	12,393.93	2,643.73	1,495.64	244.85	370.67
AVERAGE	2007 SPRING	12,331.89	14,300.38	2,439.12	1,595.10	242.74	391.03
AVERAGE	2008 SPRING	10,550.97	12,089.02	2,539.52		263.21	436.33
AVERAGE	2009 SPRING	16,263.26	13,156.45	3,108.41		257.38	452.56
AVERAGE	2010 SPRING	13,318.67	14,062.64	2,823.19		245.92	407.63
SPRING AVERAGE		**13,360.81**	**13,352.15**	**2,650.23**	**1,545.37**	**250.82**	**403.77**
AVERAGE	2005 SUMMER	11,561.74	12,575.23	2,121.79			349.63
AVERAGE	2006 SUMMER	9,873.77	11,916.93	2,269.81	1,361.81	209.71	363.87
AVERAGE	2007 SUMMER	11,150.42	13,536.29	2,257.43		221.28	366.15
AVERAGE	2008 SUMMER	12,374.64	12,606.19	2,362.36		264.77	402.20
AVERAGE	2009 SUMMER	13,275.23	13,275.98	2,680.61		252.99	406.54
AVERAGE	2010 SUMMER						
SUMMER AVERAGE		**11,647.16**	**12,782.12**	**2,338.40**	**1,361.81**	**237.19**	**377.68**
AVERAGE	2005 WINTER	9,317.25	12,958.71	2,281.10			355.24
AVERAGE	2006 WINTER	9,377.81	13,275.51	2,423.57	1,558.96	226.90	365.33
AVERAGE	2007 WINTER	10,477.43	13,700.89	2,349.10	1,475.01	235.61	373.44
AVERAGE	2008 WINTER	9,591.54	11,830.48	2,252.55		248.96	372.62
AVERAGE	2009 WINTER	9,965.73	12,303.69	2,429.07		249.54	397.23
AVERAGE	2010 WINTER	11,152.22	13,054.53	2,610.78		225.46	372.60
WINTER AVERAGE		**9,980.33**	**12,853.97**	**2,391.03**	**1,516.98**	**237.30**	**372.74**

Table 5: SEWPCC Seasonal Influent Waste Loads Summary (2005 January through 2010 April)

Table 6 summarizes the respective month averages during the 2005 January through 2010 April Period. From the month averages it is noted that April is the wettest month of the year while February is the driest.

	Flow (ML)	Temp (°C)	TSS (mg/L)	BOD (mg/L)	TKN (mg/L)	NH3-N (mg/L)	Ortho P (mg/L)	Tot. P (mg/L)
January	47.84	13.77	209.36	274.11	49.90	32.20	5.10	7.93
February	47.67	12.81	202.21	262.64	49.70	30.38	5.20	7.81
March	61.58	12.24	223.67	235.60	44.82	26.41	4.47	7.12
April	82.84	12.33	178.49	179.67	37.55	20.55	3.61	5.77
May	70.77	13.73	175.27	196.56	39.75	22.95	3.63	5.95
June	78.92	15.12	180.09	200.33	35.39	26.00	3.52	5.85
July	72.19	16.81	161.34	191.05	34.76	26.00	3.86	5.56
August	61.33	17.94	182.03	211.15	40.21	25.25	4.14	6.37
September	57.60	18.01	189.57	230.86	41.09	26.50	4.41	6.66
October	57.00	17.20	182.01	234.57	42.83	30.60	4.50	6.71
November	52.98	16.06	196.90	245.54	44.61	29.67	4.81	7.15
December	48.56	14.77	198.73	269.09	49.84	31.85	4.95	7.68

Table 6: Monthly Averages for 2005 January through 2010 April Period

Peaking factors based on overall averages with respect to each parameter are summarized in Table 7 while that with respect to mass loads are summarized in Table 8.

Note: annual peaking factors are calculated with respect to the overall period average while the maximum day and minimum day peaking factors are calculated with respect to each year.

		Flow (ML)	PF Flow	TSS (mg/L)	PF TSS	BOD (mg/L)	PF BOD	TKN (mg/L)	PF TKN	Tot. P (mg/L)	PF TP
AVERAGE	2005	68.99	1.14	183.32	0.94	222.97	0.96	37.98	0.87	6.14	0.90
AVERAGE	2006	58.92	0.97	178.50	0.91	226.26	0.98	42.85	0.98	6.56	0.96
AVERAGE	2007	58.51	0.97	195.07	1.00	247.29	1.07	41.41	0.95	6.58	0.97
AVERAGE	2008	58.25	0.96	186.59	0.95	218.42	0.94	42.53	0.98	7.21	1.06
AVERAGE	2009	64.76	1.07	201.22	1.03	217.69	0.94	44.90	1.03	6.91	1.02
AVERAGE	2010	53.58	0.89	230.76	1.18	258.48	1.11	51.67	1.19	7.43	1.09
ANNUAL AVERAGE		**60.50**	**1.00**	**195.91**	**1.00**	**231.85**	**1.00**	**43.56**	**1.00**	**6.80**	**1.00**
MAXIMUM DAY	2005	272.10	3.94	469.00	2.56	392.00	1.76	53.00	1.40	9.01	1.47
MAXIMUM DAY	2006	278.50	4.73	420.00	2.35	449.00	1.98	65.00	1.52	16.40	2.50
MAXIMUM DAY	2007	168.60	2.88	536.00	2.75	475.00	1.92	85.00	2.05	13.20	2.01
MAXIMUM DAY	2008	163.00	2.80	414.00	2.22	439.00	2.01	88.00	2.07	17.40	2.41
MAXIMUM DAY	2009	216.40	3.34	768.00	3.82	626.00	2.88	82.00	1.83	15.10	2.19
MAXIMUM DAY	2010	93.96	1.75	380.00	1.65	365.00	1.41	68.00	1.32	9.90	1.33
MAXIMUM DAY		**278.50**	**4.73**	**768.00**	**3.82**	**626.00**	**2.88**	**88.00**	**2.07**	**17.40**	**2.50**
MINIMUM DAY	2005	46.10	0.67	20.00	0.11	50.00	0.22	8.00	0.21	1.51	0.25
MINIMUM DAY	2006	41.20	0.70	60.00	0.34	50.00	0.22	15.00	0.35	2.37	0.36
MINIMUM DAY	2007	40.20	0.69	64.00	0.33	50.00	0.20	14.00	0.34	2.80	0.43
MINIMUM DAY	2008	37.80	0.65	46.00	0.25	50.00	0.23	14.00	0.33	2.80	0.39
MINIMUM DAY	2009	41.95	0.65	32.00	0.16	50.00	0.23	20.00	0.45	2.40	0.35
MINIMUM DAY	2010	42.05	0.78	132.00	0.57	148.00	0.57	30.00	0.58	4.50	0.61
MINIMUM DAY		**37.80**	**0.65**	**20.00**	**0.11**	**50.00**	**0.20**	**8.00**	**0.21**	**1.51**	**0.25**

Table 7: Parameter Peaking Factors

ANNUAL SUMMARY		Flow (ML)	PF Flow	TSS (Kgs/day)	PF TSS	BOD (Kgs/day)	PF BOD	TKN (Kgs/day)	PF TKN	Tot. P (Kgs/day)	PF TP
AVERAGE	2005	68.99	1.14	11,209.28	0.98	13,103.06	1.01	2,228.93	0.91	361.23	0.94
AVERAGE	2006	58.92	0.97	10,303.12	0.91	12,556.21	0.96	2,410.32	0.98	367.08	0.95
AVERAGE	2007	58.51	0.97	11,092.91	0.97	13,736.66	1.05	2,294.89	0.93	366.33	0.95
AVERAGE	2008	58.25	0.96	10,704.88	0.94	12,251.94	0.94	2,379.29	0.97	405.54	1.06
AVERAGE	2009	64.76	1.07	12,717.07	1.12	12,933.90	0.99	2,730.48	1.11	415.43	1.08
AVERAGE	2010	53.58	0.89	12,274.13	1.08	13,572.21	1.04	2,720.78	1.11	390.74	1.02
ANNUAL AVERAGE		**60.50**	**1.00**	**11,383.57**	**1.00**	**13,025.67**	**1.00**	**2,460.78**	**1.00**	**384.39**	**1.00**
MAXIMUM DAY	2005	272.10	3.94	27,785.80	2.48	32,826.20	2.51	3,108.90	1.39	502.37	1.39
MAXIMUM DAY	2006	278.50	4.73	50,130.00	4.87	23,617.40	1.88	4,647.50	1.93	995.48	2.71
MAXIMUM DAY	2007	168.60	2.88	29,185.60	2.63	27,634.10	2.01	4,576.00	1.99	755.04	2.06
MAXIMUM DAY	2008	163.00	2.80	44,940.00	4.20	29,357.40	2.40	4,444.00	1.87	878.70	2.17
MAXIMUM DAY	2009	216.40	3.34	86,688.00	6.82	33,196.00	2.57	4,725.00	1.73	808.40	1.95
MAXIMUM DAY	2010	93.96	1.75	23,963.35	1.95	21,144.14	1.56	3,637.98	1.34	607.89	1.56
MAXIMUM DAY		**278.50**	**4.73**	**86,688.00**	**6.82**	**33,196.00**	**2.57**	**4,725.00**	**1.99**	**995.48**	**2.71**
MINIMUM DAY	2005	46.10	0.67	5,050.00	0.45	5,265.00	0.40	904.00	0.41	248.71	0.69
MINIMUM DAY	2006	41.20	0.70	3,686.40	0.36	3,085.00	0.25	859.20	0.36	177.75	0.48
MINIMUM DAY	2007	40.20	0.69	3,545.60	0.32	7,430.00	0.54	1,212.50	0.53	184.30	0.50
MINIMUM DAY	2008	37.80	0.65	2,779.20	0.26	4,470.00	0.36	1,486.80	0.62	223.02	0.55
MINIMUM DAY	2009	41.95	0.65	1,812.48	0.14	3,603.50	0.28	1,806.26	0.66	270.86	0.65
MINIMUM DAY	2010	42.05	0.78	7,393.94	0.60	8,080.20	0.60	2,136.16	0.79	306.89	0.79
MINIMUM DAY		**37.80**	**0.65**	**1,812.48**	**0.14**	**3,085.00**	**0.25**	**859.20**	**0.36**	**177.75**	**0.48**

Table 8: Mass Load Peaking Factors

Seasonal flow and mass load peaking factors were computed for the various parameters based on the overall average. These are shown in Table 9.

	FLOW		LOAD			
	MAX	MIN	TSS	BOD	TKN	TP
	MLD	MLD	Kg/d	Kg/d	Kg/d	Kg/d
WINTER						
Average	0.79	0.79	0.88	0.99	0.97	0.97
Max month	0.80	0.79	0.88	1.00	0.98	0.98
Max week	0.92	0.72	1.85	1.58	1.19	1.28
Max day	1.30	0.66	2.34	1.75	1.64	2.04
SPRING						
Average	1.17	1.17	1.17	1.03	1.08	1.05
Max month	1.37	1.02	1.19	1.04	1.12	1.08
Max week	2.80	0.76	2.26	1.67	1.54	1.77
Max day	4.60	0.75	7.61	2.55	1.92	2.29
SUMMER						
Average	1.17	1.17	1.02	0.98	0.95	0.98
Max month	1.30	1.01	1.41	1.06	0.99	1.05
Max week	2.78	0.72	2.44	1.52	1.24	1.28
Max day	4.50	0.62	3.95	2.52	1.86	2.59
FALL						
Average	0.92	0.92	0.92	1.00	0.96	0.98
Max month	0.95	0.88	0.96	1.01	0.97	0.99
Max week	1.28	0.77	1.28	1.19	1.36	1.34
Max day	1.80	0.72	2.41	1.68	1.68	1.93
ANNUAL						
Average	1.00	1.00	1.00	1.00	1.00	1.00

Table 9: Seasonal Flow and Mass Load Peaking Factors

I.2.2 EXISTING PER CAPITA FLOWS AND LOADS

It is normal practice to use per capita flows and loads for projecting contributions from population growth.

For an existing community historic per capita flows and loads serve as a base line and are useful in projecting future flows and loads. It is useful to compare historic values to bench marks which can identify the need for adjustments. These adjustments may be positive due to extraneous flows / loads (groundwater infiltration, rainfall-derived inflow/infiltration, etc.), commercial and / or industrial contributions or negative due to positive steps taken by the City or Community to reduce flows and loads.

Table 10 hereafter summarizes the annual and seasonal per capita flows and loads for the SEWPCC service area.

	Year	Population	WWTP Inf. Flow (L/Cap/day)	WWTP Inf. TSS (Kgs/Cap/day)	WWTP Inf. BOD (Kgs/Cap/day)	WWTP Inf. TKN (Kgs/Cap/day)	WWTP Inf. TP (Kgs/Cap/day)
ANNUAL SUMMARY							
AVERAGE	2005	174,275	395.88	0.0643	0.0752	0.0128	0.0021
AVERAGE	2006	174,811	337.02	0.0589	0.0718	0.0138	0.0021
AVERAGE	2007	177,404	329.82	0.0625	0.0774	0.0130	0.0021
AVERAGE	2008	180,716	322.32	0.0592	0.0678	0.0133	0.0023
AVERAGE	2009	185,139	349.81	0.0687	0.0699	0.0151	0.0023
AVERAGE	2010	188,982	283.50	0.0649	0.0718	0.0149	0.0021
ANNUAL AVERAGE		180,221	335.70	0.0632	0.0723	0.0138	0.0022
SEASONAL SUMMARY							
AVERAGE	2005	167,100	301.90	0.0558	0.0776	0.0137	0.0021
AVERAGE	2006	167,614	291.43	0.0559	0.0792	0.0145	0.0022
AVERAGE	2007	170,100	274.68	0.0616	0.0805	0.0138	0.0022
AVERAGE	2008	173,275	276.79	0.0554	0.0683	0.0130	0.0022
AVERAGE	2009	177,516	268.84	0.0561	0.0693	0.0137	0.0022
AVERAGE	2010	181,202	250.76	0.0615	0.0720	0.0144	0.0021
WINTER AVERAGE		172,801	276.95	0.0578	0.0744	0.0138	0.0022
AVERAGE	2005	173,250	446.50	0.0860	0.0814	0.0135	0.0021
AVERAGE	2006	173,783	461.93	0.0737	0.0713	0.0152	0.0021
AVERAGE	2007	176,361	385.92	0.0699	0.0811	0.0138	0.0022
AVERAGE	2008	179,653	310.23	0.0587	0.0673	0.0141	0.0024
AVERAGE	2009	184,050	441.45	0.0884	0.0715	0.0169	0.0025
AVERAGE	2010	187,871	327.77	0.0709	0.0749	0.0150	0.0022
SPRING AVERAGE		179,161	394.67	0.0746	0.0745	0.0148	0.0023
AVERAGE	2005	179,400	510.85	0.0644	0.0701	0.0118	0.0019
AVERAGE	2006	179,952	305.77	0.0549	0.0662	0.0126	0.0020
AVERAGE	2007	182,621	360.73	0.0611	0.0741	0.0124	0.0020
AVERAGE	2008	186,030	359.86	0.0665	0.0678	0.0127	0.0022
AVERAGE	2009	190,583	388.81	0.0697	0.0697	0.0141	0.0021
AVERAGE	2010	194,540	-	-	-	-	-
SUMMER AVERAGE		185,521	381.19	0.0628	0.0689	0.0126	0.0020
AVERAGE	2005	177,350	316.62	0.0647	0.0755	0.0127	0.0021
AVERAGE	2006	177,896	295.80	0.0524	0.0723	0.0133	0.0021
AVERAGE	2007	180,534	293.26	0.0576	0.0743	0.0118	0.0019
AVERAGE	2008	183,904	338.68	0.0560	0.0679	0.0128	0.0022
AVERAGE	2009	188,405	293.63	0.0588	0.0691	0.0142	0.0021
AVERAGE	2010	192,317	-	-	-	-	-
FALL AVERAGE		183,401	304.60	0.0573	0.0711	0.0129	0.0021

Table 10: Per Capita Flows and Loads

Important note: the Windsor Park swing district in the SEWPCC service area complicates the per capita analysis, i.e., the population contributing to SEWPCC is not a constant through the year. From discussions with the City it is noted that the shift to SEWPCC occurs around April 15 and to NEWPCC around November 15. As a consequence the population contributing to SEWPCC each season, i.e., winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug) and fall (Sep-Nov), is different. The contributing population during each year as well as season is also summarized in Table 10.

Table 11shows a comparison of SEWPCC per capita flows and loads to those recommended for design in the absence of actual data as well as to literature values. Ref. 1 and 2 are those recommended for design in absence of actual data while Ref. 3 refers to typical residential wastewater and Ref. 4 is individual contributions on a dry weight basis. It should be noted that typical values are annual averages and not seasonal.

Parameters, Annual Average	SEWPCC Annual Average	Ref. 1	Ref. 2	Ref. 3	Ref. 4
Flow, L/cap/day	336[a]	225[b]	380[c]	225	197-281
TSS, Kg/cap/day	0.063	0.09	0.09[d] (0.11[e])	0.035-0.075	0.06-0.15
BOD, Kg/cap/day	0.072	0.075	0.08[d] (0.10[e])	0.035-0.065	0.05-0.12
TKN, Kg/cap/day	0.0138	NR	NR	0.006-0.017	0.009-0.0217
TP, Kg/cap/day	0.0022	NR	NR	0.001-0.002	0.0027-0.0045

Note:

Ref. 1	Design Guidelines for Sewage Works 2008, Ministry of Environment, Ontario
Ref. 2	Recommended Standards for Wastewater Facilities 2004 (Ten State Standards), Great Lakes - Upper Mississippi River Board
Ref. 3	Table 22-2 Mass Loadings and Concentrations in Typical Residential Wastewater, Design Guidelines for Sewage Works 2008, Ministry of Environment, Ontario
Ref. 4	Table 2.10 and Table 2.11, WEF Manual of Practice No. 8, Design of Municipal Wastewater Treatment Plants, Fifth Edition, 2010, WEF
NR	No Recommendations
a	Overall average includes industrial, institutional, commercial and extraneous flows (groundwater and surface runoff)
b	Domestic flows exclusive of extraneous flows (groundwater and surface runoff)
c	Average daily flow including normal infiltration
d	Without garbage grinders
e	With garbage grinders

Table 11: Comparison of SEWPCC Per Capita Flows and Loads to recommended and literature values

As one community is not identical to another and there are various factors involved in data collection and reporting one has to exercise care when comparing per capita flows and loads. SEWPCC primarily receives sewage from residential areas with no significant industrial contributions. However, it is important to note that the SEWPCC loads include hauled-in wastewater (septage, etc.). With respect to flows, the SEWPCC per capita flows are higher than Ontario Ministry of Environment (MOE) flow of 225 L/cap/day which excludes infiltration but is less than the Ten State Standard (10SS) flow of 380 L/cap/day which includes some amount of infiltration.

The SEWPCC per capita TSS load of 0.063 Kg/cap/day is lower than either the MOE or 10SS load of 0.09 Kg/cap/day but is within the range of typical residential wastewater and individual contributions.

The SEWPCC per capita BOD load of 0.072 Kg/cap/day is close to the MOE load of 0.075 Kg/cap/day as well as the 10SS load of 0.077 Kg/cap/day. It is higher than the residential wastewater range but is within the range of individual contributions.

With respect to TKN or TP, there are no design guidelines for comparison. The SEWPCC TKN per capita load of 0.0138 Kg/cap/day and the TP per capita load of 0.0022 Kg/cap/day are within the range of typical residential wastewater and individual contributions.

I.3 2031 FLOWS AND LOADS PROJECTIONS

I.3.1 POPULATION PROJECTION

Projecting future flows and loads requires knowledge of the contributing population. In preparation of the PDR, one of the first steps by Stantec was to arrive at the 2031 population for the SEWPCC service area. The base line 2005 population for the SEWPCC service area was 179,400. Following historic population growth analysis and other assumptions with respect to migration rate and population distribution between service areas, Stantec arrived at a 2031 population of 229,800 for the SEWPCC service area. This represents an increase of 50’400 persons.

A census survey is conducted in Canada once every 5 years, the latest of which was in 2006. With new survey data available, it was prudent to compare population forecasts in the PDR to actual. From the 2006 Census Survey it is noted that the CoW population was 633,451. Comparing this to the CoW Population Forecast in Table C2 (Appendix C of PDR), one of the references used by Stantec in population projection, it is noted that the CoW 2006 forecast population of 656,187 is high compared to actual census numbers. From discussions with City personnel it is noted that the census undercounts population. Comparing the 2006 forecast population in the PDR to the April 6, 2010 estimated population by CoW - Office of the CFO, (see attachment) which includes about 20,000 persons to account for the census undercount, it is noted that the 2006 forecast of 656,187 in the PDR is slightly higher than the estimated population of 653,500. But the CoW – Office of the CFO population projections for future years increases at a faster rate than that in the PDR. Following discussions with the City, the 2031 SEWPCC population is assumed to be 250,000.

I.3.2 FLOWS AND LOADS PROJECTION

Projected 2031 flows and loads are summarized in Table 12. In projecting future flows and loads, per capita flows and loads from existing SEWPCC population were assumed to remain consistent through the design period, i.e., the current population would not significantly change their habits over the years. This is different from the assumptions in the PDR. In the PDR flows were assumed to decrease by about 2% due to water conservation efforts such as renovation to low flow toilets, low water use washers, etc. by the community. Even with this decrease due to the 2% Renovation Factor, the projected 2031 per capita flow of 298 L/cap/day assumed in the PDR was almost the same as the average per capita flow of 297 L/cap/day over the last four years (2002-2005) of the time period in the PDR.

	TEMPERATURE		FLOW		LOAD				CONCENTRATION			
	Max Day	Min Week	MAX	MIN	TSS	BOD	TKN	TP	TSS	BOD	TKN	TP
	℃	℃	MLD	MLD	Kg/d	Kg/d	Kg/d	Kg/d	mg/l	mg/l	mg/l	mg/l
Annual Average			87.5	87.5	15,912	18,777	3,532	552	182	215	40.4	6.3
WINTER												
Average			69.2	69.2	13,949	18,529	3,432	535	201	268	49.6	7.7
Max Month			70.2	69.0	13,990	18,848	3,472	538	199	268	49.4	7.7
Max Week			80.9	63.4	29,490	29,663	4,210	708	364	367	52.0	8.7
Max Day			113.7	58.2	37,309	32,807	5,796	1,126	328	289	51.0	9.9
SPRING												
Average			102.3	102.3	18,675	19,247	3,804	579	183	188	37.2	5.7
Max Month			119.8	89.1	18,929	19,622	3,952	596	158	164	33.0	5.0
Max Week			245.1	66.7	36,036	31,341	5,428	979	147	128	22.1	4.0
Max Day			402.9	65.2	121,165	47,852	6,783	1,261	301	119	16.8	3.1
SUMMER												
Average			102.3	102.3	16,279	18,425	3,357	542	159	180	32.8	5.3
Max Month			114.2	88.7	22,414	19,917	3,501	581	196	174	30.7	5.1
Max Week			243.0	63.3	38,837	28,557	4,397	707	160	118	18.1	2.9
Max Day			393.6	54.7	62,813	47,319	6,569	1,428	160	120	16.7	3.6
FALL												
Average			80.8	80.8	14,693	18,787	3,387	542	182	232	41.9	6.7
Max Month			83.3	76.6	15,284	18,960	3,444	547	183	228	41.3	6.6
Max Week			112.4	67.3	20,338	22,410	4,809	738	181	199	42.8	6.6
Max Day			157.1	62.8	38,398	31,595	5,922	1,067	244	201	37.7	6.8

Table 12: Projected 2031 Flows and Loads

Considering the most recent historical data (2005 through 2010) summarized earlier, it is noted that the dry weather (winter) per capita sewage flows to SEWPCC over the last few years are declining further compared to per capita flows in the PDR. This is shown in Figure 1.

Among others, reasons for this decline include

- Conscientious consumers conserving water or due to renovations already implemented
- Collection system rehabilitation efforts by the City to minimize inflow / infiltration
- Low ground water levels during winter due to antecedent dry weather conditions resulting in low infiltration

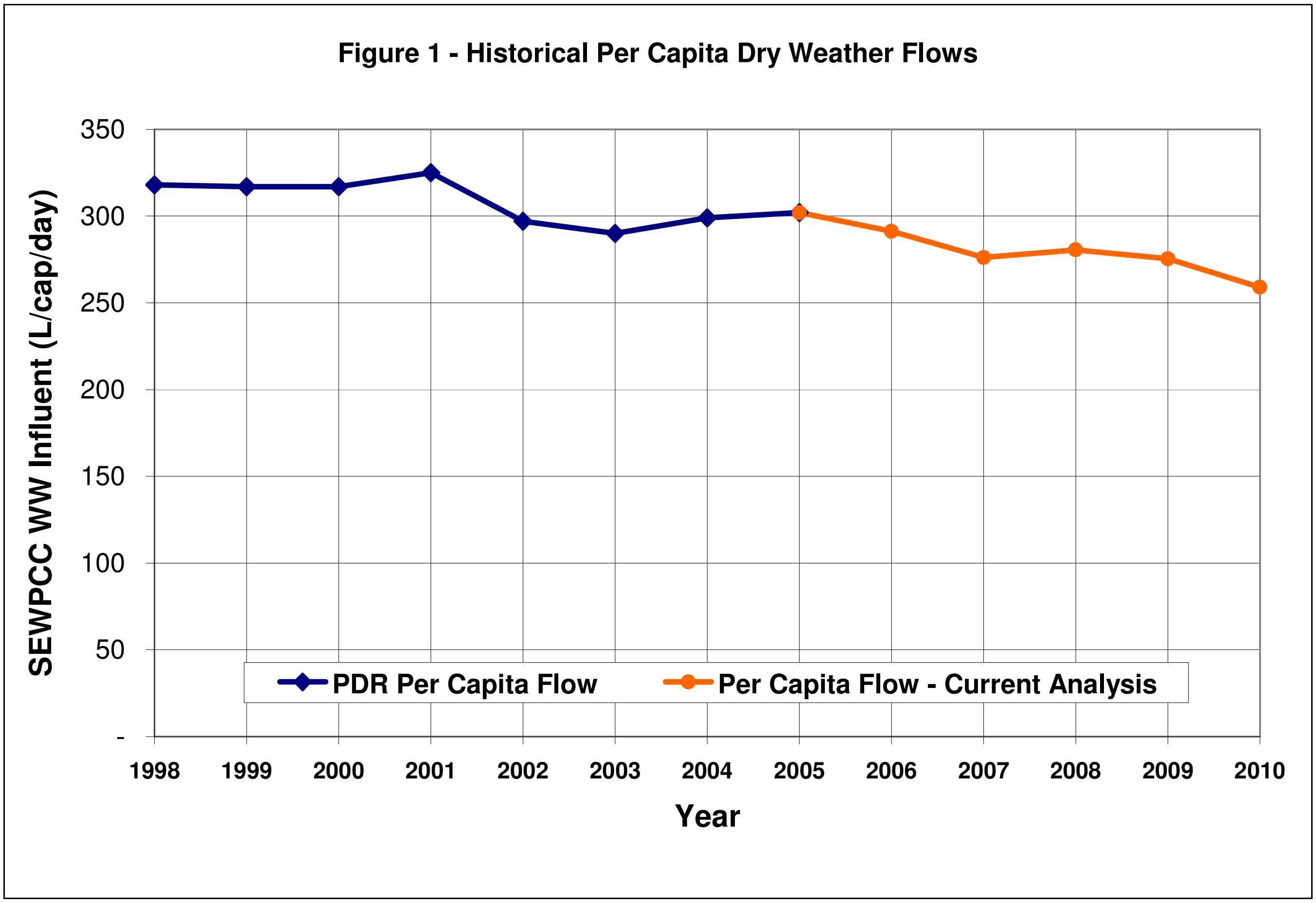

Figure 1: Historical per capita dry weather flows

Since the per capita flows were already in a declining trend over the last decade, the Program decided to use the average per capita flows from the current analysis to project future flows from the existing population without any adjustment for renovation etc.

The per capita loads assumed by Stantec in load projections were based on the Ontario MOE values as there were questions regarding the accuracy of the historical data (as discussed earlier). Additional data analysis completed as part of the Project indicates that the per capita loads computed for latter years in the PDR analysis were reflective of Winnipeg. Therefore in current projections, it is assumed that there will be no change in per capita loads from existing population.

In projecting flows and loads from new population it is customary to use existing per capita flows and loads when available in projections. In fact this is the recommendation in the Ontario MOE Guidelines as well as the Ten State Standards when actual data are available. When actual data are not available, the recommendation is to use data from similar communities or typical values in projections. As SEWPCC per capita flows and loads were available, the Program decided to use the historical per capita flows and loads for the new population.

I.4 CONCLUSION

Significant differences were noticed when the projected 2031 flows and loads from this analysis were compared to those proposed by Stantec. Percent differences compared to the PDR recommended loads are summarized in Table 13. The current comparison is with respect to the PDR as its recommendations had supporting documentation while the CDR recommendations did not. During clarification meetings in July 2010, Stantec reiterated that there were no changes in assumptions between PDR and CDR and therefore there should be no differences in the PDR and CDR recommended flows and loads. However, a summary table provided by Stantec with respect to CDR flows and loads did show some differences compared to PDR recommendations. Therefore, a comparison to CDR flows and loads was not done. It is important that the Max Day flow in the PDR was restricted to 300 MLD, the firm capacity of the existing influent pumps. Therefore the comparison in Table 13 is with respect to this restricted flow for Max Day Spring and Max Day summer conditions. Negative numbers in the table indicate that the current projections are lower that in the PDR while positive numbers indicate that the current projections are higher.

Most of these differences can be explained by the difference in methodology used by Stantec and the Program:

- As the data set used by Stantec was unreliable, Stantec use the MOE Guidelines in arriving at projected flows and loads. The guideline per capita loads were applied over the entire 2031 population. On the other hand, the Program had the benefit of the most recent data set which the City believes to be more meaningful. A simple solids mass balance by the Program across the primary clarifiers using sludge hauled out to NEWPCC confirmed that the influent TSS concentrations were close to analytical results rather than to those calculated using MOE values. The Program utilized the actual per capita loads to project future flows and loads from existing population and for the new population.
- Stantec utilized 92 percentile and 98 percentile values to arrive at Max Month and Max Day loads for determining the peaking factors. The Program utilized actual values, not available to Stantec, over the 5 year period to arrive at the Max Day and Max Month values to compute actual peaking factors.

	FLOW		LOAD			
	MAX	MIN	TSS	BOD	TKN	TP
	% Difference	% Difference	% Difference	% Difference	% Difference	% Difference
Annual Average	-3.2%	-3.2%	-27.1%	8.9%	13.9%	0.1%
WINTER						
Average	1.2%	1.2%	-22.1%	19.5%	8.5%	-4.2%
Max Month	0.6%	10.9%	-50.7%	-10.0%	-6.7%	-20.0%
Max Week	9.5%	5.4%	-15.6%	12.8%	-2.4%	-9.0%
Max Day	43.4%	5.0%	-18.6%	-6.7%	26.2%	27.5%
SPRING						
Average	15.1%	15.1%	-28.7%	-1.2%	16.8%	-2.8%
Max Month	8.0%	28.9%	-57.3%	-35.3%	-3.5%	-26.5%
Max Week	71.4%	10.8%	-35.8%	-17.0%	15.1%	-1.0%
Max Day	33.9%	30.7%	39.3%	-16.1%	20.3%	-14.0%
SUMMER						
Average	15.1%	15.1%	-32.8%	5.8%	15.1%	10.4%
Max Month	-13.5%	29.7%	-40.3%	-18.0%	0.8%	-7.0%
Max Week	36.5%	-0.5%	-31.8%	-30.1%	9.0%	-5.9%
Max Day	0.0%	-1.3%	-42.9%	-25.4%	9.9%	27.8%
FALL						
Average	18.1%	18.1%	-22.6%	13.5%	10.3%	-2.9%
Max Month	19.4%	23.2%	-50.0%	-15.4%	-5.1%	-22.7%
Max Week	52.1%	11.9%	-43.5%	-10.9%	27.1%	-14.9%
Max Day	98.1%	13.3%	-1.7%	22.2%	55.2%	15.1%

Table 13: Difference between Program's recommendation and PDR for projected flows and loads

Inlet characterization based on the following:

- Actual population in SEWPCC area: 194,152 inhabitants
- 2031 population in SEWPCC area: 250,000 inhabitants
- F_{2031} (Flows 2031) = $Pop_{2010} \times PcF_{2005\text{-}2010} + (Pop_{2031} - Pop_{2010}) \times PcF_{2005\text{-}2010}$
- L_{2031} (Loads 2031) = $Pop_{2010} \times PcL_{2005\text{-}2010} + (Pop_{2031} - Pop_{2010}) \times PcL_{2005\text{-}2010}$

, where $PcL_{2005\text{-}2010}$ and $PcF_{2005\text{-}2010}$ are the values calculated from the existing record data base at the entrance of SEWPCC from 2005 to 2010.

This inlet characterization includes the current septage and excludes the leachate.

II. OUTLET REQUIREMENTS

-ooOoo-

After defining the inlet conditions, the next step is to define the outlet requirements of the plant. Effluent requirements are set by the Manitoba Conservation, also called the Regulator, in the license it issues for every treatment plant. A new license for SEWPCC was issued in March 2006 which requires more stringent treatment on both nitrogen and phosphorus. The license is deemed to come into force in **December 31st 2012**.

II.1 LICENSE REQUIREMENTS

The new license requirements are as shown in the table below.

		LICENSE			
TSS	on effluent	never to exceed	30	mg/l	24 h effluent composite sample
$CBOD_5$	on effluent	never to exceed	25	mg/l	24 h effluent composite sample
TN	on effluent	30-day rolling average	<15	mg/l	24 h effluent composite sample
TP	on effluent	30-day rolling average	<1	mg/l	24 h effluent composite sample
E-coli	on effluent	30-day geometric mean	<200	MPN/100 mL	Grab sample collected at equal time intervalle on each of a minimum of 3 consecutive days per week
Fecal coliform	on effluent	30-day geometric mean	<200	MPN/100 mL	Grab sample collected at equal time intervalle on each of a minimum of 3 consecutive days per week
Ammonia Nitrogen	on effluent	never to exceed	1975 (january)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	2403 (February)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	4196 (March)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	12926 (April)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	5311 (May)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	3103 (June)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1517 (July)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	607 (August)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	703 (September)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	811 (October)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1152 (November)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1550 (December)	kg N/day	24 h effluent composite sample
Lethal to fish	on mixing zone	never to exceed	50 % mortality	fish	96- h static acute lethality test

Table 14: new license requirements

Designing the Project to achieve a strict compliance with the proposed license conditions (specifically never to exceed for $CBOD_5$ and TSS) would result in over sizing the plant for normal operating conditions. This over sizing would incur a significantly capital and operating cost penalty for limited environmental benefit and create difficult operating conditions under normal operation.

The City has initiated a discussion on this issue (Aug 17th 2010) with the Regulator who has indicated that monthly averages on the $CBOD_5$ and TSS would be accepted. Meanwhile, with the support of the City Council (Minute No. 198 – Report – Standing Policy Committee on Infrastructure Renewal and Public Works – February 14, 2011), the process selection has been made on the Program's best assessment of how to meet the license, specifically the never to exceed constraints is replaced by a 30 day rolling average for $CBOD_5$ and TSS:

II.2 EVALUATION OF LICENSE REQUIREMENTS

The Program designs SEWPCC for the following requirements:

		DESIGN ASSUMPTIONS			
TSS	on effluent	30-day rolling average	<25 *	mg/l	24 h effluent composite sample
$CBOD_5$	on effluent	30-day rolling average	<25	mg/l	24 h effluent composite sample
TN	on effluent	30-day rolling average	<15	mg/l	24 h effluent composite sample
TP	on effluent	30-day rolling average	<1	mg/l	24 h effluent composite sample
E-coli	on effluent	30-day geometric mean	<200	MPN/100 mL	Grab sample collected at equal time intervalle on each of a minimum of 3 consecutive days per week
Fecal coliform	on effluent	30-day geometric mean	<200	MPN/100 mL	Grab sample collected at equal time intervalle on each of a minimum of 3 consecutive days per week
Ammonia Nitrogen	on effluent	never to exceed	1975 (january)	kg N/day	24 h effluent composite sample
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	on effluent	never to exceed	3103 (June)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1517 (July)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	607 (August)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	703 (September)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	811 (October)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1152 (November)	kg N/day	24 h effluent composite sample
	on effluent	never to exceed	1550 (December)	kg N/day	24 h effluent composite sample
lethal to fish	on mixing zone	never to exceed	50 % mortality	fish	96- h static acute lethality test

Table 15: Program's assumptions of license requirements

(*) Important note: the max value for TSS and $CBOD_5$ considered is as per the Federal Effluent Guidelines (to which Manitoba is on board with). However the "never to exceed" condition is replaced by 30 day rolling average.

The design of the options and the comparison process are based on the license interpretation presented above. For the avoidance of doubt, the "never to exceed" requirements for $CBOD_5$ and TSS are replaced by "30 day rolling average" and that the TSS concentration is decreased to 25 mg/L.

PART III - PROCESS SOLUTIONS DESCRIPTION

I. PRESELECTION OF THE PROCESS TECHNOLOGIES

-ooOoo-

The SEWPCC extension / upgrade project has been previously studied by a local consultancy consortium led by Stantec before the Program was implemented. The pre-selection of treatment technologies to be used for SEWPCC started at that time.

During its studies, Stantec evaluated some 22 treatment alternatives, covering a wide range of technologies. Among which, Stantec studied but finally didn't retain membrane and BAF (Biological Aerated Filter) technologies.

Membrane based technologies were withdrawn by Stantec because of their high cost and BAF technologies because of the recourse to chemical Phosphorus removal. Therefore, at the end of the selection process, the preferred treatment alternatives put forward by Stantec were:

- Option C: AS/BNR/MJ high rate with CEP side stream
- Option G: AS/BNR/MJ/IFAS with CEP side stream

The Program analysed work done previously and assessed modifications and improvements that could be brought to the project from the expertise and experience of the Program. The conclusions were:

- Membrane based technologies were still expensive compare to the other technologies and their treatment capabilities were not required by the license and
- BAF technology could be of interest for the SEWPCC project for following reasons:
    - Significant capital investment savings expected
    - Significant reduction of the construction duration (in relation with the license deadline)
    - Significant land advantages due to the small footprint and
    - Potential commonality to future solutions for the NEWPCC which is subject to severe restrictions on available space.

Consequently, the Program decided to retain the two preferred alternatives from Stantec's work (Option C and Option G) and add two new options based on i) BAF technology and ii) BAF technology with bioP removal.

<u>Note</u>: Stantec's two preferred options were updated and upgraded using experience and expertise available within the Program. As these are now modified options from Stantec's work these options have been renamed "option 1" and "option 2". Although minor modifications have been made, the process principles remain the same as in the original Stantec options C & G.

The Appendix 2 presents for information the update of Stantec's option G pricing realized in December 2010.

> The pre-selection of the process technologies has been based on the work done previously by Stantec. Its two preferred options are retained and updated/upgraded. In addition, the Program re-introduced the BAF technology into the process selection because of its significant advantages with respect to project constraints not known to Stantec.

II. REVIEW WORKSHOP RESULTS

-ooOoo-

II.1 THE EAP SCOPE OF WORK AND ITS RESULTS

II.1.1 THE REVIEW WORKSHOP

The review workshop which was the frame of the EAP intervention took place in Winnipeg from Aug 31st to Sept 3rd 2010.

The following people have attended the workshop, those shaded grey attended the full workshop:

EAP	Prof. J. Oleszkiewicz	University of Manitoba
	Dr. Jong Hyuk Hwang	University of Manitoba
	Qiuyan Yuan (Ph.D candidate)	University of Manitoba
	F. Rogalla	Aqualia - Madrid, Spain
	JB. Neethling	HDR - Sacramento CA
	J. Husband	Malcolm & Pirnie - New York, USA
City of Winnipeg	N. Szoke	D. Gibson
	A. Permut	M. Shkolny
	A. Zaleski	T. Pearson
	K. Smyrski	B. Borlase
	R. Hahlweg	
Veolia	A. Simon	K. Sorrensen
	A. Fioravanti	B. Valla
	D. Lamarre	
	K. Upendrakumar	
	J. Hestad	
	Permanent attendees	

Table 16: workshop attendees

The purposes of the workshop and more generally the scopes of the EAP were to:

1. Validate the assumptions of the project
2. Validate or optimize the pre-selected process options
3. Review the design of the pre-selected options
4. Pre-score the options

The scope of the EAP was completed by a report presenting its opinion about the work done by the Program.

II.1.2 THE EAP REPORT

Following the workshop, the Expert Advisory Panel (EAP) produced a report to summarise what had been discussed and the results of the technical discussions during the workshop. This report is presented in Appendix 3: EAP report, together with the Program's responses to EAP questions following the workshop.

II.1.3 THE EAP CONCLUSION

During the workshop the EAP validated the abandonment of option 1. In addition and as presented in the EAP report, the EAP validated the work done so far on the three remaining options and acknowledged that more process and design discussions at this stage would not bring significant benefits to the Program.

II.2 FORMER OPTION 1 PRESENTATION

II.2.1 TREATMENT LINE OVERVIEW

The design consisted of a BNR treatment line with disinfection using UV. Flows in excess of 125 MLD, to a maximum of 300 MLD, were to be treated on a separate ballasted primary settler downstream of the headworks and were also to be disinfected using UV. Flows beyond 300MLD are discharged to river without further treatment to a maximum flow of 415 MLD.

Figure next page illustrates the treatment lines.

II.2.2 DESCRIPTION OF WASTEWATER TREATMENT

The main steps of SEWPCC are listed here below:

- <u>Headworks</u>
    - Raw water pumps
    - Bar screens (12 mm)
    - Grit removal
- <u>BNR line (125 MLD)</u>
    - 4 Primary clarifiers (3 existing + 1 new)
    - 4 Low Load Activated Sludge (A.S.) tanks including refurbishment of existing one
    - 6 Secondary clarifiers (3 existing + 3 new)
    - UV treatment
- <u>Excess Flows line</u>
    - 1 Ballasted Primary settler
    - UV treatment

II.2.3 DESCRIPTION OF SLUDGE TREATMENT

- Thickening for secondary sludge
- Storage tanks
- Truck loading facilities

II.2.4 DESCRIPTION OF ODOUR TREATMENT

New works were deemed to be connected to the existing odour control system, which consists of a dispersion stack without treatment.

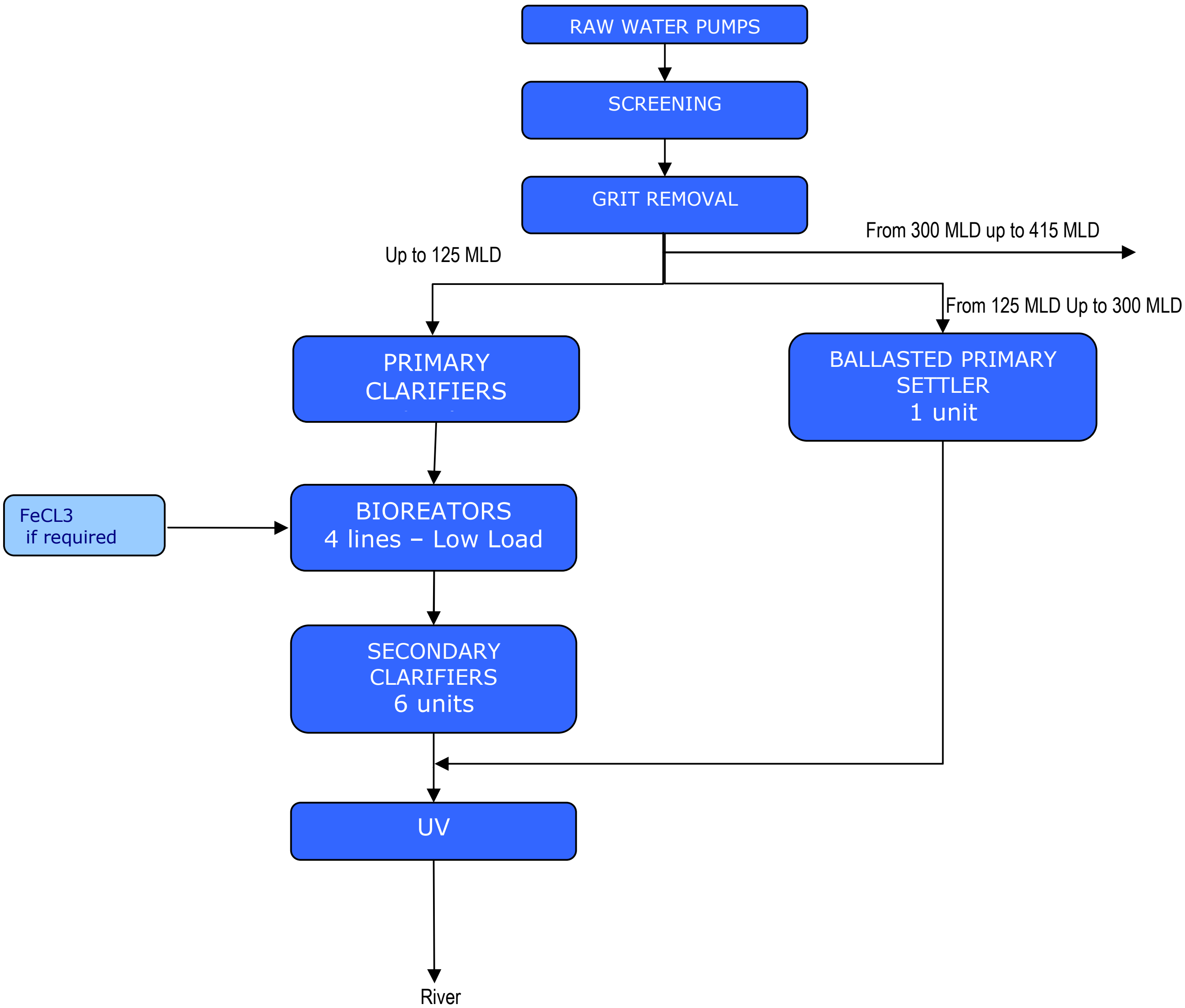


Figure 2: Option 1 PFD

This option has been abandoned after the review workshop as it was considered by the all workshop attendees as providing no significant advantage over the other three options.

Option 1 is not preselected for the further work as all the attendees of the workshop acknowledged that it provided no significant advantage over the other three options.

III. DESIGN REPORT FOR OPTION 2

-ooOoo-

III.1 DESIGN DATA

The plant is design for the year 2031 for a population of 250,000 inhabitants.

III.1.1 DESIGN INFLUENT FLOWS

The seasonal flows are detailed in Table 2. Main design flows are summarized in table below. This data is used for the design of all options.

	Units	Flowmeters
Annual average flow	MLD	88
Average dry weather flow (ADWF)	MLD	70
Spring max month	MLD	120
Peak wet weather flow (PWWF)	MLD	403
Peak hourly flow	MLD	415

Table 17: Main design flows – all options

Note: flow higher than 300 MLD will be bypassed after pre-treatment (before the primary clarifiers). No guarantee will be given on this part of the flow.

III.1.2 DESIGN INFLUENT LOADS AND TEMPERATURE

Refer to Table 18: Seasonal flows – all options

WINTER

	TEMPERATURE		FLOW		LOAD				CONCENTRATION			
	Max day °C	Min week °C	MAX MLD	MIN MLD	TSS Kg/d	BOD Kg/d	TKN Kg/d	TP Kg/d	TSS mg/l	BOD mg/l	TKN mg/l	TP mg/l
	19	12										
Average			69,2	69,2	13 949	18 529	3 432	535	201	268	49,6	7,7
Max month			70,2	69,0	13 990	18 848	3 472	538	199	268	49,4	7,7
Max week			80,9	63,4	29 490	29 663	4 210	708	364	367	52,0	8,7
Max day			113,7	58,2	37 309	32 807	5 796	1 126	328	289	51,0	9,9
Hourly												

SPRING

	TEMPERATURE		FLOW		LOAD				CONCENTRATION			
	Max day °C	Min week °C	MAX MLD	MIN MLD	TSS Kg/d	BOD Kg/d	TKN Kg/d	TP Kg/d	TSS mg/l	BOD mg/l	TKN mg/l	TP mg/l
	17	10										
Average			102,3	102,3	18 675	19 247	3 804	579	183	188	37,2	5,7
Max month			119,8	89,1	18 929	19 622	3 952	596	158	164	33,0	5,0
Max week			245,1	66,7	36 036	31 341	5 428	979	147	128	22,1	4,0
Max day			402,9	65,2	121 165	47 852	6 783	1 261	301	119	16,8	3,1
Hourly												

SUMMER

	TEMPERATURE		FLOW		LOAD				CONCENTRATION			
	Max day °C	Min week °C	MAX MLD	MIN MLD	TSS Kg/d	BOD Kg/d	TKN Kg/d	TP Kg/d	TSS mg/l	BOD mg/l	TKN mg/l	TP mg/l
	19	13										
Average			102,3	102,3	16 279	18 425	3 357	542	159	180	32,8	5,3
Max month			114,2	88,7	22 414	19 917	3 501	581	196	174	30,7	5,1
Max week			243,0	63,3	38 837	28 557	4 397	707	160	118	18,1	2,9
Max day			393,6	54,7	62 813	47 319	6 569	1 428	160	120	16,7	3,6
Hourly												

FALL

	TEMPERATURE		FLOW		LOAD				CONCENTRATION			
	Max day °C	Min week °C	MAX MLD	MIN MLD	TSS Kg/d	BOD Kg/d	TKN Kg/d	TP Kg/d	TSS mg/l	BOD mg/l	TKN mg/l	TP mg/l
	17	15										
Average			80,8	80,8	14 693	18 787	3 387	542	182	232	41,9	6,7
Max month			83,3	76,6	15 284	18 960	3 444	547	183	228	41,3	6,6
Max week			112,4	67,3	20 338	22 410	4 809	738	181	199	42,8	6,6
Max day			157,1	62,8	38 398	31 595	5 922	1 067	244	201	37,7	6,8
Hourly												

ANNUAL AVERAGE

	TEMPERATURE	FLOW		LOAD				CONCENTRATION			
	Avg °C	MAX MLD	MIN MLD	TSS Kg/d	BOD Kg/d	TKN Kg/d	TP Kg/d	TSS mg/l	BOD mg/l	TKN mg/l	TP mg/l
	15										
Average		87,5	87,5	15 912	18 777	3 532	552	182	215	40,4	6,3

Table 18: Seasonal flows – all options

III.1.3 INLET WATER CHARACTERIZATION HYPOTHESIS

The design is based on the following influent characterization. This data is used for the design of all options.

Parameters	Units	Spring Summer Winter
$N\text{-}NO_3$-	mg/l	0
COD/BOD	%	2.2
VSS/SS	%	80
Settleable TSS / TSS	%	60
NH_4-N/ TKN	%	67
Psol/Pt	%	80
Sol COD/Tot COD	%	38
Sol non deg COD/ Tot COD	%	8
Alkalinity	mg/l $CaCO_3$	250

Table 19: Influent characterization – all options

III.1.4 PERFORMANCE GUARANTEES

Effluent guarantees as per SEWPCC license are as follows. This data is used for the design of all options.

Parameters	Units	Value	
BOD_5	mg/l	25	30 day rolling average
SS	mg/l	25	30 day rolling average
TN	mg/l	15	30 day rolling average
TP	mg/l	1	30 day rolling average
E Coli and F.Coli	MPN/100 ml	200	30 days geometric average
Daily ammonia limit (*)	Kg N/day	Monthly values. Refer to the license	Never to Exceed

Table 20: Effluent guarantees – all options

(*) based on the rain event assumptions available and presented in Chart 1: Annual flows assumptions

III.1.5 SIMULATIONS

The design case is based on the max month load (spring max month), with a minimum temperature of 9°C (minimum daily temperature). The most stringent case for air blower sizing is the spring max month loads but at a water temperature of 17 °C, rather than the summer max month at 19°C. The average annual flow, loads and temperature (15°C) are used for operation estimations.

III.1.6 SLUDGE HANDLING

Primary sludge is thickened in the primary clarifiers and stored in tanks before being sent to NEWPCC. Secondary sludge is thickened prior to be stored and sent to the NEWPCC.

The design is based on the liquid stream return from sludge processing at NEWPCC being totally handled at NEWPCC.

III.2 TREATMENT LINE OVERVIEW

The design includes a BNR treatment line with a design capacity of 120 MLD. Effluent from the bioreactors is UV disinfected before final discharge.

Flows in excess of 120 MLD and lower than 300 MLD are treated on a separate ballasted primary clarification system downstream of the headworks. This overflow is chemically disinfected using chlorine.

Flows larger than 300 MLD are bypassed downstream of headworks and no guarantees are provided on this flow. Figure 3: Option 2 PFD illustrates the proposed treatment train.

II.2.1 DESCRIPTION OF WASTEWATER TREATMENT

The main steps of SEWPCC are listed here below:

- Headworks
    - Raw water pumps
    - Fine screens (6 mm punched-holes)
    - Grit removal
- BNR line (125 MLD)
    - 4 Primary clarifiers (3 existing + 1 new)
    - 4 IFAS lines with bioP including refurbishment of existing reused systems;
    - 5 Secondary clarifiers (3 existing + 2 new)
    - UV treatment
- Excess Flows line
    - Ballasted Primary clarification (2 units)
    - Chemical disinfection

III.2.2 DESCRIPTION OF SLUDGE TREATMENT

- Thickening for biological and Ballasted Primary Settler sludge
- Storage tanks
- Truck loading facilities

III.2.3 DESCRIPTION OF ODOUR TREATMENT

New works will be connected to the odour control system, which consists of a dispersion stack without treatment.

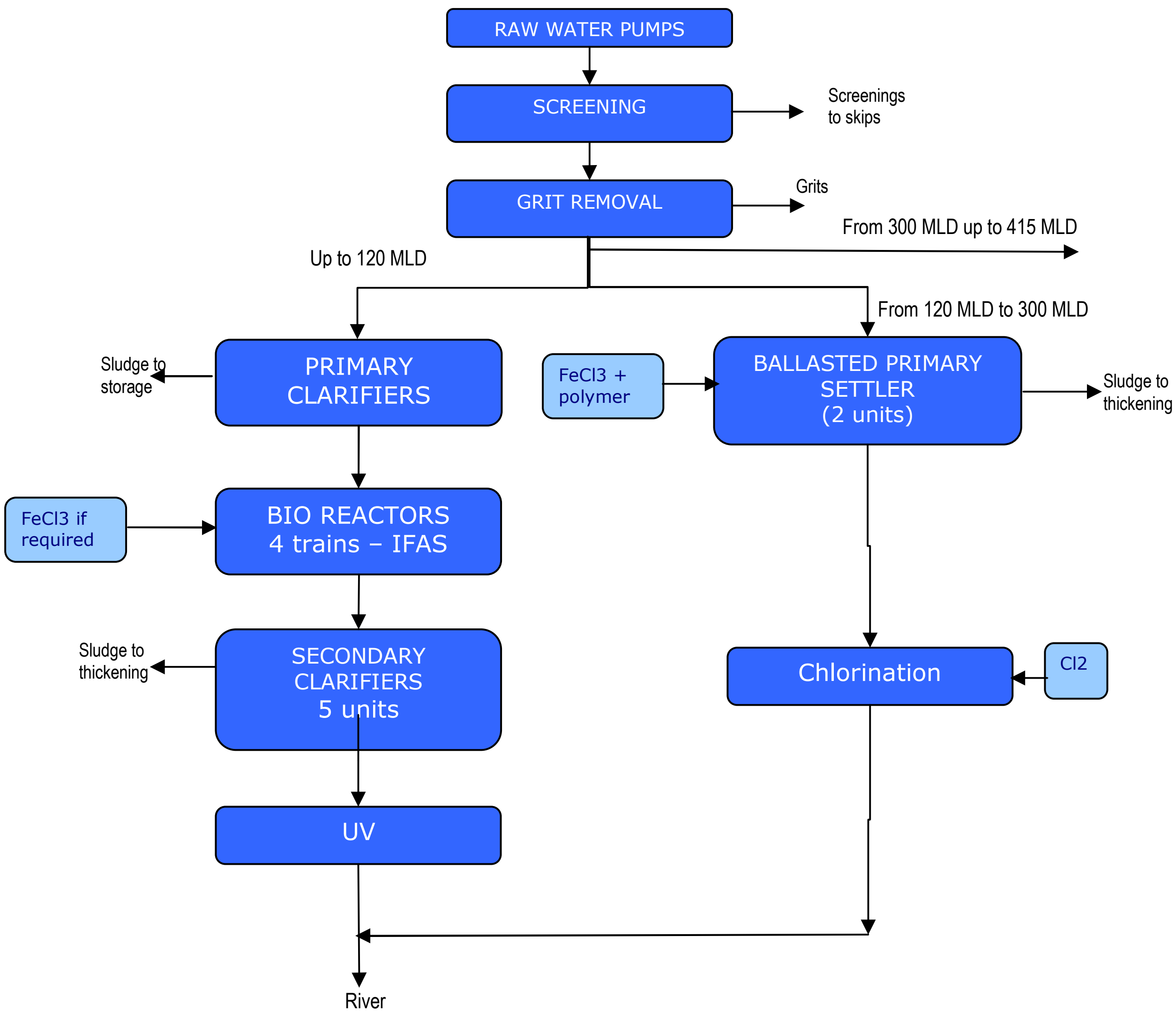


Figure 3: Option 2 PFD

III.3 PROCESS CALCULATIONS - HEADWORKS

The existing pumping station is described here below:

Parameters	TAG on PID n. SEP 863	Flow m^3/h	HMT m	Power kw
Existing pump n.1	Pump G101 RSP	4 800	16	373
Existing pump n.2	Pump G102 RSP	3 300	16	187
Existing pump n.3	Pump G103 RSP	3 300	16	187
Existing pump n.4	Pump G104 RSP	4 800	16	373

Table 21: Existing pumping station characteristics – all options

Modifications expected:

- Replacement of one small pump (3 300 m3/h) by a big one (4 800 m3/h).
- Replacement of the three existing screens (12 mm) by fine screens (6 mm).

All pumps will be working during the hourly max flow (415 000 m3/d).
One pump will be in stand by during the rest of the time (all different seasons' flows).

III.4 PROCESS CALCULATIONS – BNR TREATMENT

III.4.1 DESIGN CAPACITY

The BNR treatment line, including primary and secondary treatment is designed for the following flows. Peak hydraulic flows are handled by the excess flow treatment line.

Parameters	Units	Values
Max daily flow	m^3/d	120 000
Max hydraulic flow	m^3/h	5000

Table 22: BNR treatment line design capacity – options 2 & 3

The design loads are based on the spring max month loads given in Table 9: Seasonal Flow and Mass Load Peaking Factors.

III.4.2 PRIMARY SETTLING

a. INLET WATER QUALITY

Parameters	Units		Units	
Inlet Water Quality				
COD	mg/l	360	kg/d	43 200
BOD_5	mg/l	164	kg/d	19 680
SS	mg/l	158	kg/d	18 960
TKN	mg/l	33	kg/d	3 960
Total P	mg/l	5.0	kg/d	600

Table 23: Inlet water quality – primary settling – options 2 & 3

b. SIZING OF THE PRIMARY CLARIFIERS

Parameters	Units	
Type	-	Gravity, rectangular, non lamellar
Chemical injection	-	No
Total area of the settling zone	**m²**	**2410**
Average flow velocity	m/h	1.5
Peak velocity	m/h	2.07

Table 24: Design of primary clarifiers – options 2 & 3

c. EXISTING AND NEW WORKS

The design allows the reuse of the existing primary clarifiers plus construction of a new unit.

Parameters	Units	Existing 1 &2	Existing 3	New 4
Number		2	1	1
Settling tank width	m	9.1	19.2	9.1
Settling tank length	m	51.8	51.8	51.8
Area of the settling zone /unit	m²	472	995	472
Total area of the settling zone	m²	1940		472
Total area of the settling zone	m²	2410		
Total water depth	m	4.3*	4.3*	4.3*

Table 25: Arrangements for primary settling – options 2 & 3

* From drawings

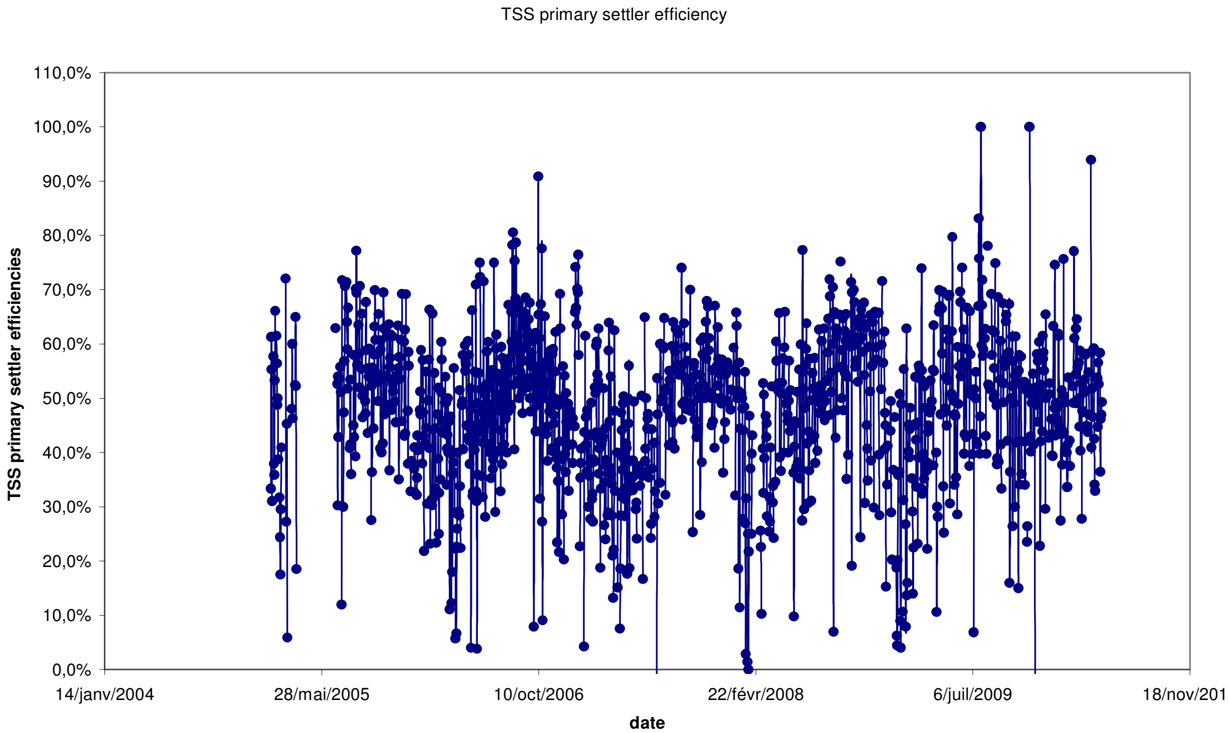
d. EXPECTED EFFICIENCY OF THE PRIMARY SETTLING

Parameters	Units	DESIGN Spring max month		AVERAGE Yearly avg
Expected Removal Efficiency				
COD	%	18		23
BOD_5	%	16		22
SS	%	34		44
TKN	%	6.0		8.0
Total P	%	3.8		6.0
Expected Settled Water Quality		FOR DESIGN SITUATION		
COD	mg/l	295	kg/d	35 400
BOD_5	mg/l	138	kg/d	16 560
SS	mg/l	104	kg/d	12 480
TKN	mg/l	31	kg/d	3 720
Total P	mg/l	4.8	kg/d	576

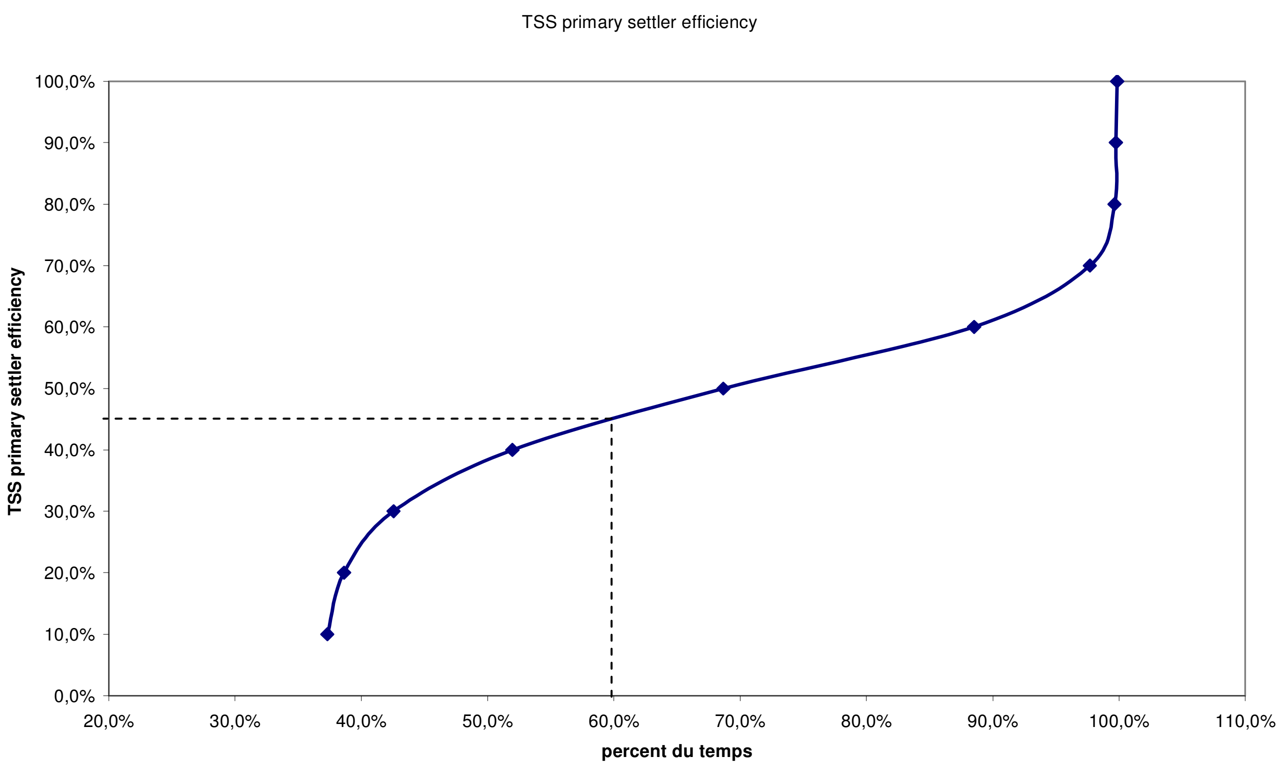
Table 26: Expected performances for primary settling – options 2 & 3

The efficiencies on the primary clarifiers have been estimated from actual results on existing primary clarifiers with consideration that there will be a small increase in velocities. The quality of the water (very diluted water) is also considered in the efficiencies calculations.

The results on TSS efficiencies from existing primary clarifiers during last five years and the percentile curve are provided below.



Graph 1: TSS primary settler efficiency 1/2



Graph 2: TSS primary settler efficiency 2/2

e. PRIMARY SLUDGE PRODUCTION AND EXTRACTION FROM SETTLING TANKS

Parameters	Units	Design	Average
Total primary sludge production	**kg SS/d**	**14 550 (max week in winter)**	**7 000**
Primary sludge concentration	g SS/L	40	40
Volatile Suspended Solids (VSS)	% of SS	78	73
Total primary sludge flow	m³/d	365	175

Table 27: Primary sludge production – options 2 & 3

Note: primary sludge is currently extracted at 3 to 4 %.

Extraction of primary sludge is designed on a 12 hr/d basis. A complete new set of sludge pumps is planned for the primary clarification step.

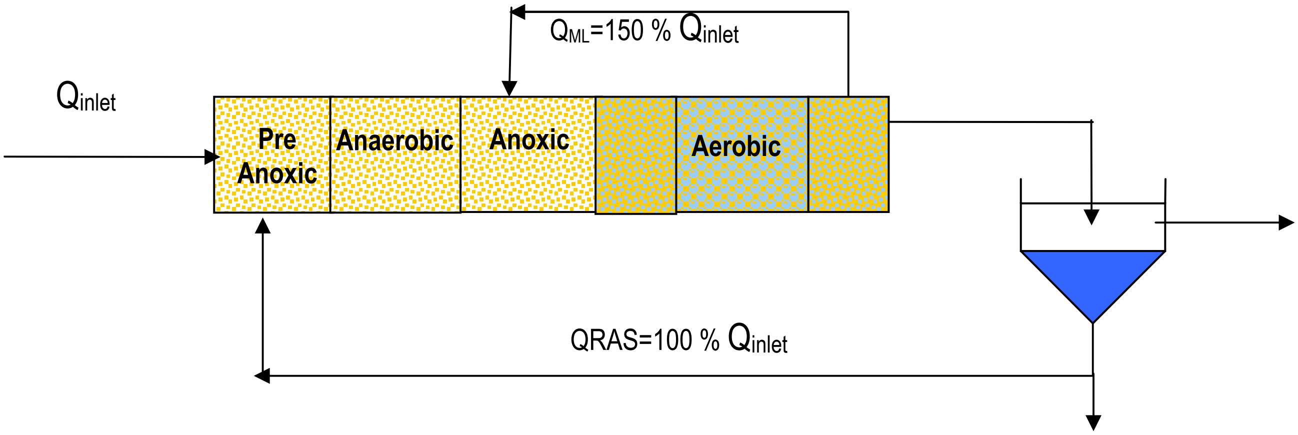
	Units	Existing	Existing	New
Servicing		**For Existing clarifiers 1 &2**	**For Existing settler 3**	**For New settler 4**
Duty Pumps	u	1	1	1
Stand-by Pumps	u	1	1	1
Design Flowrate	m3/h	10	10	10
Head	bar	2	2	2

Table 28: Required set of pumps for primary sludge extraction – options 2 & 3

III.4.3 BIOLOGICAL REACTORS

The design of the biological treatment has been carried out using the software SIMULO®

Design is based on an IFAS (Integrated Fixed Activated Sludge), for biological carbon, nitrogen and phosphorus removal. Media is added only in part of the aerobic zones. In addition FeCl3 is added to the biological reactors for further chemical phosphorus removal ensuring constant effluent quality to achieve the license requirement of 1 mg/L TP.



a. SIZING OF THE REACTORS

Parameters	Units	Design
Sludge age at 9°C	days	8.5
Total volume	**m³**	**42 000**
Total pre anoxic	m³	4 000
Total anaerobic zone	m³	8 000
Total anoxic zone	m³	11 500
Total Aerobic zone	m³	18 500
C stage	m³	4 000
IFAS reactor	m³	10 500
DeOx zone	m³	4 000
MLSS concentration	g SS/l	4
Volatile Suspended Solids (VSS)	% of SS	80
F/M ratio (applied)	kg BOD_5/ kg SS/d	0.1
Volume loading rate (applied)	kg $BOD_5/m^3/d$	0.4
Sludge Recirculation rate from clarifiers to AS tanks (RAS)	%	100
Mixed liquor recirculation rate (MLR)	%	150

Table 29: Sizing of the biological reactors – option 2

b. CHEMICAL REQUIREMENT

$FeCl_3$ is added for chemical phosphorus removal, to assist the biological P removal.

Parameters	Units	Design	Max	Annual average
Chemical injection	mg/l	7		7

Table 30: Chemical requirement in biological reactor – option 2

c. EXISTING AND NEW WORKS

The existing HPO reactors will be retrofitted into pre anoxic and anaerobic zones. Two additional tanks must be constructed to complete the required volume of 12 000 m^3.

Parameters	Units	Existing 1 &2	Existing 3 & 4	New 5&6
Number		2	2	2
Width	m	9.1	10.6	16
Length	m	37.5	37.5	37.5
Liquid depth	m	4.5	4.5	4.5
Total available surface	m^2	1480		1 200
Total available volume	m^3	6600		5 400
Total available volume	m^3	12 000		

Table 31: Arrangements for biological reactors – option 2

Four bio reactors will be constructed to ensure carbon and nitrogen removal.

Parameters	Units	**New**
Number		4
Width	m	16
Length	m	72
Liquid depth	m	6.5
Total available surface	m^2	4 615
Total available volume	m^3	30 000

Table 32: Oxidation ditches characteristics – option 2

Each bio reactor is divided into 5 zones: anoxic zone, aerobic zone for C removal, Aerobic zone with media for Nitrification divided into two zones and De-oxygenation zone.

d. IFAS MEDIA

Parameters	Units	
Media type		K3
Media effective area	m^2/m^3	500
NNH_4 to be nitrified on the media	Kg/d	1 500
NNH_4 load on the media	$g/m^2/d$	0.6
Media filling in Aerobic zone 1	%	48 (expandable up to 67%)
Media filling in aerobic zone 2	%	48 (expandable up to 67%)
Total media volume	m^3	5 000

Table 33: Media characteristics – option 2

e. OXYGEN REQUIREMENT & PRODUCTION

The selected aeration system in both the C stage and in the IFAS stages is coarse bubble diffusers with turbo air blower system.

Parameters	Units	Design case	Spring maxi T (Air blower design)	Annual Average (OPEX estimation)
Temperature	°C	9	17	15
Total Actual Oxygen requirement (AOR)	kg O_2/d	13 900	20 000	16 550
Peak hourly AOR	kg O_2/h	683	967	905
AOR in C tank	kg O_2/d	3 000	5 300	4 600
AOR in Nitrification tanks	kg O_2/d	8 900	12 200	10 150
AOR in De Ox tank	kg O_2/d	2 000	2 500	1 800
Diffusers type		Coarse bubbles		
Diffusers submerged depth	m	6.2	6.2	6.2
Transfer rate in clean water in nit tanks	%	21.7		
Factor K		0.6	0.58	0.58
Daily air requirement	Nm^3/d	355 860	530 000	438 317
Peak hourly air requirement	Nm^3/h	17 500	25 600	24 000
Required air blower total capacity (@ 750 mbar discharge pressure)	Nm^3/h	26 000		

Table 34: Oxygen requirement – option 2

Turbo type air blowers will be installed to ensure air production

	Units	
Duty blowers	u	2
Stand-by blowers	u	1
Design Flowrate	Nm^3/h	13 000
Head	mbar	850

Table 35: Oxygen production – option 2

f. MIXED LIQUOR CIRCULATION

The mixed liquor recirculation rate is around 150% of the inlet flow. One duty and one stand-by submersible pump will be installed in each bioreactor to ensure mixed liquor circulation from the aerobic zone outlet to the anoxic zone inlet.

	Units	**News**
Duty pumps	u	4
Stand-by pumps	m	4
Design Flowrate per pump	m^3/h	1875
Head	bar	0.2

Table 36: Mixed liquor circulation design – option 2

III.4.4 CLARIFICATION

a. SIZING OF THE CLARIFIERS

III.4.5 SIZING OF THE CLARIFIERS

The design is based on classical gravity clarifiers with double scraper and suction:

Parameters	Units	Values
Total surface of clarification	**m^2**	**6 680**
Sludge recirculation RAS	m^3/h	5 000
SVI	ml/g	140
Surface overflow rate at average flow	m/h	0.55
Surface overflow rate at max flow	m/h	0.75
Useful water depth in the clarifiers	m	4.0
Excess Sludge concentration	g SS/l	8
Surface solids loading rate at max flow (recirculation ratio = 100%)	Kg SS/(m^2.h)	6.0

Table 37: Clarification characteristics – option 2

b. EXISTING AND NEW WORKS

The design allows the reuse of the existing secondary clarifiers plus construction of additional units.

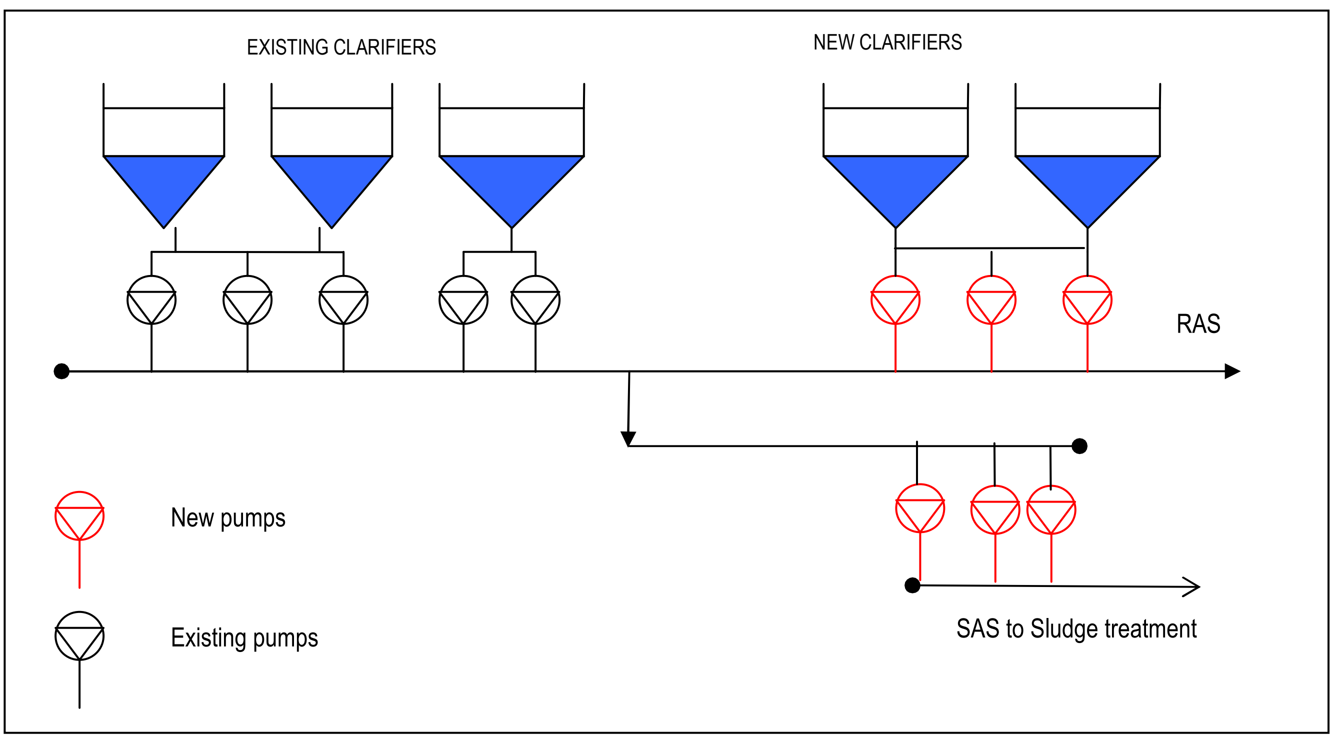
Parameters	Units	Existing 1&2	Existing 3	New 4&5
Number of clarifiers		2	1	2
Diameter	m	33.5	45.7	45.7
Area of the settling zone/unit	m2	880	1640	1640
Total area of the settling zone	m²	3400		3280
Total area of the settling zone	m²	6680		

Table 38: Clarification arrangements – option 2

c. RAS

The recirculation design flow is 100% of the inlet flow.

Additional RAS pumps will be installed to service the new clarifiers.



RAS Pumps characteristics are as follows:

	Units	Existing	Existing	New
Servicing		Existing 1 &2	Existing 3	New 4&5
Duty Pumps	u	2	1	2
Stand-by Pumps	u	1	1	1
Design Flowrate	m3/h	550	1 050	1 425
Head	bar	1.5	1.5	1.5

Table 39: RAS pumps characteristics – option 2

d. EXCESS BIOLOGICAL SLUDGE PRODUCTION (FROM THE CLARIFIERS TO THE SLUDGE THICKENING)

Parameters	Units	Design	Average
Excess biological sludge production	**kg SS/d**	**14 100**	**10 600**
Excess biological sludge concentration	g SS/l	7 - 8	5 - 6
Volatile Suspended Solids (VSS)	% of SS	80%	78%
Total excess biological sludge flow	m^3/d	2 000	2 120

Table 40: Excess biological sludge production – option 2

Extraction of waste activated sludge is based on 18hr of operation per day. A complete new set of WAS pumps is installed.

	Units	Values
Total Required capacity	m^3/h	120
Duty Pumps	u	2
Stand-by Pumps	u	1
Design Flowrate	m^3/h	60
Head	bar	2

Table 41: Excess activated sludge pumping system – option 2

e. CLARIFIED EFFLUENT CHARACTERISTICS

Parameters	Units	Design	Units	Design
Expected Removal Efficiency on biological step				
COD	%	76		
BOD_5	%	86		
TSS	%	76		
Total N	%	61		
Total P	%	80		
Expected Settled Water Quality				
COD	mg/l	70	kg/d	8 400
BOD_5	mg/l	20	kg/d	2 400
SS	mg/l	25	kg/d	3 000
Total N	mg/l	12	kg/d	1 440
Total P	mg/l	1.0	kg/d	120

Table 42: Clarified effluent characteristics – option 2

III.4.6 UV DISINFECTION FOR BNR LINE

Effluent from the biological treatment stage (up to 120 MLD) will be UV disinfected. Wet weather stream coming from ballasted flocculation clarifiers will be chemically disinfected.
The two effluents will be mixed after disinfection to meet the required standards on fecal coliforms and Escherichia Coli and rejected to the river.

UV disinfection is designed on the spring maxi week for flows and loads (see Table 1).
To design the UV treatment, following hypothesis have been taken:

E.coli concentration in the raw water: 10^7 MPN/100 ml
E.coli concentration decrease on the biological treatment: 2 log

Required standards:
E.coli reject limit on 30 day rolling average after UV disinfection: 200 MPN/100 ml

The table below gives an example of the UV disinfection system and the BNR-Ballasted Primary Settler mixing during a max month:

	BNR OUTLET		BALLASTED PRIMARY SETTLER OUTLET		MIXING OF THE BNR AND BALLASTED PRIMARY SETTLER
Composition of the flow during the month	BNR outlet Flow (m3/d)	Reject limit on the E.Coli after UV (MPN/100 ml)	Ballasted Primary Settler outlet Flow (m3/d)	Reject limit on the E.Coli after Cl2 (MPN/100 ml)	Reject limit on the E.Coli in the river (MPN/100 ml) as geometric average
3 days of max summer day flow	120000	$1.10{\wedge}^{+2}$	180000	$5,00.10{\wedge}^{+3}$	$2*10{\wedge}^{+2}$
4 days of max summer week flow	120000	$1.10{\wedge}^{+2}$	125000	$2,50.10{\wedge}^{+3}$	
Flow on 23 days to get monthly average around 120 000 m3/d all over the month	97000	$1.10{\wedge}^{+2}$	0		

Table 43: UV disinfection system and BNR Ballasted Primary Settler mixing example – all options

Some lamps exist on site (Trojan UV4000 system) and the necessary lamps to complete the disinfection for all the flow will be added.

Here below, some parameters considered in the calculations:

Parameters	**Units**	**Design**	**Average**
Transmittivity	%	40	45
Dose of necessary energy to disinfect	J/m^2	478	378

Table 44: Design assumptions for UV disinfection – all options

III.4.7 DAILY AMMONIA LIMIT

As indicated previously, the license requires a daily never to exceed ammonia limit at the outlet of the plant. The limit varies each month of the year in order to consider the seasonality of the environmental conditions of the watershed.

Ammonia is only treated in the BNR line. There is no removal expected in the CSO line. Therefore, the most critical conditions to meet the license will be during the months when the combination of rain events and low ammonia limits occur.

The rain data available at the present time come from Stantec's CDR and are presented in table below.

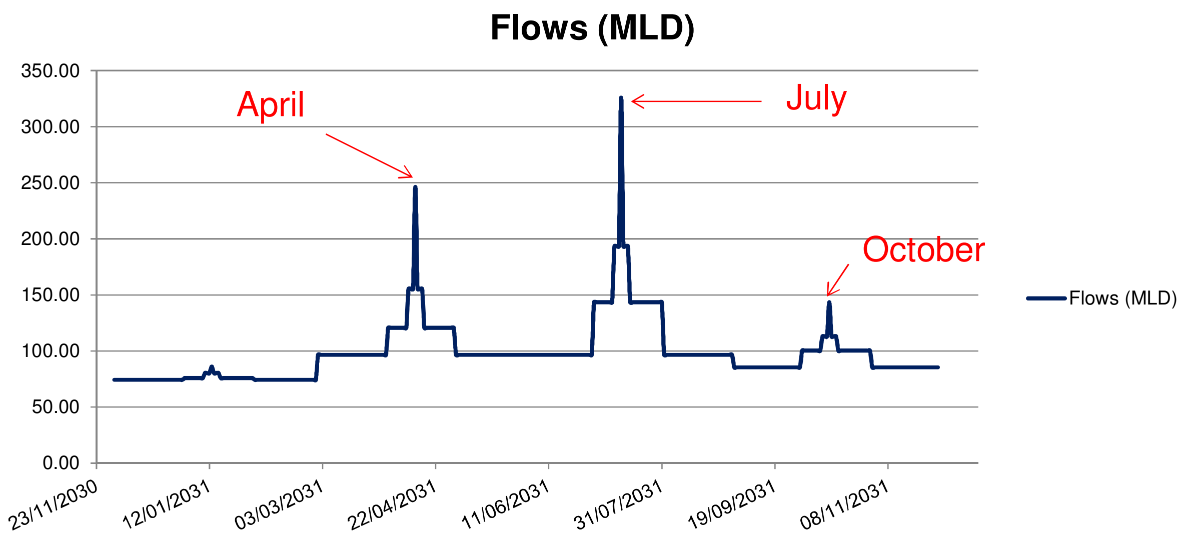


Chart 1: Annual flows assumptions

Looking at this chart and at the license table (Table 15: Program's assumptions of license requirements), the most stringent month is July, with 1,517 kg N/d.
During this month, assuming an inlet temperature of 19ºC, the BNR line will accept up to 182.25 MLD and will still meet all the requirements at the outlet.

III.5 PROCESS CALCULATIONS – EXCESS FLOWS TREATMENT

III.5.1 DESIGN CAPACITY

Flows in excess of 120 MLD and up to 300 MLD are treated on a separate ballasted primary settler downstream of headworks. The excess flow treatment line is designed for the following flows. Note that when the excess flow line is in service the hourly peak flow is taken by this line

Parameters	Units	Values	Comments
Max daily flow (spring max week)	MLD	125	(=245-120)
Max daily flow (spring max day)	MLD	180	(=300-120)
Max daily flow (summer max week)	MLD	123	(=243-120)
Max daily flow (summer max day)	MLD	180	(=300-120)
Peak flow	m^3/h	7 500	(=180/24)

Table 45: Design flows for wet weather stream – all options

The design is based on the spring max week loads given in Table 9: Seasonal Flow and Mass Load Peaking Factors.

It has been assumed that this line will be put in service 30 days per year including 15 days of spring max week and 15 days in summer max week (including 6 maxi days: 3 of spring and 3 of summer).

III.5.2 BALLASTED PRIMARY CLARIFICATION

a. INLET WATER QUALITY: SPRING MAX WEEK

Parameters	Units		Units	
Inlet Water Quality				
COD	mg/l	282	kg/d	35 250
BOD_5	mg/l	128	kg/d	16 000
SS	mg/l	147	kg/d	18 375
TKN	mg/l	22	kg/d	2 750
Total P	mg/l	4	kg/d	500

Table 46: Inlet water quality in wet weather stream – all options

b. SIZING OF THE BALLASTED CLARIFIERS

Parameters	Units	
Type	-	BALLASTED PRIMARY SETTLER
Chemical injection ($FeCl_3$)	mg/l	75-100
Number of clarifiers	u	2
Unit area of the settling zones	m²	45
Total area of the settling zones	m²	90
Spring Max week velocity	m/h	58
Spring max day velocity	m/h	83
Peak hourly velocity	m/h	83
Settling tank diameter	m	6.9

Table 47: Sizing of ballasted clarifiers – all options

For this application, two smaller Ballasted Primary Settler units are used. The design has been based on a two unit configuration, each rated for 50% of the flow (90 MLD) at the nominal clarifier capacity, but each being able to handle up to 100% of the flow (i.e. 180 MLD) if one unit is off-line. This twin unit configuration can thus better handle the small rain events while offering full redundancy.

c. EXPECTED EFFICIENCY OF THE BALLASTED PRIMARY SETTLER BALLASTED CLARIFICATION

Spring max week:

Parameters	Units			
Expected Removal Efficiency				
COD	%	63		
BOD_5	%	60		
SS	%	85		
TKN	%	21		
Total P	%	76		
Expected Settled Water Quality				
COD	mg/l	105	kg/d	13 125
BOD_5	mg/l	51	kg/d	6 375
SS	mg/l	22	kg/d	2 750
TKN	mg/l	17	kg/d	2 125
Total P	mg/l	1	kg/d	125

Table 48: Expected performances of ballasted settling – all options

d. BALLASTED PRIMARY SETTLER SLUDGE PRODUCTION AND EXTRACTION FROM SETTLING TANKS

Parameters	Load	Concentration	Occurrences
	Kg/day	g/l	Days/year
CSO Sludge production- spring max week	23 150	10	12
CSO Sludge production- spring max day	62 500	10	3

Table 49: Ballasted Primary Settler sludge production from settling tanks – all options

e. CHEMICAL CONSUMPTION

$FeCl_3$ and polymer are injected in the ballasted clarification process.

Parameters	Dosing $FeCl_3$	Dosing Polymer	Occurrences
	mg/l	mg/l	Days/year
Chemical injection- spring max week	75	1	12
Chemical injection- summer max week	75	1	12
Chemical injection- spring and summer max days	100	1	6

Table 50: Chemical consumption on wet weather stream – all options

III.5.3 CL2 DISINFECTION FOR WET WEATHER

The wet weather flow after the Ballasted Primary Settler treatment will be disinfected using chemical addition (as a first approach). This will only be during a maximum of one month per year when the flow is higher than 120 000 m3/d.

E.coli concentration in the raw water: 10^7
E.coli removal over Ballasted Primary Settler treatment: 1.5 log
E. coli concentration at chemical disinfection inlet $5*10^5$

The disinfection unit was designed for the following treated wastewater characteristics:

Parameters	Units	Values
Max daily Flow	m^3/d	180 000
Max week flow	m^3/d	125 000
TSS	mg/l	25
E.Coli inlet disinfection	MPN/100ml	$\leq 5*10^5$
E. Coli treated water	MPN/100ml	$\leq 10^3$

Table 51: Treated wastewater characteristics – all options

Parameters	Units	Values
Volume of Chlorine contact tank	m^3	6 000 (existing HPO reactors for option 4)
Chlorine dose	mg/l pure Cl_2	20
Average contact time during max week	min	75
Average contact time during max day	min	48

Table 52: Cl_2 disinfection system design – all options

Dechlorination with SO_2 system will be installed after disinfection if necessary. Other disinfection alternatives could be studied if chlorination is not an acceptable option. However, since this disinfection step would be the same for all three options proposed (options 2, 3 and 4), chlorine disinfection was selected for this preliminary evaluation of options, without being a differentiating process step between the three options.

III.6 PROCESS CALCULATIONS – SLUDGE HANDLING

The main sludge characteristics for the design conditions are presented in the following table:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	14 550	78	Extracted at 40 g/l	365
BNR sludge production	14 100	80	After onsite thickening at 25 g/l	564
CSO Sludge production- spring max week	23 150	58	After onsite thickening at 25 g/l	926
CSO Sludge production – spring max day	62 500	65	After onsite thickening at 25 g/l	2 500

Table 53: Sludge production for design conditions – option 2

The yearly average sludge production is presented in the table below:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	7 000	73	Extracted at 40 g/l	175
BNR sludge production	10 600	78	After onsite thickening at 25 g/l	424
Wet weather Ballasted Primary Settler sludge	2 500	63	After onsite thickening at 25 g/l	100
Total, yearly average	20 100	74	30 g/l	700

Table 54: Yearly average sludge production– option 2

III.7 PROCESS REDUNDANCY APPROACH

The maintenance philosophy for the option is explained below. A more detailed assessment of maintenance requirements will be completed during the detailed engineering phase.

Process design for option selection allows for removal of process units for maintenance without affecting processes unstream or downstream of that process unit. The design allows for one process unit in each stage to be removed from service at any time without compromising effluent compliance.

Primary clarifiers
If one primary settler is out of service, the velocity will increase on the remaining three clarifiers.

To achieve the same results on the settled water and not to have any influence on the following IFAS biological reactor, chemical can be added in the remaining primary units (on line) during the period of maintenance. Alternatively, one of the Ballasted Primary Clarifiers can be used for part of the flow. There are two Ballasted Primary Clarifiers available that will only be required during one month of the year and, as a consequence of their quick start up, they are available for different applications.

IFAS biological reactors
If one line of biological reactors is out of service during winter, the concentration will increase in the other biological reactors, in this situation the concentration will remain below 4 g/l which is within their design envelope. In this configuration the design allows aeration capacity for full treated flow to be installed in three tanks (more coarse bubble diffusers will be installed in each tank than is required when all tanks are in service). In addition, if one process stream is off-line for an extended period of time all the media from that stream has to be transferred to the streams that remain in operation.

The amount of media loaded into each IFAS tank will be designed to be below 50% of the available volume for normal conditions allowing space for the transfer of media from other tanks. With one unit out of service the other units will still be less than 67% of full.

If one line of biological reactors is out of service during spring (design conditions), chemicals can be dosed on line in the primary clarifiers to reduce the TSS load in the biological reactors maintaining an acceptable concentration on the clarifiers.

Clarifiers
Design is such that if one clarifier is out of service, the velocity is still acceptable on the remaining 5 clarifiers (0.9 m/h instead of 0.75 m/h). Polymer can be added to increase the settling-ability of the sludge and to obtain good results on TSS outlet (without decreasing UV effectiveness).

Ballasted Primary Settler
The design will allow for one wet weather Ballasted Primary Settler to out of service, with the other one dealing with the full flow at the higher velocity. In this configuration there will be a slight increase in chemical dosage and a slight deterioration of the effluent quality.

IV. DESIGN REPORT FOR OPTION 3

-ooOoo-

IV.1 DESIGN DATA

The plant is design horizon is to the year 2031 and a population of 250,000 inhabitants.

IV.1.1 DESIGN INFLUENT FLOWS

Please refer to paragraph III.1.1 - PartIII.

IV.1.2 DESIGN INFLUENT LOADS AND TEMPERATURE

Please refer to Table 18: Seasonal flows – all options.

IV.1.3 INLET WATER CHARACTERIZATION HYPOTHESIS

Please refer to Table 19: Influent characterization – all options.

IV.1.4 PERFORMANCE GUARANTEES

Please refer to Table 20: Effluent guarantees – all options.

IV.1.5 SIMULATIONS

The design case is based on the max month load (spring max month), with a minimum temperature of 9°C (minimum daily temperature). The most stringent case for air blower sizing is the spring max month loads with a water temperature of 17 °C, rather than the summer max month at 19°C. The average annual flow, loads and temperature (15°C) are used for operation estimates.

IV.1.6 SLUDGE HANDLING

Primary sludge is thickened in the primary clarifiers and stored in tanks before being sent to the NEWPCC. Secondary sludge is thickened prior to be stored and sent to the NEWPCC.

The design is based on the liquid stream return from sludge process at NEWPCC being totally handled at NEWPCC.

IV.2 TREATMENT LINE OVERVIEW

The design includes a BNR treatment line with a design capacity of 120 MLD. Effluent from the bioreactors is UV disinfected before final discharge.

Flows between excess 120 MLD and 300 MLD are treated on a separate ballasted primary clarification system downstream of the headworks. This overflow is chemically disinfected using chlorine. Flows larger than 300 MLD are bypassed downstream of headworks and no guarantees is provided on this flow.

IV.2.1 DESCRIPTION OF WASTEWATER TREATMENT

The main steps for treatment at SEWPCC are listed here below:

- Headworks
  - Raw water pumps
  - Fine screens (6 mm punched-holes)
  - Grit removal
- BNR line (120 MLD)
  - 4 Primary clarifiers (3 existing + 1 new)
  - 4 Intermediate load Activated Sludge (AS) with anaerobic and anoxic tanks including refurbishment of existing HPO reactors
  - 5 Secondary clarifiers (3 existing + 2 new)
  - 6 Biofilters N
  - 2 Biofilter Post DN
  - UV treatment
- Excess Flows line
  - Ballasted Primary clarification (2 units)
  - Chemical disinfection

IV.2.2 DESCRIPTION OF SLUDGE TREATMENT

- Thickening for secondary sludge
- Storage tanks
- Truck loading facilities

IV.2.3 DESCRIPTION OF ODOUR TREATMENT

The new works will be connected to the existing odour control system, which consists of a dispersion stack without treatment.

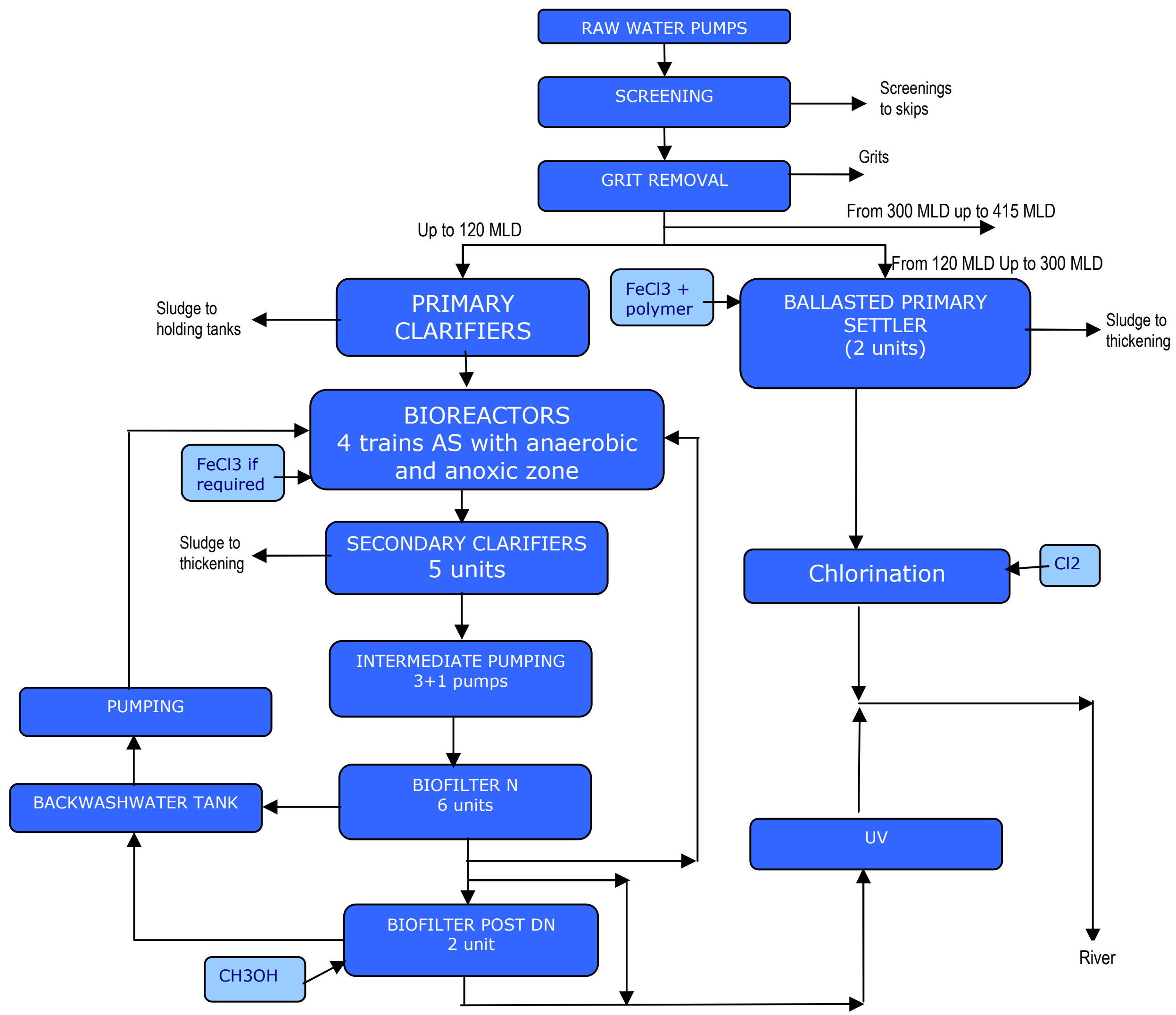


Figure 4: Option 3 PFD

IV.3 PROCESS CALCULATIONS - HEADWORKS

Headworks upgrade / expansion will be the same for all options.

IV.4 PROCESS CALCULATIONS – BNR TREATMENT

IV.4.1 DESIGN CAPACITY

Please refer to Table 22: BNR treatment line design capacity – options 2 & 3.

IV.4.2 PRIMARY SETTLING

a. INLET WATER QUALITY

Please refer to Table 23: Inlet water quality – primary settling – options 2 & 3.

b. SIZING OF THE PRIMARY CLARIFIERS

Please refer to Table 24: Design of primary clarifiers – options 2 & 3.

c. EXISTING AND NEW WORKS

Please refer to Table 25: Arrangements for primary settling – options 2 & 3.

d. EXPECTED EFFICIENCY OF THE PRIMARY SETTLING

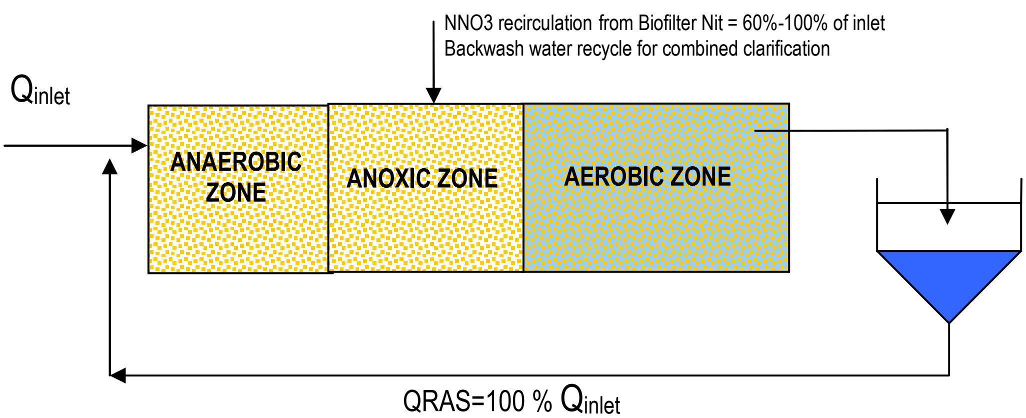
Please refer to Table 26: Expected performances for primary settling – options 2 & 3.

e. PRIMARY SLUDGE PRODUCTION AND EXTRACTION FROM SETTLING TANKS

Please refer to Table 27: Primary sludge production – options 2 & 3 and Table 28: Required set of pumps for primary sludge extraction – options 2 & 3.

IV.4.3 BIOLOGICAL REACTORS

The design of the biological treatment has been carried out using the software SIMULO®.
Design is based on an intermediate load biological reactor for bioP removal. This system includes an anaerobic zone for biological phosphorus release, followed by an anoxic zone where nitrates are consumed along with phosphorus uptake, and is completed by a final aerated zone where phosphorus uptake is completed before secondary clarification. This activated sludge process is followed by a nitrifying BAF system, and part of the effluent is then denitrified through dosage of an external carbon source.



a. SIZING OF THE REACTORS

Flows and loads of recirculated nitrifying Biofilter effluent (nitrate recycle) as well as Biofilter N and PDN backwash water:

Parameters	Units	Design
Nitrifying Biofilter Effluent	m^3/d	60,000
Sludge from Nitrifying Biofilter	m^3/d	7,700
Sludge from Post denitrification Biofilter	m^3/d	1,100
Total flow	m^3/d	69,000
COD	mg/l	134
BOD5	mg/l	60
TSS	mg/l	70
TKN	mg/l	8
N-NH4	mg/l	1
N-NO3	mg/l	11
TP	mg/l	3

Table 55: Flows and loads of recirculated nitrifying Biofilter effluent – option 3

Parameters	Units	
AS Sludge age at 9°C	days	4
Total volume	m^3	28 000
Pre anoxic zone (as first section of the anaerobic zone)	m^3	1 000
Total anaerobic zone (excluding pre-anoxic zone volume)	m^3	8 000
Anoxic zone	m^3	11 000

Parameters	Units	
Total Aerobic zone	m^3	8 000
Liquid depth	m	4.5
Total surface	m^2	6 230
MLSS concentration	g SS/l	3.2
Volatile Suspended Solids (VSS)	% of SS	85
F/M ratio (applied)	kg BOD_5/ kg SS/d	0,23
Volume loading rate (applied)	kg $BOD_5/m^3/d$	0,73
Sludge Recirculation from clarifiers to AS tanks (RAS)	m^3/h	5 000 (100% recycle rate)
SVI	ml/g	150

Table 56: Sizing of the biological reactors – option 3

b. CHEMICAL REQUIREMENT

FeCl3 is added for chemical phosphorus removal, to assist the biological P removal.

Parameters	Units	Design	Max	Annual average
Chemical injection	mg/l	3	0	5

Table 57: Chemical requirement in biological reactor – option 3

Simulations indicate that FeCl3 is not required for this option, but in order to deal with the daily variations in COD/P ratio, a small coagulant dosage is planned.

c. EXISTING AND NEW WORKS

The existing HPO reactors will be retrofitted into part of the pre anoxic / anaerobic zones, while some additional tanks must be provide to complete to total required volume of 9000 m3. Additional tanks must also be constructed for the anoxic and aerobic tanks. These tanks will be completely mixed with mixers.

Parameters	**Units**	**Existing 1 &2**	**Existing 3 & 4**	**New 5&6**
Number	u	2	2	2
Tank width	m	9.1	10.6	7
Tank length	m	37.5	37.5	37.5
Liquid depth	m	4.5	4.5	4.5
Total available surface	m^2	1 480		522
Total available volume	m^3	6 650		2 360
Total available volume	m^3	9 000		

Table 58: Arrangements for biological reactors – option 3

Four anoxic-aerobic bioreactors will be constructed to ensure carbon removal and denitrification of the recirculated NNO3 from the nitrifying Biofilter.

Parameters	Units	**New**
Number	u	4
Width	m	16.3
Length	m	45
Liquid depth	m	6.5
Total available surface	m^2	2 923
Total available volume	m^3	19 000

Table 59: Aerated bioreactor characteristics – option 3

Each bio reactor is divided in 2 zones: anoxic and aerobic.

d. OXYGEN REQUIREMENT & PRODUCTION

The selected aeration system is coarse bubbles diffusers Turbo type air blower installed to ensure air production.

Parameters	Units	Design case	Max T (Air blower design)	Annual Average (OPEX estimation)
Temperature	°C	9	17	15
Total Actual Oxygen requirement (AOR)	kg O_2/d	3 850	6 331	5 000
Peak hourly AOR	kg O_2/h	176	295	247
Coarse bubble diffusers submerged depth	m	6.2	6.2	6.2
Factor K		0.68	0.67	0.67
Transfer rate in clean water	%	18.6	18.6	18.6
Daily air requirement	Nm^3/d	101 500	169 400	133 750
Peak hourly air requirement	Nm^3/h	4 650	7 890	6 600
Required air blower total capacity (@ 750 mbar discharge pressure)	Nm^3/h	8 000		

Table 60: Oxygen requirement – option 3

Parameters	**Units**	
Duty Blower	u	2
Stand-by Blower	u	1
Design Flowrate	m^3/h	4 000
Head	bar	850

Table 61: Oxygen production – option 3

IV.4.4 CLARIFICATION

a. SIZING OF THE CLARIFIERS

Design is based on a classical clarifier with double scraper and suction:

Parameters	Units	
Total surface of clarification	**m²8 320**	**6 680**
Sludge recirculation RAS	m^3/h	5 000
SVI	ml/g	150
Surface overflow rate at max flow	m/h	1.18
Useful water depth in the clarifiers	m	4.0
Excess Sludge concentration	g SS/l	6 - 7
Surface solids loading rate at max flow (recirculation ratio = 100%)	Kg SS/(m^2.h)	7.5

Table 62: Design of clarifiers – option 3

b. EXISTING AND NEW WORKS

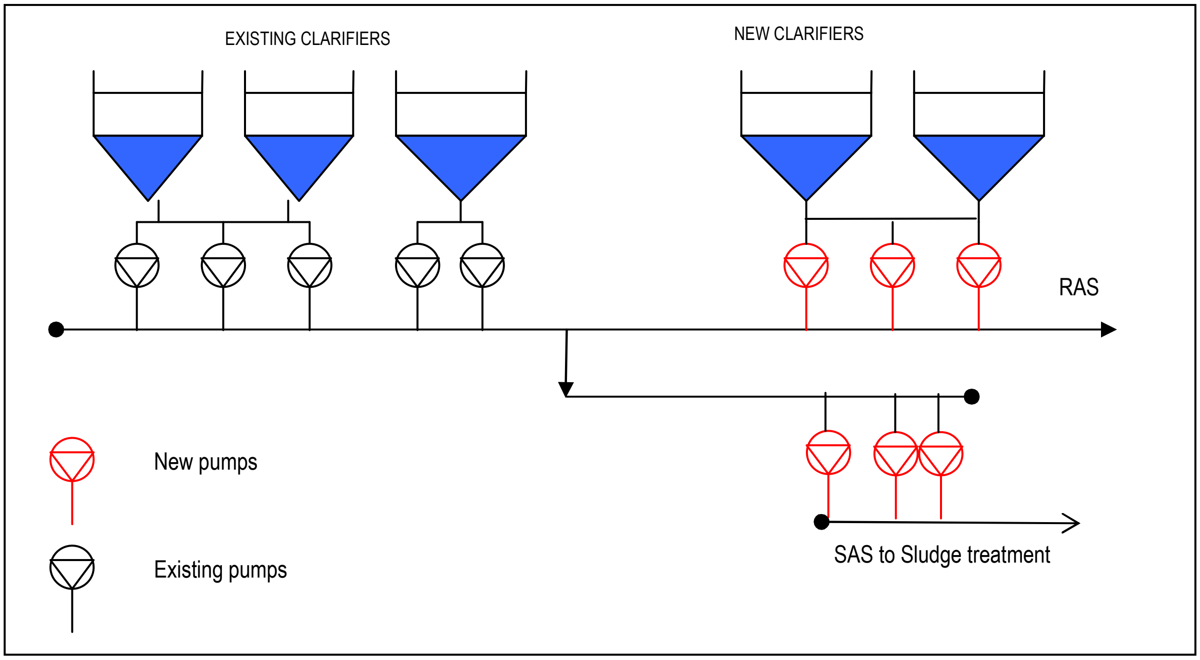
The design allows the reuse of the existing secondary clarifiers plus construction of two additional ones.

Parameters	Units	Existing 1&2	Existing 3	New 4&5
Number of clarifiers		2	1	2
Diameter	m	33.5	45.7	45.7
Area of the settling zone/unit	m^2	880	1 640	1 640
Total area of the settling zone	m^2	3 400		3 280
Total area of the settling zone	m^2	6 680		

Table 63: Clarification arrangements – option 3

c. RAS

Additional RAS pumps will be installed to service the new clarifiers.



The RAS Pump characteristics are as follows:

	Units	Existing	Existing	New
Servicing		Existing 1 & 2	Existing 3	New 4 & 5
Duty Pumps	u	2	1	2
Stand-by Pumps	m	1	1	1
Design Flowrate per pump	m^3/h	550	1 050	1 425
Head	bar	1,50	1,50	1,50

Table 64: RAS pumps characteristics – option 3

d. EXCESS BIOLOGICAL SLUDGE PRODUCTION (FROM THE CLARIFIERS TO THE SLUDGE THICKENING)

Parameters	Units	Design	Average
Excess biological sludge production	**kg SS/d**	**16 000**	**12 000**
Excess biological sludge concentration	g SS/l	6 - 7	4.5
Volatile Suspended Solids (VSS)	% of SS	85	84
Total excess biological sludge flow	m^3/d	2 700	2 700

Table 65: Excess biological sludge production – option 3

Extraction of waste activated sludge is based on 18 hrs of operation per day. A complete new set of WAS pumps will be installed.

	Units	Values
Total Required capacity	m^3/h	150
Duty Pumps	u	2
Stand-by Pumps	u	1
Design Flowrate	m^3/h	75
Head	bar	2.0

Table 66: Excess activated sludge pumping system – option 3

e. CLARIFIED EFFLUENT CHARACTERISTICS

Expected Clarified Water Quality

COD	mg/l	86	kg/d	16 254
BOD_5	mg/l	30	kg/d	5 670
TSS	mg/l	30	kg/d	5 670
Total N	mg/l	16.5	kg/d	3 118
Total P	mg/l	2.0	kg/d	378

Table 67: Clarified effluent characteristics – option 3

IV.4.5 INTERMEDIATE PUMPING

New pumps are required to lift the secondary effluent to the Nitrification/Denitrification Biofiltration process stage.

	Units	
Flow to be lifted (including Biofilter N effluent recycle and Backwash water recycle)	m^3/d	194 000
Duty pumps	u	3
Stand-by pumps	m	1
Design Flowrate per pump	m^3/h	2 694
Head	bar	0.5 (TBD)

Table 68: Intermediate pumping system – option 3

IV.4.6 BIOFILTERS FOR NITRIFICATION AND POST DENITRIFICATION

The Nitrification stage is carried out by Nitrifyng Biofilters. The denitrification stage is accomplished by Post denitrification Biofilters. The influent first flows through Biofilter-N which ensures the biological removal of NNH_4 and then through a Biofilter- PDN which ensures the removal of $N\text{-}NO_3$. Only part of the flow is sent to the Biofilter- PDN to optimise (minimize) CH_3OH consumption and to minimize NNO_2 emission, as illustrated on the figure below.

In the Biofilter process, the water passes through a low density media from the bottom to the top of the filter. Biomass develops on the media and allows for carbon and ammonia oxidation as well as nitrate reduction to gaseous nitrogen. Process air is distributed though coarse bubble aeration by perforated pipes located at the bottom of the filter. The air goes through the media and allows oxidation of the pollution (for the N filters). Nozzles are located on top of the filter and used to maintain the filtration media inside the filtration cell. Treated water is stored on top of the filter nozzle deck and is used for gravity backwash of the filters (no pumps needed for backwashing).

Washing phases include alternating air scouring and water backwashes, and are typically performed at a maximum frequency of 24 hours, and up to 72 hours. For the PDN Biofilter, backwash frequency is allowed to be higher (up to 12 hours).

Backwash water from the BAF are stored into backwash tanks, before being pumped and thickened in two existing secondary clarifiers and then pumped back to the BAF inlet.

a. BIOFILTER-N

❖ SIZING OF THE BIOFILTER-N

The velocity is calculated on N-1 filters in operation (one cell in backwash).

Parameters	Units	Values
Number	u	6
Filter Area	m^2	147
Filter Length	m	14
Filter width	m	10.5
Media characteristics (Ø)	mm	4
Media depth	m	3.5
Media volume per filter	m^3	515
Media Total volume	m^3	3 087
Applied loads: - N to nitrify	$kg/m^3.j$	0,71
Average filtration velocity on N cells	m/h	9.3
Peak velocity on N-1 filters during operation	m/h	11.2
Wash water for one filter	m^3	1 286
Daily dirty wash waters	m^3/d	7 717

Table 69: Biofilters-N characteristics – option 3

❖ EXPECTED OUTLET WATER QUALITY

Outlet water characteristics from Biofilter-NIT to Biofilter-PDN are

		DESIGN	YEARLY AVG
COD	mg/l	60	66
BOD_5	mg/l	16	16
TSS	mg/l	16	16

NH_4	mg/l	1.1	1.3
$N\text{-}NO_3$	mg/l	11.4	10
TN	mg/l	15	14
P_T	mg/l	1.6	1.3

Table 70: Expected biofilters-N outlet water quality 1/2 – option 3

Recirculation of AS will be a maximum of 60 000 m3/d during spring (50% of spring max month inlet flow) and 88 000 m3/d during yearly average (100% of yearly average inlet flow).

Parameter	Units	Design conditions	Yearly average
Tot $N\text{-}NO_3$ to denitrify recirculated to AS*	Kg/d	772	961
Tot $N\text{-}NO_3$ inlet in AS	mg/l	4.0	5.2
Tot $N\text{-}NO_3$ outlet from AS	mg/l	1.5	2.0
TN outlet from AS	mg/l	16.5	14.6
Denitrification efficiency in AS	%	62.5	61.5

Table 71: Expected biofilters-N outlet water quality 2/2 – option 3

* includes the Nitrifying Biofilter recirculation and the Biofilter N and PDN backwash water recycle.

❖ PROCESS AIR REQUIREMENT

The air production is centralized using HV turbo. Flow distribution is controlled for each filter with a regulating valve.

Parameters	Units	Design case	Max T (spring)	Annual Average OPEX estimation
Temperature	°C	9	17	15
Target oxygen concentration (DO level measured above nozzle deck)	mg/l	6	6	6
Total Actual Oxygen requirement (AOR)	kg O_2/d	11 200	10 000	9 000
Peak hourly AOR	kg O_2/h	650	600	540
Blower discharge pressure requirement	bars	1.0	1.0	1.0
Oxygen transfer rate in clean water	%	29.5	29.5	29.5
Average daily air flow rate	Nm^3/d	127 300	113 000	103 000
Peak hourly air flow rate	Nm^3/d	7 350	6 800	6 100
Required air blower total capacity (@ 1000 mbar discharge pressure)	Nm^3/d	7 500		

Table 72: Biofilters-N process air requirement – option 3

❖ BACKWASH AIR SCOUR REQUIREMENT

Backwash air scour is provided by the same centralized air blower system as used for process air, for both NDN & PDN filters, and is distributed within the filters using the same aeration grid located at the bottom of each filter (an air grid is installed into the PDN filters for this purpose).

Parameters	Units	Value
Air velocity	Nm/h	12
Surface	m^2	147
Air flowrate	Nm^3/h	1 800

Table 73: Biofilters-N&PDN wash air requirement – option 3

❖ WASH WATER REQUIREMENT

Filters are washed at a maximum of once per day, triggered by a timer or on headloss (clogging of the filter). The volume on top of the nozzle deck is the treated water reservoir, used for washing of both Biofilter-N & Biofilter-PDN.

The dirty backwash water from the washing phase is stored in a dedicated backwash storage tank, located at the end of the filter gallery. The backwash storage tank capacity allows for full redundancy, meaning enabling operation of the plant with one backwash tank out of service. As a result, two backwash tanks are included, each allowing storage of one complete backwash cell (plus some safety), meaning 1,20 x volume of a backwash per tank.

Treated water reservoir = 1540 m^3 X 2 tanks = 3080 m^3 total.

Two new tanks will be provided, each have full flexibility to operate as separate tanks, or as combined tanks (then acting as one large tank). Mechanical mixers are provided into each tank to prevent settling of the solids.

This tank will be located in the BAF building.

b. BIOFILTER PDN

❖ SIZING OF THE BIOFILTER-PDN

Parameters	Units	Value
Number	u	2
Filter Area	m^2	84
Filter Length	m	14
Filter width	m	6.1
Media characteristics (Ø)	mm	4.5
Media depth	m	2.5
Media volume per filter	m^3	210
Media Total volume	m^3	420
Applied loads: N-N03	$kg/m^3.d$	0.81
Average filtration velocity	m/h	7.5
Peak velocity on N-1 filters	m/h	15
Wash water for one filter	m^3	525
Daily dirty wash waters	m^3/d	1 050

Table 74: Biofilters-PDN sizing – option 3

❖ EXPECTED OUTLET WATER QUALITY

The combined outlet water characteristics from the Biofilter-PDN plus the PDN bypass (Biofilter N effluent) are:

Parameters	Units	Design conditions	Yearly average
COD	mg/l	55	60
BOD_5	mg/l	15	15
TSS	mg/l	15	15
NH_4	mg/l	1	1
$N\text{-}NO_3$	mg/l	9	9
TN	mg/l	12	13
PT	mg/l	1	1

Table 75: Expected biofilters-PDN outlet water quality – option 3

❖ AIR REQUIREMENT

Air is required only for washing. The blower will be in common with nitrification.

❖ WASH WATER REQUIREMENT

The back wash tank will be in common with the backwash tank for biofilter N.

❖ CHEMICAL REQUIREMENT

Methanol is injected in Post Denitrification Biofilter to complete the denitrification that takes place in the AS stage

Parameters	Units	Design case	Annual Average OPEX estimation
Effluent treated on PDN	%	25	8
Pure CH_3OH dosing	mg/l	38	45
Pure CH_3OH dosing	Kg/d	1 150	300

Table 76: Biofilters-PDN chemical requirement – option 3

c. WASH WATER TREATMENT

Backwash waters are collected in the backwash storage tank and sent back to the Activated sludge reactors along with the nitrate recycle stream.

IV.4.7 UV DISINFECTION FOR BNR LINE

The design is the same for all options. Please refer to paragraph III.4.6 – Part III.

IV.4.8 DAILY AMMONIA LIMIT

In the case of option 3, the daily ammonia limit requirement is met by treating 180 MLD in the BAF cells. Among these 180 MLD, 120 MLD are coming from the primary clarifiers and 60 MLD are diverted from the ballasted primary clarifiers from the CSO stream.

This partial diversion allows a sufficiently low TSS concentration to be achieved at the entrance the BAF units in order not to accelerate the clogging of the filters that would lead to a decrease in the treatment performances.

IV.5 PROCESS CALCULATIONS – EXCESS FLOWS TREATMENT

The CSO stream is the same for all options. Please refer to paragraph III.5 – Part III.

IV.6 PROCESS CALCULATIONS – SLUDGE HANDLING

The main sludge characteristics for the design conditions are presented in the following table:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	14 550	78	Extracted at 40 g/l	365
BNR sludge production	16 000	85	After onsite thickening at 25 g/l	640
CSO Sludge production-spring max week	23 150	58	After onsite thickening at 25 g/l	926
CSO Sludge production – spring max day	62 500	65	After onsite thickening at 25 g/l	2 500

Table 77: Sludge production summary for design conditions – option 3

The yearly average sludge production is presented in the table below:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	7 000	73	Extracted at 40 g/l	175
Secondary sludge production (WAS)	12 000	84	After onsite thickening at 25 g/l	480
Wet weather Ballasted Primary Settler sludge	2 500	63	After onsite thickening at 25 g/l	100
Total, yearly average	21 500	78	30 g/l	755

Table 78: Yearly average sludge production – option 3

IV.7 PROCESS REDUNDANCY APPROACH

The maintenance philosophy for the option is explained below. A more detailed assessment of maintenance requirements will be completed during the detailed engineering phase.

Process design for option selection allows for removal of process units for maintenance without affecting processes unstream or downstream of that process unit. The design allows for one process unit in each stage to be removed from service at any time without compromising effluent compliance.

Primary clarifiers
If one primary settler is out of service, the velocity will increase on the remaining three clarifiers. Chemical can be added in the remaining primary during this period.

Activated Sludge
If one biological reactor is out of service during winter, the activated sludge concentration can be increased. The aeration capacity in each tank will be sized to handle this situation.

If one biological reactor is out of service during spring (design conditions), chemicals can be dosed on line in the primary clarifiers to reduce the TSS load in the biological reactors keeping to an acceptable concentration in the clarifiers. Aeration capacity for full flow will be installed in three reactors (more coarse bubble diffusers).

Ballasted Primary Settler
The design will allow for one wet weather Ballasted Primary Settler to out of service, with the other one dealing with the full flow at the higher velocity. Both Ballasted Primary Clarifiers are required for only one week per year.

BIOFILTERS
If one N cell is out of service, the Biofilters can still accept the higher velocities and loads. Washing will be more frequent and one mini washing can be done every day in addition to the usual situation. For the PDN Biofilter, two cells are provided to allow some redundancy. If one cell is off line, the remaining cell can be operated to its maximum hydraulic capacity and methanol dosage adjusted to allow sufficient DN to reach the effluent TN requirement. Backwash frequency can increase under such condition.

V. DESIGN REPORT FOR OPTION 4

-ooOoo-

V.1 DESIGN DATA

The plant is design horizon is to the year 2031 for a population of 250,000 inhabitants.

V.1.1 DESIGN INFLUENT FLOWS

Please refer to paragraph III.1.1 - PartIII.

V.1.2 DESIGN INFLUENT LOADS AND TEMPERATURE

Please refer to Table 18: Seasonal flows – all options.

V.1.3 INLET WATER CHARACTERIZATION HYPOTHESIS

Please refer to Table 19: Influent characterization – all options.

V.1.4 PERFORMANCE GUARANTEES

Please refer to Table 20: Effluent guarantees – all options.

V.1.5 SIMULATIONS

The design case is based on the max month load (spring max month), with a minimum temperature of 9°C (minimum daily temperature).

The most stringent case for air blower sizing is the spring max month loads but at a water temperature of 17 °C, rather than the summer max month at 19°C.

The average annual flow, loads and temperature (15°C) are used for operation estimations.

V.1.6 SLUDGE HANDLING

Primary sludge is thickened in the primary clarifiers and stored in tanks before being sent to the NEWPCC. Secondary sludge is thickened prior to be stored and sent to the NEWPCC.

The design is based on liquid stream return from sludge processes at NEWPCC being totally handled at NEWPCC.

V.1.7 TREATMENT LINE OVERVIEW

The design includes a Chemically Enhanced Primary clarification (CEPT) step followed by a Biological Aerated Filter (BAF) allowing for a nutrient removal treatment train with a design capacity of 120 MLD. Effluent from the bioreactor is UV disinfected before final discharge.

Flows between 120 MLD and 300 MLD are treated in a separate ballasted primary clarification system downstream of the headworks. This overflow is chemically disinfected using chlorine.

Flows larger than 300 MLD are bypassed downstream of headworks and no guarantees is provided on this flow.

The figure on the next page illustrates the treatment lines.

V.1.8 DESCRIPTION OF WASTEWATER TREATMENT

The main steps of for the SEWPCC treatment process are listed here below:

- Headworks
    - Raw water pumps
    - Fine screens (6 mm punched-holes)
    - Grit removal
- Biofiltration line (120 MLD)
    - 3 existing Primary clarifiers + 1 new (coagulant will be added to all four clarifiers)
    - 1 new set of eight cells, NDN biofilter
    - 1 new set of two cells, post-DN biofilter
    - 1 new backwash storage tank
    - 3 existing secondary clarifiers for clarification of the backwash water;
    - UV treatment
- Excess Flows line
    - Ballasted Primary clarification (2 units)
    - Chemical disinfection

V.1.9 DESCRIPTION OF SLUDGE TREATMENT

- Thickening of Ballasted Primary Settler sludge
- Storage tanks
- Truck loading facilities

V.1.10 DESCRIPTION OF ODOUR TREATMENT

The new works will be connected to the odour control system, which consists of a dispersion stack without treatment.

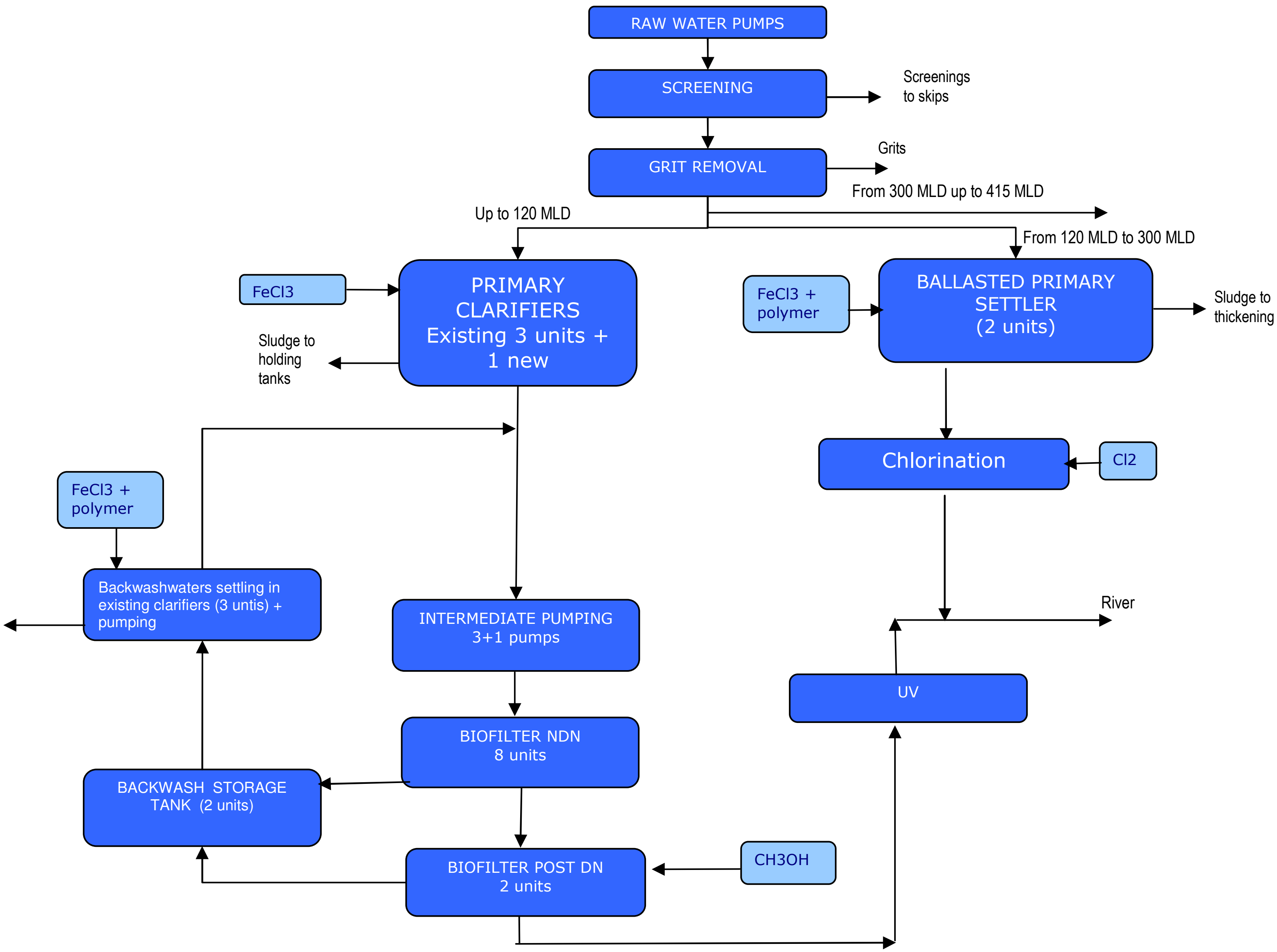


Figure 5: Option 4 PFD

V.2 PROCESS CALCULATIONS - HEADWORKS

Headworks upgrade / expansion will be the same for all options.

V.3 PROCESS CALCULATIONS – BNR TREATMENT

V.3.1 DESIGN CAPACITY

The CEPT + BAF treatment line, including primary and secondary treatment is designed for the following flows. Peak hydraulic flows are handled by the excess flow treatment line

Parameters	Units	
Max daily flow	m^3/d	120 000
Max hydraulic flow	m^3/h	5 000

Table 79: BNR treatment line design capacity – option 4

The design loads are based on the spring max month loads given in Table 18: Seasonal flows – all options.

V.3.2 PRIMARY SETTLING

a. INLET WATER QUALITY

Please refer to Table 19: Influent characterization – all options.

b. SIZING OF THE PRIMARY CLARIFIERS

The existing primary clarifiers are reused to act mainly as FOG / scum removal as well as removal of settleable solids and TP removal (through coagulation). One new clarifier is added. Coagulant (ferric chloride) will be added to the primaries to enhance P precipitation. The primary treated effluent will then go to BAF.

Parameters	Units	
Type of clarifiers	-	Gravity, rectangular, non lamellar
Chemical injection	-	YES
Total area of the settling zone	**m^2**	**2 410**
Peak velocity	m/h	2.07

Table 80: Design of the primary clarifiers – option 4

c. EXISTING AND NEW WORKS

The design allows the reuse of the existing primary clarifiers plus construction of a new unit.

Parameters	Units	Existing 1 &2	Existing 3	New 4
Number		2	1	1
Settling tank width	m	9.1	19.2	9.1
Settling tank length	m	51.8	51.8	51.8
Area of the settling zone /unit	m²	472	995	472
Total area of the settling zone	m²	1 940		472
Total area of the settling zone	m²	2 410		
Total water depth	m	4.3*	4.3*	4.3*

Table 81: Arrangements for primary settling – option 4

* From drawings

Chemical will be added to the 4 primary clarifiers (upstream primary clarification, in the pre-treatment zone).

d. EXPECTED EFFICIENCY OF THE PRIMARY SETTLING

Parameters	Units	**DESIGN**	**YEARLY AVG**
Expected Removal Efficiency			
COD	%	36.5	44
BOD_5	%	35	42
SS	%	53.5	66
TKN	%	12.1	14.5
Total P	%	48.2	53.2
Ferric chloride dosage	mg/L	40	
Expected Settled Water Quality			
COD	mg/l	228.5	265
BOD_5	mg/l	107	125
SS	mg/l	73.5	62
TKN	mg/l	29	34.5
Total P	mg/l	2.6	3.0
COD	kg/d	27 420	23 320
BOD_5	kg/d	12 840	11 000
SS	kg/d	8 820	5 456
TKN	kg/d	3 480	3 036
Total P	kg/d	312	264

Table 82: Expected performances for primary settling – option 4

The efficiencies on the primary clarifiers have been estimated from actual results on existing primary clarifiers, the quality of water (very diluted) with chemical addition.

e. PRIMARY SLUDGE PRODUCTION AND EXTRACTION FROM SETTLING TANKS

Parameters	Units	Design	Yearly average
Total primary sludge production	kg SS/d	**26 260 (winter max week)**	**14 123**
Primary sludge concentration	g SS/L	40	40
Volatile Suspended Solids (VSS)	% of SS	73.5	65
Total primary sludge flow	m^3/d	657	353

Table 83: Primary sludge production – option 4

Extraction of primary sludge is designed on a 12 h/d basis. A complete new set of sludge pumps is planned for the primary clarification step.

Parameters	**Units**	**For Existing clarifiers 1 & 2**	**For existing settler 3**	**For New settler 4**
Duty Pumps	u	1	1	1
Stand-by Pumps	u	1	1	1
Design Flowrate	m^3/h	20	20	20
Head	bar	2	2	2

Table 84: Required set of pumps for primary sludge extraction – option 4

V.3.3 INTERMEDIATE PUMPING

New pumps are required to lift the primary clarification effluent to the Nitrification/Denitrification Biofiltration process stage.

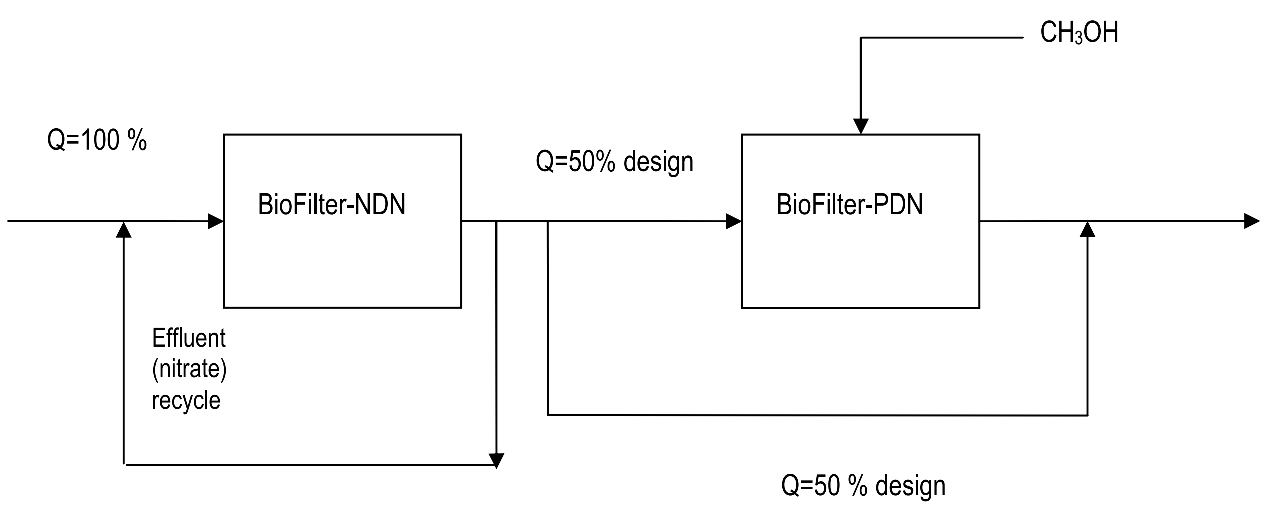
	Units	
Duty pumps	u	3
Stand-by pumps	m	1
Design Flowrate	m^3/h	1 670
Head	bar	0.5 (TBD)

Table 85: Intermediate pumping system – option 4

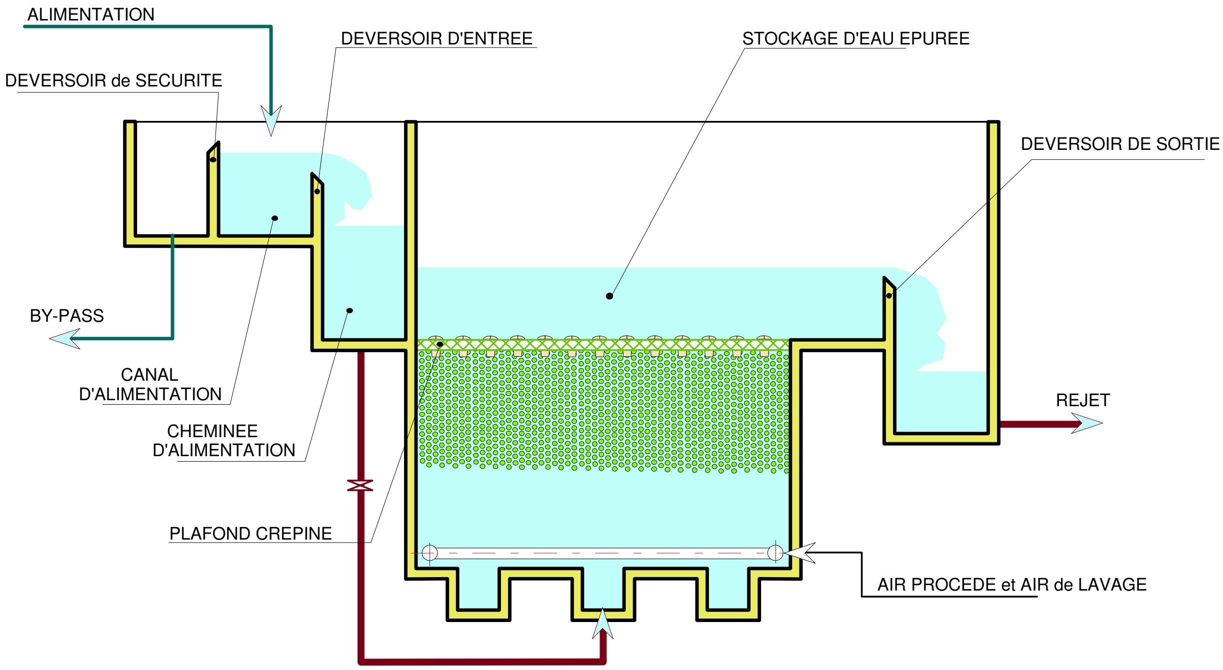
V.3.4 BIOFILTERS FOR NITRIFICATION AND POST DENITRIFICATION

A first stage of biofilters is used to achieve nitrification + primary denitrification. This biofilter is based on a simultaneous nitrification / denitrification (NDN) operation, allowing nitrification of the incoming ammonia while providing denitrification using the incoming primary effluent carbon source. Remaining carbon is also removed within that biological treatment stage, so that treated effluent, low in BOD (COD), is nitrified and is partly denitrified.

A final post-denitrification step is provided through another Biofilter, based on dosage of an external carbon source. Only part of the flow is sent on the Biofilter- PDN to optimise (minimize) CH_3OH consumption and to minimize N-NO_x emission, as illustrated on the figure below.



In the Biofilter process, the water passes through a low density media from the bottom to the top of the filter. Biomass develops on the media and allows for carbon and ammonia oxidation as well as nitrate reduction to gaseous nitrogen. Process air is distributed though coarse bubble aeration by perforated pipes located at the bottom of the filter. The air goes through the media and allows oxidation of the pollution (for the NDN filters). Nozzles are located on top of the filter and used to maintain the filtration media inside the filtration cell. Treated water is stored on top of the filter nozzle deck and is used for gravity backwash of the filters (no pumps needed for backwashing).



Washing phases include alternating air scouring and water backwashes, and are typically performed at a maximum frequency of 24 hours, and up to 72 hours. For the PDN Biofilter, backwash frequency is allowed to be higher (up to 12 hours).

Backwash water from the BAF is stored into backwash tanks, before being pumped and thickened in three existing secondary clarifiers and then pumped back to the BAF inlet.

a. BIOFILTER-NDN

❖ SIZING OF THE BIOFILTER-NDN

The following table presents a summary of the sizing based on the Peak month Flows and loads as defined in section 1.

Parameters	Units	Values Design conditions
Number of filters	u	8
Unit filter Area	m^2	180
Filter Length	m	17.4
Filter width	m	10.3
Media characteristics (Ø)	mm	4
Media depth	m	3.5
Media volume per filter	m^3	630
Media Total volume	m^3	5 040
Effluent recycle (for denitrification)	%	60
Applied loads: - COD	$kg/m^3.d$	5.8
Applied loads: - TSS	$kg/m^3.d$	1.9
Applied loads: - N-NH4 to nitrify	$kg/m^3.d$	0.58
Average filtration velocity on N cells, including effluent recycle flow	m/h	6.2
Peak velocity on N-1 filters (one cell in BW)	m/h	7.7
Wash water for one filter	m^3	1 575
Daily dirty backwash water (@ 24h backwash frequency)	m^3/d	12 600
Washwaters return (based on 12h/d backwash thickening operation)	m^3/h	1 050

Table 86: Design of biofilters-NDN– option 4

❖ EXPECTED OUTLET WATER QUALITY

Effluent water characteristics from Biofilter-NDN are:

Parameters	Units	Design conditions
COD	mg/l	65
BOD	mg/l	20
TSS	mg/l	20
NH_4	mg/l	4.0
$N\text{-}NO_3$	mg/l	8.0
TN	mg/l	15
PT	mg/l	1.1

Table 87: Biofilters-NDN expected outlet water quality– option 4

❖ PROCESS AIR REQUIREMENT

The air production is a centralized-type system and is based on turbo-type high efficiency blowers. Air flow distribution is controlled for each filter using a flowmeter + regulating valve system.

Parameters	Units	Design case	Max T (spring)	Annual Average OPEX estimation
Temperature	°C	9	17	15
Target oxygen concentration (DO level measured above nozzle deck)	m/l	4	4	4
Total Actual Oxygen requirement (AOR)	kg O_2/d	13 800	15 800	13 750
Peak hourly AOR	kg O_2/h	896	1 027	1 060
Blower discharge pressure requirement	bar	1.0	1.0	1.0
Oxygen transfer rate in clean water	%	26 -29	26-29	24 - 28
Average daily air flow rate	Nm^3/d	160 600	184 270	168 160
Peak hourly air flow rate	Nm^3/h	11 640	13 350	14 700
Required air blower total capacity (@ 1000 mbar discharge pressure)	Nm^3/h	15 000		

Table 88: Biofilters-NDN process air requirement– option 4

❖ BACKWASH AIR SCOURING REQUIREMENT

Backwash air scour is provided by the same centralized air blowers system as for process air, for both NDN & PDN filters, and is distributed within the filters using the same aeration grid located at the bottom of each filter (an air grid is installed into the PDN filters for this purpose).

Parameters	Units	Value
Air scour velocity	Nm/h	12
Surface	m^2	180
Air scour flowrate	Nm^3/h	2 160

Table 89: Biofilters-NDN wash air requirement– option 4

- WASH WATER REQUIREMENT

Filters are washed at a maximum once a day, triggered by a timer or on headloss (clogging of the filter). The volume on top of the nozzle deck is the treated water reservoir, used for washing of both Biofilter-NDN & Biofilter-PDN.

The dirty backwash water from the washing phase is stored in a dedicated backwash storage tank, located at the end of the filter gallery. The backwash storage tank capacity allows for full redundancy, enabling operation of the plant with one backwash tank out of service. As a result, two backwash tanks are included, each allowing storage of one complete cell backwash (plus some safety), meaning 1,20 x volume of a backwash per tank.

=>Treated water reservoir = 1 890 m^3 X 2 tanks = 3 780 m^3 total.

Two new tanks will be provided, each with full flexibility to operate as separate tanks, or as combined tanks (which then act as one large tank). Mechanical mixers are provided into each tank to prevent settling of the solids.

This tank will be located in the BAF building.

b. BIOFILTER POST-DN

❖ SIZING OF THE BIOFILTER-PDN

Parameters	Units	Value
Number	U	2
Filter Area	m^2	84
Filter Length	m	14
Filter width	m	6.1
Media characteristics (Ø)	mm	4.5
Media depth	m	2.5
Media volume per filter	m^3	210
Media Total volume	m^3	420
Applied loads: N-N03	$kg/m^3.d$	1.1
Average filtration velocity	m/h	15
Peak velocity on N-1 filters during operation	m/h	20
Wash water for one filter	m^3	525
Daily dirty wash waters	m^3/d	1 050

Table 90: Design of biofilters-PDN– option 4

❖ EXPECTED OUTLET WATER QUALITY

The combined outlet water characteristics from the Biofilter-PDN plus the PDN bypass (Biofilter N effluent) are:

Parameters	Units	Design conditions	Yearly average
COD	mg/l	60	65
BOD5	mg/l	18	15
TSS	mg/l	15	15

NH_4	mg/l	4	4
N-NO_3	mg/l	7	8
TN	mg/l	12	12
P_T	mg/l	1	1

Table 91: Expected outlet water quality of biofilters-PDN– option 4

❖ AIR REQUIREMENT

Air is required only for washing as scouring air. The blower will be in common with the NDN Biofilter.

❖ WASH WATER REQUIREMENT

The backwash tank will be shared with the Biofilter NDN backwash tank.

❖ CHEMICAL REQUIREMENT

Methanol is dosed to sustain Post –Denitrification.

Parameters	Units	Design case	Annual Average OPEX estimation
Effluent treated on PDN	%	50	15
Pure CH_3OH dosing	mg/l	2.45	21
Pure CH_3OH dosing	Kg/d	150	275

Table 92: Biofilters-PDN chemical requirement– option 4

c. WASH WATER TREATMENT

Backwash water is treated separately on the three existing secondary clarifiers and the overflow is returned to the NDN BAF inlet.

Existing clarifier characteristics:

Parameters	Units	Existing 1&2	Existing 3
Number of clarifiers		2	1
Diameter	m	33.5	45.7
Area of the settling zone/unit	m^2	880	1 640

Total area of the settling zone	m²	3 400

Table 93: Existing clarifiers' characteristics– option 4

Parameters	Units	Design
Chemical injection (ferric chloride)	mg/l	25
Max inlet flow	m^3/h	1 575
Daily average inlet flow	m^3/d	13 650
Peak hourly velocity	m/h	0.5
Average hourly velocity	m/h	0.2

Table 94: Washwater treatment characteristics– option 4

Sludge production from wash water treatment:

Parameters	Load	Concentration	Occurrence
	Kg/day	g/l	Days/year
Sludge production for washwater settling design condition	10 900	25	
Sludge production for washwater settling yearly average	7 730	25	365

Table 95: Washwater Ballasted Primary Settler sludge production– option 4

V.3.5 UV DISINFECTION FOR BNR LINE

The design is the same for all options. Please refer to paragraph III.4.6 – Part III.

V.3.6 DAILY AMMONIA LIMIT

In the case of option 4, the daily ammonia limit requirement is met by treating 200 MLD in the BAF cells. Among these 200 MLD, 120 MLD are coming from the primary clarifiers and 80 MLD are diverted from the ballasted primary clarifiers from the CSO stream.
This partial diversion allows a sufficiently low TSS concentration to be achieved at the entrance the BAF units in order not to accelerate the clogging of the filters that would lead to a decrease in the treatment performances.

V.4 PROCESS CALCULATIONS – EXCESS FLOWS TREATMENT

The CSO stream is the same for all options. Please refer to paragraph III.5 – Part III.

V.5 PROCESS CALCULATIONS – SLUDGE HANDLING

The main sludge characteristics for the design conditions are presented in the following table:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	26 260	73.5	Extracted at 40 g/l	657
Backwash water clarifier sludge production	10 900	88	Extracted at 25 g/l	436
CSO Sludge production-spring max week	23 120	58	After onsite thickening at 25 g/l	926
CSO Sludge production-spring max day	62 500	65	After onsite thickening at 25 g/l	2 500

Table 96: Sludge production summary for design conditions– option 4

The yearly average sludge production is presented in the table below:

Parameters	Design Load	Volatile Suspended Solids (VSS)	Concentration	Volume
	Kg/day	%	g/l	m^3/d
Primary settler sludge production	14 123	65	Extracted at 40 g/l	352
Backwash water clarifier sludge production	7 730	90	Extracted at 25 g/l	309
Wet weather Ballasted Primary Settler sludge	2 500	63	After onsite thickening at 25 g/l	100
Total, yearly average	24 353	73	34 g/l	761

Table 97: Yearly average sludge production – option 4

V.6 PROCESS REDUNDANCY APPROACH

The maintenance philosophy for the option is explained below. A more detailed assessment of maintenance requirements will be completed during the detailed engineering phase.

Process design for option selection allows for removal of process units for maintenance without affecting processes unstream or downstream of that process unit. The design allows for one process unit in each stage to be removed from service at any time without compromising effluent compliance.

Primary clarifiers
If one primary settler is out of service, the velocity will increase on the remaining three clarifiers.

In order to maintain the same cycle duration operation of the BAFs, more chemicals can be added to the remaining primaries during this period, or one of the Ballasted Primary Clarifiers can be used for part of the flow. Two Ballasted Primary Clarifiers will provided that will work only during one month of the year so thank to their quick start up they are available for different applications.

BIOFILTERS
For the NDN Biofilter, if one cell is out of service, the Biofilters can still accept the higher velocities and loads. The washing will be more frequent and it may be necessary that one additional mini-backwashing will be performed from time to time, in conditions close to the maximum month load. For the PDN Biofilter, two cells are provided to allow some redundancy. If one cell is off line, the remaining cell can be operated to its maximum hydraulic capacity and methanol dosage adjusted to allow sufficient DN to reach the effluent TN requirement. Backwash frequency can increase under such condition.

Washwater clarifiers
If one clarifier is out of service, the velocities on the remaining two clarifiers will increase; there will be no impact under this condition because of the very low velocity on these existing clarifiers. The washwater can also be pumped at a lower rate out of the backwash storage tanks, allowing the reduction of the clarification velocity over the remaining clarifiers in operation.

Ballasted Primary Settler
If one wet weather Ballasted Primary Settler is out of service, the other one will manage the full flow at higher velocities with a slight increase in chemical dosage, as well as a slight deterioration of the effluent quality.

PART IV – COMPARISON PROCESS DEFINITION

I. COMPARISON CRITERIA

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I.1 GENERAL

It is clearly acknowledged by the Program that estimates of capital and operations costs can not be the only criteria for comparison of the pre-selected options. Consequently, a project specific list of comparison criteria was set up for meeting the two following goals:

- To ensure a comprehensive coverage of themes which have to be considered for an effective comparison of the options and
- To ensure that all the criteria can be scored effectively with the information available at this stage of the study

I.2 CATEGORIES OF CRITERIA

The Program has considered the following four categories of criteria:

- **Process category** includes criteria related to the ability of each option to meet the treatment objectives
- **Constructability category** includes criteria related to the ease of construction of each option
- **Operation category** includes criteria related to the ease of operation and maintenance of each option and
- **Monetary category** includes criteria related to the CAPEX, OPEX and Whole Life Cost of each option (financial)

I.3 LIST OF CRITERIA

Twenty one criteria were identified and associated to the four categories.

N°		Criteria	Subcriteria (indicative)	Category
1		Ability to meet all the license requirements		Process
2		Reliability and risk of failure		Process
3		Redundancy / Availability of the plant		Process
4		Sensitivity of operation and cost to the sew age quality (short term variability)		Process
5		Ability to operate at low DWF (diurnal)		Process
6		Ability to accomodate WWF		Process
7		Track records in similar climate / confidence in the technology		Process
8		Flexibility regarding denitrification		Process
9		Flexibility to upgrade to more stringent requirements (TN&TP, WWF, disinfection)		Process
10		Expandability / modularity		Constructability
11		Ease of construction		Constructability
11	1		Land constrainst	Constructability
11	2		Construction phasing	Constructability
11	3		Constructability	Constructability
11	4		Ease of start-up / commissioning	Constructability
12		Environmental impact / sustainability		Constructability / operation
12	1		Fugitive emission	Constructability / operation
12	2		Odour at plant boundary	Constructability / operation
12	3		Noise at plant boundary	Constructability / operation
12	4		Truck trafic	Constructability / operation
13		Construction duration		Constructability
14		Ease of operation		Operation
14	1		Process standardization	Operation
14	2		Number of protocols (process units, equipments)	Operation
14	3		Automation	Operation
15		Ability to recover Phosphorus		Operation / Process
16		Ease of maintenance		Operation
17		Operator safety		Operation
17	1		Confined space	Operation
17	2		Odour inside the plant	Operation
17	3		Noise inside the plant	Operation
17	4		Explosion risk	Operation
17	5		Chemical release	Operation
18		Carbon foot print		Monetary
18	1		Construction	Monetary
18	2		Operation	Monetary
19		Capital cost		Monetary
20		Operating cost		Monetary
21		Whole life cost		Monetary

Table 98: List of comparison criteria

The Program has assessed that 21 criteria, in 4 categories will provide a comprehensive comparison of the process options.

I.4 CRITERIA DEFINITION

1. Ability to meet all the license requirements

Options capable of producing an effluent quality and operation conditions (odour, noise, etc...) that consistently meet the license requirements receive the most points. The license requirements considered are those presented in Table 15.

2. Reliability and risk of failure

Consistent production of high quality effluent is a major requirement for wastewater treatment plants.. This criterion aims to characterize the global robustness of the process options through:

- The internal robustness of the process (common malfunctions known on similar processes, …)
- The ability to accommodate normal fluctuations in sewage quality (ability and ease of making changes to operational process parameters, etc..)
- The sensitivity of the treatment process to exceptional pollution and the remanence of any resulting dysfunctions and
- The dependency of the plant to external factors such as dependence to any specific supplier for consumables, equipment or chemicals

The solution with the highest reliability and lowest risk of failure receives the higher mark.

3. Redundancy / availability of the plant

In addition to the requirement for internal robustness of the process described above, this criterion promotes the option that provides the best redundancy in the process or equipment installed.

The solution with the highest redundancy receives the higher mark.

4. Sensitivity of operation and cost to the sewage quality (short term variability)

This criterion scores the ability of the process to accommodate change in sewage characterization through operational adaptability without major cost implications. Solutions which most easily lend themselves to operational adaptability with the lowest cost impact receive the highest mark.

5. Ability to operate at low DWF (diurnal)

The SEWPCC license requires the plant to be designed for a wide range of flows and loads. The requirement to treat high wet weather flows and yet operate well during extended periods of dry weather flow (including low peaks at night) creates challenges for some options. The options that can accommodate extended low flow and loading events while minimizing operational challenges receive higher points.

6. Ability to accommodate WWF

Extreme high wet weather peaks occur suddenly in Winnipeg, particularly during spring snowmelt and summer storm events. Spring snowmelt flows are also accompanied by sudden temperature decreases. These events require the treatment process to adjust quickly to increased flows and loads, especially in spring when flows traditionally jump from dry weather flow rates to high, coldwater snowmelt flows within one or two days. The processes that can accommodate these sudden flow increases and temperature decreases while minimizing operational challenges receive higher points.

7. Track records in similar climate / confidence in the technology

Most of the processes considered have a track record in Canada, the USA or Europe which definitely strengthen the reliability of the proposed processes. Instead of counting the similar references for each technology, it is acknowledged that this criterion should reflect confidence in the technologies and the process unit's configuration. The higher score are assigned to options attracting the best degree of confidence in the experience of the scorer..

8. Flexibility regarding denitrification

The Program is concerned by the possibility that the Regulator withdraws or reduces his requirement on total nitrogen. In that context any option which would present a flexibility to downgrade to less stringent requirements on TN presents a noticeable advantage. The highest score is given to the most flexible option in this regard.

9. Flexibility to upgrade to more stringent requirements (TN&TP, WWF, disinfection)

The Program is concerned by the risk that the license becomes more and more stringent on TN, TP, WWF and disinfection before 2031. Thus the processes that can be easily modified to meet more stringent effluent criteria receive the highest points.

10. Expandability / modularity

A significant amount of growth is predicted in the SEWPCC service area with potential for higher growth rates during the design period as well as future growth beyond the design period. Options that most readily lend themselves to expansion by adding process trains in the future to accommodate higher growth rates or populations beyond 2031 receive the most points.

11. Ease of construction

This criterion contains four subcriteria which relate to the ease of construction, subcriteria are:

a. *Land constraint*: some options may require the acquisition of a new land. In addition to the direct cost of land acquisition (included in CAPEX) this can imply constraints (such as legal expropriation procedures) which can delay the construction works. This acquisition risk will be assessed via the analysis of the urban plan of the area (type of land and number of different current owners)
b. *Construction phasing*: the license will require the existing facility to remain in operation during construction. This complexity and risk in the required construction plan will depend on the specifics of each option
c. *Constructability*: the constructability of each option will be assessed through the possibility and extent of prefabrication of components of the works
d. *Ease of start-up / commissioning*: this project phase is difficult and presents more challenges for some options compared to others.

The option which presents the best ease of construction in terms of these subcriteria receives the higher mark.

12. Environmental impact / sustainability

The purpose of a sewage treatment plant is to provide protection for the environment. Nevertheless some process options are more environmental friendly during construction as well as during operation.

a. *Fugitive emission*: this subcriteria aims to quantify the risk of pollution generated by a dysfunction of the plant in relation with the probability it occurs. For example the risk of chemical leakage, sludge emission, etc.outside the boundaries of the plant.
b. *Odour at the plant boundaries*
c. *Noise at the plant boundaries*

d. *Traffic frequency*: This subcriterion will sort the options regarding the road traffic they will create for sludge disposal, chemical consumption, etc…

Note: this criterion is not dealing with the footprint of the plants as it is assumed by the Program that most of them are the same. Indeed, all the solutions require construction of new process buildings which will take place behind the existing buildings. Thus they won't be visible from the nearest houses to the North nor from the perimeter highway. Consequently, it is assumed that the footprint of the additional buildings will all be the same.

13. Construction duration

The new license requirements will come into force on Dec 31st, 2012 which gives less than two years for the Program to deliver the works. This period is challenging and the construction duration is an important criterion. In that context, the option with the shortest construction duration presents an advantage and shall receive a score of 10.

14. Ease of operation

Operational complexities can result from operational procedures to handle fluctuation in flows and loads, multiple numbers of unit processes, etc... Options with the more complex processes, either from a process, hydraulic, mechanical or instrumentation and control point of view, will receive a lower score. The option with the easiest expected operation will receive the highest score. For indication, this criterion has been broken down as follows:

a. *Process standardization*
b. *Number of existing protocols (process units, equipments)*
c. *Automation*

15. Ability to recover Phosphorus

The Program is concerned by the ability of recovering Phosphorus from the wastewater, thus the options are scored regarding this criterion. The options with the best phosphorus recovery rate will receive the highest score.

16. Ease of maintenance

The extent of the requirement for maintenance is related to the amount of mechanical equipment. The more pieces and extent of different types of equipment (for common unit processes) increase maintenance requirements (i.e. routine maintenance, stocking spare part, etc.). The least mechanical complex processes receive the highest score in this category and those requiring multiple mechanical pieces of equipment with significant routine adjustment and preventive maintenance receive the lowest score. The scorers also pay attention to the type of material used and the corrosion sensitivity.

17. Operator safety

Some treatment processes, although designed with operator safety as a priority, contain inherent risks to the operating staff. Unit processes that minimize any potential operational safety risks receive higher points.

For indication, this criterion is broken down as follows:

a. *Confined space*
b. *Odour inside the plant*
c. *Noise inside the plant*
d. *Explosion risk*
e. *Chemical release*

18. Carbon footprint

Sustainability is an important concern to the Program; all the options are assessed regarding their carbon footprint both during construction and for operation. The calculated carbon emissions are expressed in tonnes of CO_2.

The highest score is given to the option with the lowest carbon footprint, scores for the other options are calculated on a prorated basis.

19. Capital cost (CAPEX)

The capital cost or CAPEX is the cost of developing and providing non-consumable parts for each option. The financial evaluation of CAPEX is detailed in section 0 of this report. The option with the lowest CAPEX cost receives a score of 10 with the other options scoring as follows:

$$SCn=10 \times (1-(Cn-Cb)/(Cb))$$

With:

SCn the score for option n

Cb the lowest CAPEX value

Cn the CAPEX value of the option n

20. Operation cost (OPEX)

The operation cost or OPEX is the ongoing cost for running each option. The financial evaluation of OPEX is detailed in section in 0 of this report. The option with the lowest OPEX receives a score of 10 with the other options scoring as follows:

$$SOn=10 \times (1-(On-Ob)/(Ob))$$

With:

SOn the score for option n

Ob the lowest OPEX value

On the OPEX value of the option n

21. Whole life cost

The financial evaluation of the options is done through three sub-criteria:

i) capital cost,
ii) operation cost and
iii) whole of life cost.

The most important of these is the whole life cost of the option which represents the total cost of the asset across the asset life and is the sum of construction costs plus 30 years operating costs. However, it is important to see how costs are distributed between CAPEX and OPEX, for that reason criteria #19 (CAPEX) and #20 (OPEX) are maintained.

The whole life cost is assessed through the Net Present Value of the options. The details of the calculation are given further in section 0of this report.

The option with the lowest whole life cost receives a score of 10 and with the other options scoring as follows:

$$Wn=10 \times (1-(Wn-Wb)/(Wb))$$

With:

Wn the score for option n

Wb the lowest whole life cost value

Wn the whole life cost value of the option n

II. WEIGHTING PROCEDURE

-ooOoo-

The procedure for weighting the comparison criteria is an important step in process option selection as it allows the asset owner to apply business priorities to the option selection. For example, if the priority of the owner is to have a safety, reliable and 100% available plant, those three criteria would be weighted highly in order to enhance the corresponding options.

As it is clearly a strategic step, the weighting procedure has been set up in such a way as to prevent the scorers from being influenced by those weighting the criteria or visa versa. The procedure is described below.

II.1 WEIGHTING AND SCORING PRINCIPLES

As discussed, the weighting of the comparison criteria will influence the final result of the selection step. Consequently and to insure the impartiality of the process, the Program establishes the two following principles:

1. the weighting team and the scoring team shall be different and
2. they shall work in parallel, without receiving information from each other

II.2 WEIGHTING TEAM COMPOSITION

The weighting methodology was set and carried out by the Program Management Team (MT).

II.3 WEIGHTING METHODOLOGY

The following methodology was used for option weighting:

- Individual weighting: each MT member independently weighted each category of criteria (Process, constructability, Operation and Monetary) and then weighted each individual sub-criterion.

- Common discussion: the weightings proposed by each MT member were compared and discussed until a consensus view on the appropriate weightings was reached. In most cases an arithmetic average of each MT member's weightings provided a general consensus prior to a sense check on the overall picture of weighting.

The weighting of the criteria was determined by the Management Team.

III. SCORING PROCEDURE

-ooOoo-

III.1 SCORING TEAM COMPOSITION

As the comparison criteria deal with several areas of expertise, the technical scoring team was divided into three groups as follows:

- **Group 1: process & constructability group**: Nick Szoke (CoW), Dominika Celmer (CoW), Al Zaleski (CoW), Arnold Permut (CoW), Dwight Gibson (CoW), Antonella Fioravanti (VWS process expert), Kumar Upendrakumar (VWNA process expert), Daniel Lamarre (JMI process expert), Jean-Yves Bontonou and (VWS senior waste water manager) and Virginie Landragin (VWS commissioning manager)

- **Group 2: operation group**: Ken Smyrski (CoW), Ron Hahlweg (CoW), James Hestad (VWNA O&M manager) and Jean D'Aries (VWS O&M expert).

- **Group 3: financial group**: Management Team + Nick Szoke (CoW), Aymeric Simon (VWS)

The financial group's action was limited to a risk & opportunity analysis as the scores for the financial criteria are calculated directly from the CAPEX, OPEX and whole life costs.

III.2 SCORING METHODOLOGY

The scoring process followed the two following steps:

- Pre-scoring review of the options and
- The real scoring step.

III.2.1 PRE SCORING SCAN

The idea of going through a pre-scoring review comes initially from the opportunity of capitalizing on the EAP involvement on the project. Having some of the world best process specialists involved on the project during a one week workshop was an opportunity to capture their opinion on the pre-selected options with respect to the comparison table.

However, as not all representatives of the scoring groups were in attendance at the workshop and it was required that all persons involved in the scoring groups scored objectively and with their own opinion, the EAP were only asked for **unfigured scoring indications**. This pre-scoring, the results of which are included in Appendix 4: Pre-scoring scan results, also gave some leads to the scoring teams members with respect to the scoring of process technologies they were not familiar with.

III.2.2 FINAL SCORING

The scoring was completed after the workshop, and <u>separately</u> by each group as follows:

- **Action 1**: appointment of a group leader responsible for the scoring process of his group: i) Group 1: Nick Szoke, ii) Group 2: Ken Smyrski and iii) Group 3: Aymeric Simon

- **Action 2**: individual scoring

- **Action 3**: presentation and discussion meeting for the individual scores to give the opportunity for discussion on the individual scoring

- **Action 4**: update of the individual scoring and gathering of the results

The financial scoring follows a slightly different process, as detailed below.

The scoring is made by three independent thematic groups. The technical scoring groups were able to use information from the EAP workshop and the workshop pre-scoring when setting their scores.

III.3 FINANCIAL SCORING

III.3.1 GENERAL

Financial scoring is a critical aspect in evaluation of the process options. The financial scoring of the options involved an assessment of the CAPEX, OPEX and whole life costs of the options excluding risks and opportunities, followed by a separate risk and opportunity analysis.

As financial estimation of the project options is completed at an early stage of design, CAPEX and OPEX values are only given for purposes of comparing options and are expressed in "unit of cost". As such, these option comparison costs can not be considered as a comprehensive assessment of the final project cost, target costs or budget prices.

III.3.2 CAPEX ESTIMATION

a. BUILDUP OF CAPEX

CAPEX estimates for the options were based on a pricing methodology used by Veolia Co. and available pricing of some of the works from Stantec's previous studies, the Program has built up the CAPEX estimate in three main categories:

1. The M&E and civil work costs relating to the main process units and which are not common to all options, which include:
   - Headworks
   - Primary clarifiers
   - Bioreactors
   - Biofilters
   - Secondary clarifiers
   - CSO ballasted primary clarifiers
   - Disinfection by chlorination
   - Other mechanicals (intermediate pumping plants, …)
2. Common costs areas for which have been assessed with provisional sums, mainly based on Stantec's previous pricing. These costs can either be common to all options or specific to one of them. Areas of common cost include:
   - Site works
   - UV disinfection
   - Upgrade costs for reused works
   - By-pass and outlet pipes
   - Sludge storage
   - Odour treatment
   - Standy emergency power upgrade
   - DAF sludge thickener
3. The ancillary costs assessed by the Program. They are:
   - Site costs
   - Contingencies for construction change orders

- CAPEX risks and opportunities

Consequently, the CAPEX pricing table is as follows:

			OPTION 2	OPTION 3	OPTION 4
PRICING ITEMS ASSESSED SPECIFICALLY BY THE PROGRAM	MECHANICAL EQUIPMENTS				
	HEADWORKS	uc			
	PRIMARY CLARIFIERS	uc			
	BIOREACTORS (IFAS prop. Tech. not included)	uc			
	BIOREACTORS (IFAS prop. Tech.)	uc			
	BIOFILTERS	uc			
	SECONDARY CLARIFIERS	uc			
	CSO BALLASTED PRIMARY CLARIFIERS	uc			
	DISINFECTION - CHLORINATION	uc			
	OTHER MECHANICALS	uc			
	TOTAL M&E	uc			
	CIVIL WORKS COSTS	uc			
	GENERAL CONTRACTING	uc			
ADDITIONAL WORKS COMMON TO ALL OPTIONS - PROVISIONAL SUMS	SITE WORKS	uc			
	UV DISINFECTION	uc			
	UPGRADE COSTS	uc			
	BY-PASS AND OUTLET PIPES	uc			
	SLUDGE STORAGE	uc			
	ODOUR TREATMENT	uc			
	STANDBY EMERGENCY POWER UPGRADE	uc			
ADDITIONAL WORKS - PROVISIONNAL SUMS	DAF SLUDGE THICKENER	uc			
ANCILLARIES COSTS ASSESSED BY THE PROGRAM	SITE COSTS	uc			
	CONTINGENCIES FOR CONSTRUCTION CHANGE ORDERS	uc			
	CAPEX RISKS & OPPORTUNITIES				
	Risks	uc			
	Opportunities	uc			
	TOTAL CAPEX RISKS & OPPORTUNITIES	uc			
	TOTAL CAPEX PROJECT VALUE	uc			

Table 99: CAPEX pricing table

b. PRICING PROCEDURE FOR M&E

Project pricing can be completed in many ways and there are as many pricing tables as there are projects. However in general, estimates for option costs can be produced by benchmarking with similar projects and building up estimates into process units based on pricing of equipment lists.
Benchmark pricing presents multiple advantages amongst which the most important are: accuracy, transparency and rapidity. However, these advantages depend on the quality of the benchmark used. Indeed to be effective a benchmark has to be done with similar and recent projects. Thus it is not always possible to use benchmark pricing, for example when reference projects are not easily comparable to the current project, in such cases it can be preferable to assess option costs through a second methodology.

For SEWPCC, the Program was successful in finding appropriate benchmarks for the project items presented in Table 99. The reference projects used are indicated in the table.

Items	Reference projects
BIOREACTORS (IFAS prop. Tech.)	RFP provided by JMI to Stantec on 08/29/2008 for SEWPCC
BIOFILTERS	RFPs for the WWTP of Cornw all - Ontario, 2010. RFP from JMI and Degremont
	RFP provided by JMI to Earthtech for NEWPCC on feb 2007
CSO BALLASTED PRIMARY CLARIFIERS	RFP provided by JMI to Stantec on 11/07/2006 for SEWPCC
	Drinking w ater Actiflo executed in Portage la Prairie by JMI in 2001

Table 100: Available benchmarks for SEWPCC

Details of the benchmark analysis are presented Appendix 5: Benchmark analysis details.

Where benchmarking was not possible, the Program built up an estimatation of the price of the major items on the basis of a main equipment list, the price build up calculation is shown in the following table.

		Option 2	Option 3	Option 4		
M&E PROCESS UNIT #1						
M&E DIRECT COSTS						
Total equipment cost	uc				A	Equipment selling price
Interconnection piping and valves above ground	%	15.00%	15.00%	15.00%		Applied on A
	uc				B	
Electricity, Automation and Instrumentation	uc	variable	variable	variable	C	Based on the quotation made by VWS for each option and the rate (price of the concerned equipement / total M&E cost)
Spare parts	%	2.00%	2.00%	2.00%		Applied on A + B + C
	uc				D	
Transport	%	8.00%	8.00%	8.00%		Applied on A + B + C + D
	uc				E	
Mechanical installation	%	27.50%	27.50%	27.50%		Applied on A + B + C
	uc				F	
Mechanical Price inflation (proc duration @ 2%/y)	%	variable	variable	variable		Applied on A + B + C + D + E + F
	uc				G	
Contingencies on direct costs	%	15.00%	15.00%	15.00%		Applied on A + B + C + D + E + F + G
	uc				H	
TOTAL M&E DIRECT COSTS	**uc**				I	A + B + C + D + E + F + G + H
M&E INDIRECT COSTS						
Professional costs M&E	%	15%	15%	15%		Applied on I
	uc				J	
Contingencies on prof costs	%	5.00%	5.00%	5.00%		Applied on J
	uc				K	
General requirements (bonds, insurance, financial and miscellaneous costs)	%	10.00%	10.00%	10.00%		Applied on I + J + K
	uc				L	
TOTAL M&E INDIRECT COSTS	uc				M	J + K + L
TOTAL M&E PROCESS UNIT #1	uc				N	M + I

Table 101: Breakdown for M&E equipments pricing and calculation methodology

The calculation methodology is detailed on the right side of the table. Except for the EIC cost (Electrical, Instrumentation & Control) which is assessed by a project's specific quotation, all the items are costed by application of a rate on the equipment costs.

These applied rates originate either from data tested through other projects, or assessed by benchmarking of similar projects previously completed all around the world. For some specific process units, the rates were modified to better fit the specific situation of that process. This adjustment was made for instance for the "Mechanical installation" rate and for the item "Bioreactor IFAS proprietary technology". Installing the IFAS media is less complex than installing pumps, blowers, etc, therefore the rate is reduced from 27.5% to 15%. The rate for installation of the Bioreactors (IFAS proprietary technology excluded) has been increased to 45% to reflect the complexity and the number of erection procedures for pumps, mixers, blowers, etc.

c. PRICING PROCEDURE FOR CIVIL WORKS

The civil works pricing is based on the application of standard unit rates to a simplified civil works bill of quantities (BOQ). The BOQ for each option is an account of the **volume of concrete** and the **surface of building** needed to erect the works.

The unit rates assumed by the Program are as follows:

CAPEX unit rates

Civil works			Source of information
Tank roofing cost */**	1280	$/m2	Ratio from concrete cost for AS
Building cost */**	1920	$/m2	Ratio from concrete cost for AS
Concrete cost for activated sludge **	1500	$/m3	CoW (last day of process selection w orkshop)
Concrete cost for clarifiers or settling **	1600	$/m3	Ratio from concrete cost for AS
Concrete cost for biofilters and actiflo **	1700	$/m3	Ratio from concrete cost for AS
Piling density	9	m2/pile	Veolia
Piling unit cost	1250	$/pile	Veolia

(*) : earthw orks, HVAC, electricity and finition included
(**) : earthw orks included / deep foundation excluded

Table 102: Civil works unit rates

Note: without any information about the ground conditions on site, the Program has taken the reasonable assumption that the same type of foundations used in the existing plant shall be adapted for the extension works.

The calculation methodology used for populating the BOQ is detailed in Appendix 6: Civil works bill of quantities methodology. The main assumptions for the calculations are:

- Wall thickeness: 0.4 to 0.5 m depending on the height of the wall
- Slab thickeness: 0.6 m
- Slab dimension: 1 m increase in length and width to ensure stability when the basin is empty and the groundwater level is high

CIVIL WORKS COSTS		Option 2	Option 3	Option 4		
Concrete	uc	Variable	Variable	Variable	O	
Building	uc	Variable	Variable	Variable	P	
Professional costs CW	%	15.00%	15.00%	15.00%		Applied on O + P
	uc				Q	
Contingencies on Professional costs	%	15.00%	15.00%	15.00%		Applied on Q
	uc				R	
Civil w ork Price inflation (constr duration @ 3%/y)	%	Variable	Variable	Variable		Applied on O + P
	uc				S	
Contingencies on quantities	%	15.00%	15.00%	15.00%		Applied on O + P + S
	uc				T	
General requirements (bonds, insurance, financial and miscellaneous costs)	%	8.00%	8.00%	8.00%		Applied on O + P + Q + R + S + T
	uc				U	
CIVIL WORKS COSTS					V	O+P+Q+R+S+T+U

Table 103: Breakdown for civil works pricing and calculation methodology

d. PRICING PROCEDURE FOR PROVISIONAL SUMS

The provisional sums are assessed by either an application of rates tested from other projects or by using existing cost estimates which were updated and adjusted for the Project. The existing cost estimates used originated from the Stantec CDR. The calculation methodology is presented in the following table.

		Option 2	Option 3	Option 4		
GENERAL CONTRACTING	%	10%	10%	10%		
	uc				W	Applied on O + P + S + T + I
SITE WORKS	uc	Stantec			X	Stantec price + 2% CPI + 15% engineering + 10% contingencies
UV DISINFECTION	uc	Stantec			Y	Stantec price + 2% CPI + 15% engineering + 10% contingencies
UPGRADE COSTS						
Headworks upgrade (provisional sum)	uc	Stantec			Z	
Primary upgrade (provisional sum)	uc	Stantec			AA	Stantec price + 2% CPI + 15% engineering + 10% contingencies
Secundary upgrade (provisional sum)	uc	Stantec			AB	
UPGRADE COSTS	uc				AC	
BY-PASS AND OUTLET PIPES	uc	Stantec			AD	Stantec price + 2% CPI + 15% engineering + 10% contingencies
SLUDGE STORAGE	uc	Stantec			AE	Stantec price + 2% CPI + 15% engineering + 10% contingencies
ODOUR TREATMENT	uc	Stantec			AF	Stantec price + 2% CPI + 15% engineering + 10% contingencies
STANDBY EMERGENCY POWER UPGRADE	uc	Stantec			AG	Stantec price + 2% CPI + 15% engineering + 10% contingencies
DAF SLUDGE THICKENER	uc	Stantec			AH	Stantec price + 2% CPI + 15% engineering + 10% contingencies
SITE COSTS	%	Prorata constr duration	Prorata constr duration	8.00%		
	uc				AI	Applied on N + V + W + X + Y + AC + AD + AE + AF + AG + AH
CONTINGENCIES FOR CONSTRUCTION CHANGE ORDERS	%	10%	10%	10%		
	uc				AJ	Applied on N + V + W + X + Y + AC + AD + AE + AF + AG + AH + AI
CAPEX RISKS & OPPORTUNITIES						
Risks	uc	Refer to R&O Matrix			AK	
Opportunities	uc				AL	
TOTAL CAPEX RISKS & OPPORTUNITIES	uc				AM	
TOTAL CAPEX PROJECT VALUE	uc				AN	N + V + W + X + Y + AC + AD + AE + AF + AG + AH + AI + AJ + AM

Table 104: Breakdown for provisional sums and calculation methodology

III.3.3 OPEX ESTIMATION

a. OPEX BUILDUP

OPEX for each option was assessed by the Program on the basis of the following consumable items:

- electricity,
- chemicals,
- sludge hauling,
- UV bulb replacement and
- maintenance costs.

A specific OPEX risk and opportunity analysis is provided to complete the OPEX estimate.

Important note:

- Labor costs are not assessed in the OPEX as it is acknowledged that they will be similar for all options;
- Sludge treatment costs are excluded from the current calculation except for the sludge hauling cost from SEWPCC to NEWPCC.

b. CALCULATION METHODOLOGY

The assessment of OPEX costs was based on an estimate of required annual quantity or volume of each consumable to which the unit rates in the following table were applied.

OPEX UNIT RATES	in CAD		Source of information
Power			
Electricity cost	0.047	$/kWh	CoW - Eng Dpt
Chemicals			
Ferric chloride cost	328.57	$/m3	CoW - Eng Dpt (e-mail 29/11/10)
Methanol cost	368.26	$/m3	From http://w w w .methanex.com/products/methanolprice.html
Polymer cost	3.89	$/kg	CoW - Eng Dpt (e-mail 25/11/10)
Sludge transportation			
Sludge truck volume	30	m3/load	CoW - Eng Dpt (e-mail 29/11/10)
Sludge truck cost	130.8	$/load	CoW - Eng Dpt (e-mail 29/11/10)
UV bulbs			
Replacement cost	350	$/bulb	CoW - Op Dpt
Life time	8000	hours / bulb	CoW - Op Dpt

Table 105: OPEX unit rates

Consumable quantities and volumes were modelled as being variable with flows and loads received at the plant. With such flows and loads evolving over the 30 year contract period.
The assessment of the OPEX evolution is based on the assumptions listed in the Table 106: OPEX breakdown.

		Evolution	Proportional to
POWER	Raw water	Linear	Flow
	Pretreatment	Linear	Flow
	Primary treatment	Linear	Flow
	Activated Sludge	Linear	DBO5
	Biofiltration	Linear	Flow
	Tertiary treatment	Linear	Flow
	CSO ACTIFLO	Linear	Flow
	Sludge	Linear	DBO5
	Chemicals	Linear	Flow
	Utilities	Linear	Constant price
CHEMICAL	FeCl3- CSO -35 % , d=1,37	Linear	Flow
	Polymer - CSO -100 %, d=1,1	Linear	Flow
	FeCl3- P precipitation -35 % , d=1,37	Linear	Flow
	Polymer - Sludge treatment -100 %, d=1,1	Linear	Flow
SLUDGE HAULING	Primary sludge	Linear	Sludge
	Secondary sludge	Linear	Sludge
	Actiflo wet weather sludge	Linear	Sludge
OTHER OPEX COST	Maintenance for equipment	Linear	Constant price
	UV bulbs	Linear	Flow

Table 106: OPEX breakdown

III.3.4 NPV AND WHOLE LIFE COST

NPV (Net Present Value) is a standard financial methodology which is used in the appraisal of long term projects to account for the time value of money. In an NPV analysis relevant project cash flows are identified and discounted back to its present value (PV) by application of an appropriate discount rate. The individual presesent value cash flows are then summed to obtain the NPV. Therefore the NPV is the sum of all terms,

$$R_t / (1+i)^t$$

, where:

- t - the time of the cash flow (year)
- i - the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk)
- R_t - the net cash flow (the amount of cash, inflow minus outflow) at time t

For the SEWPCC project, the NPV of the three options was calculated based on the following assumptions, the discount rate and CPI rate were provided by the City finance team:

	CPI	Discount rate	Duration	Start	End
Option 2	2%	6%	45 months construction + 30 years of operation	May 2015	May 2045
Option 3			46 months construction + 30 years of operation	June 2015	June 2045
Option 4			34 months construction + 30 years of operation	June 2014	June 2044

Table 107: NPV calculation assumptions

Note: Table 107: NPV calculation assumptions assumes no construction phasing is done. Some phasing scenarios have been set up and their impact on each option's whole life cost is assessed and presented in Appendix 12: Assessment of options 2 and 4 possible delivery options.

III.3.5 RISK AND OPPORTUNITY ANALYSIS

a. RISK AND OPPORTUNITY IDENTIFICATION

All risks and opportunities identified which are specific to a particular options were gathered by the Program and presented in a risk table. Risks that were common to all three options were not considered as they would not be relevant to selection between options. However risks which were applicable to two out of three options were considered as relevant to the option selection. In some cases although risks and opportunities may be common to all options they could affect one option more or less than another, in this case these risks were considered as specific to that particular option.

b. RISK ASSESSMENT MATRIX

A risk matrix was used to assess the identified risks and opportunities which analysed both the severity and likelihood of each risk or opportunityTable 108: Risk assessment matrix. An example of the risk assessment matrix is presented in Table 108: Risk assessment matrix.

c. R&O COST ESTIMATION

The most likely cost impact of the risks and opportunities were evaluated and integrated in the whole of life cost. The cost evaluation of the risks and opportunities was made by:

- Evaluating the likelihood of the risk occurring on a % basis.
- Evaluating the severity of the impact of the risk on the basis of total financial / delay (i.e. how much would it cost in total if the identified risk was to occur)
- Multiplication of the likelihood and severity to produce a score for each risk, (cost weighted by probablility of the risk occurrence before any mitigation measure)
- For the most important risks, a mitigation plan was proposed with an assessment of the expected result of this plan

Separate R&O matrices were made for CAPEX and OPEX issues, although both follow the same methodology.

The preliminary R&O matrix identifies the specific risks and opportunities of the three preselected options, for the purpose of comparing options.

RISK ASSESSEMENT MATRIX

							Increasing Probabililty				
							1 (VL)	2 (L)	3 (M)	4 (H)	5 (VH)
Increasing Severity	Severity	Estimate of likely injuries	Estimated environnemental effect	Estimate loss of reputation	Estimate cost	Estimated schedule delay	Never heard of in industry	Has occurred in industry	Has occurred in Business Unit	Occurs several times a year in Business Unit	Occurs several times a year location
	1 (VL)	Slight Injury (FAC, MTC)	Slight effect (within fence line - no breach)	Slight impact (public awareness)	Slight cost (< € 6,000 & no disruption to operations)	Slight delays (less than 1 week)	1	2	3	4	5
	2 (L)	Minor Injury (LTI 4 days or less)	Minor effect (temporary contamination slight breach)	Limited impact (local public / media)	Minor cost (<€ 60,000 & brief disruption)	Limited delays (> 1 week, 1 month)	2	4	6	8	10
	3 (M)	Major Injury (LTI, PPD >4 days)	Local effect (recoverable environnemental loss/repeated breach)	Considerable impact (region state public / media)	Local damage (< € 300,000 & partial shutdown)	Major delays (> 1 months<2 months)	3	6	9	12	15
	4 (H)	Single fatality	Major effect (severe damage recoverable / Extended breach)	National Impact (Extensive adverse media)	Major damage (< € 3M & partial operation loss)	Major delays (> 2 months<4 months)	4	8	12	16	20
	5 (VH)	Multiple Fatalities	Massive effect (widespread chronic effects / constant high breach)	International impact (extensive adverse media)	Extensive damage (> € 3M & substantial operation loss)	Extensive delays (> 4 months)	5	10	15	20	25

Legend : FAC - First Aid Case; MTC - Medical Treatement Case; LTI - Loss Time Injury; PPD - Permanent Partial Disability

Table 108: Risk assessment matrix

III.4 THE SPECIFIC CASE OF THE CARBON FOOTPRINT SCORING

III.4.1 GENERAL

In a context of climate change and decreasing resources, the reduction of global greenhouse gas emissions (GHG) is at the core of debates among international institutions, countries and companies. In order to address this issue in the most efficient way, Veolia Environment has committed to a Carbon Footprint approach, which aims to analyse and optimize the Greenhouse Gas emissions linked to solutions that are offered. It is important to consider the carbon footprint of a wastewater treatment process when assessing the sustainability of process alternatives. Veolia strives to provide solutions and technologies designed to improve the energy efficiency and to reduce the carbon emissions. A "carbon footprint" consists of the total amount of all GHG emissions caused directly or indirectly by an individual, an organisation, a product, an event, etc. The term of GHG encompasses several gases (carbon dioxide, methane, etc.) but always refers to a single unit, i.e. one metric ton of CO_2 equivalent.

III.4.2 CARBON FOOTPRINT CALCULATION METHODOLOGY

The carbon footprint of a project is made up of the sum of the primary footprint and the secondary footprint, also known as direct and indirect emissions.

1. The primary footprint is a measure of the direct emissions of CO_2 from i) the burning of fossil fuels (e.g. heating, transportation) during construction and operation, and ii) the process biological activity.
2. The secondary footprint is a measure of the indirect CO_2 emissions from the whole lifecycle of products the project is composed of, as well during construction and operation (emissions associated with their manufacture and eventual breakdown).

Thus the first step of a carbon footprint calculation is to realize the breakdown of a project into a list of tasks and elements for which an "emission factor" (EF) expressed in kg CO_2 / unit is given in a specific database. The EF database used in SEWPCC is given in Appendix 7: CO2 emission factors database.

PART V - PROCESS SELECTION RESULTS

I. COMPARISON TABLE

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I.1 WEIGHTING OF THE CRITERIA

The weighting of the comparison criteria decided by the Program's Management Team is as follows:

N°	Criteria	Subcriteria (indicative)	Category	Category Weight	Criteria Weight	Overall Weight
1	Ability to meet all the license requirements		Process	34%	0%	0%
2	Reliability and risk of failure		Process		22%	7%
3	Redundancy / Availability of the plant		Process		23%	8%
4	Sensitivity of operation and cost to the sew age quality (short term variability)		Process		0%	0%
5	Ability to operate at low DWF (diurnal)		Process		12%	4%
6	Ability to accomodate WWF		Process		12%	4%
7	Track records in similar climate / confidence in the technology		Process		17%	6%
8	Flexibility regarding denitrification		Process		7%	2%
9	Flexibility to upgrade to more stringent requirements (TN&TP, WWF, disinfection)		Process		7%	2%
10	Expandability / modularity		Constructability	17%	30%	5%
11	Ease of construction		Constructability		55%	9%
11 1		Land constrainst	Constructability		0%	
11 2		Construction phasing	Constructability		20%	
11 3		Constructability	Constructability		10%	
11 4		Ease of start-up / commissioning	Constructability		25%	
12	Environmental impact / sustainability		Constructability / operation		5%	1%
12 1		Fugitive emission	Constructability / operation			
12 2		Odour at plant boundary	Constructability / operation			
12 3		Noise at plant boundary	Constructability / operation		3%	
12 4		Truck trafic	Constructability / operation		3%	
13	Construction duration		Constructability		10%	2%
14	Ease of operation		Operation	28%	34%	10%
14 1		Process standardization	Operation			
14 2		Number of protocols (process units, equipments)	Operation			
14 3		Automation	Operation			
15	Ability to recover Phosphorus		Operation / Process		13%	4%
16	Ease of maintenance		Operation		34%	10%
17	Operator safety		Operation		19%	5%
17 1		Confined space	Operation			
17 2		Odour inside the plant	Operation			
17 3		Noise inside the plant	Operation			
17 4		Explosion risk	Operation			
17 5		Chemical release	Operation			
18	Carbon foot print		Monetary	21%		
18 1		Construction	Monetary			
18 2		Operation	Monetary			
19	Capital cost		Monetary		20%	4%
20	Operating cost		Monetary		30%	6%
21	Whole life cost		Monetary		50%	11%

Table 109: Weighting results

I.2 TECHNICAL SCORING RESULTS

I.2.1 GLOBAL RESULTS

Based on the weighting presented above, the results of the technical scoring are as follows:

I. Option 4 with 728.6 points
II. Option 2 with 660.28 points and
III. Option 3 with 629.6 points

The details are given in Table 110: Technical scoring results hereinafter.

	N°	Criteria	N. Szoke	D. Celmer	A. Permut	A. Zaleski	A. Fioravanti	D. Lamarre	K. Upendrakumar	D. Gibson	JY Bontonou	V. Landragin	K. Smyrski	R. Hahlweg	J. Hestad	J. D'Ariès	Average scores	Weight	Weighted scores
Option 2			10	10	10	10	10	10	10		10	10					10.00		0.00
Option 3	1	Ability to meet all the license requirements	10	10	10	10	10	10	10		10	10					10.00	0.00%	0.00
Option 4			10	10	10	10	10	10	10		10	10					10.00		0.00
Option 2			10	10	10	10	8	7	8		9	8					8.89		66.49
Option 3	2	Reliability and risk of failure	8	8	9	7.5	8	6	9		10	7					8.06	7.48%	60.26
Option 4			9	7	7	5	9	8	10		9	9					8.11		60.67
Option 2			10	10	10	10	7	8	8		10	8					9.00		70.38
Option 3	3	Redundancy / Availability of the plant	9	10	10	10	8	9	8		10	9					9.22	7.82%	72.12
Option 4			9	9	8	10	10	10	10		10	10					9.56		74.72
Option 2			10	10	10	10	7	9	10		9	7					9.11		0.00
Option 3	4	Sensitivity of operation and cost to the sewage quality (short term variability)	10	10	10	10	8	9	9		10	7					9.22	0.00%	0.00
Option 4			10	10	10	10	9	9	8		10	10					9.56		0.00
Option 2			10	10	10	7.5	7	8	8		9	9					8.72		35.59
Option 3	5	Ability to operate at low DWF (diurnal)	9	10	10	7.5	8	9	9		10	6					8.72	4.08%	35.59
Option 4			9	10	10	10	10	10	10		10	8					9.67		39.44
Option 2			10	10	10	10	10	10	10		9	10					9.89		40.35
Option 3	6	Ability to accomodate WWF	10	9	10	7.5	10	10	10		10	10					9.61	4.08%	39.21
Option 4			10	8	10	7.5	10	10	10		10	10					9.50		38.76
Option 2			10	10	10	7	10	10	10		10	10					9.67		55.87
Option 3	7	Track records in similar climate / confidence in the technology	8	9	8	10	8	8	10		8	7					8.44	5.78%	48.81
Option 4			9	10	10	10	10	10	10		10	10					9.89		57.16
Option 2			8	8	8	8	7	8	10		8	7					8.00		19.04
Option 3	8	Flexibility regarding denitrification	10	10	10	10	9	9	8		10	9					9.44	2.38%	22.48
Option 4			9	10	10	8	10	10	8		10	10					9.44		22.48
Option 2			10	10	10	7	8	10	8		8	7					8.67		20.63
Option 3	9	Flexibility to upgrade to more stringent requirements (TN&TP, WWF, disinfection)	10	9	10	7	9	8	10		9	8					8.89	2.38%	21.16
Option 4			9	8	8	10	10	10	10		10	9					9.33		22.21
Option 2			8	8	8	6	7	7	8	8	8	7					7.50		38.25
Option 3	10	Expandability / modularity	9	9	9	6	8	7	9	9	9	8					8.30	5.10%	42.33
Option 4			10	10	10	10	10	10	10	10	10	10					10.00		51.00
Option 2			8	8	8		7	7	9	9	8	8.33					8.04		75.15
Option 3	11	Ease of construction	6	6	6		8	7	10	8	7	6.67					7.19	9.35%	67.18
Option 4			10	10	10		10	10	10	10	9.5	10					9.94		92.98
Option 2			10	9	10	10	9	10	10	9	8.75	9.5	8	8.50	8	8.50	9.16		7.79
Option 3	12	Environmental impact / sustainability	8	8	8	8	9	9	9	8	8.75	8.5	7	7.50	7	8	8.13	0.85%	6.91
Option 4			9	7	7	5	8	8	8	7	9	8	7	7.50	8	8.75	7.66		6.51
Option 2			6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76					6.76		11.50
Option 3	13	Construction duration	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47					6.47	1.70%	11.00
Option 4			10	10	10	10	10	10	10	10	10	10					10.00		17.00
Option 2													8	7	8	7.67	7.67		72.99
Option 3	14	Ease of operation											7	7.33	7	6	6.83	9.52%	65.05
Option 4													10	9.67	10	8	9.42		89.65
Option 2			10	10	10	10	9	10	10		10		7	7	7		9.09		33.09
Option 3	15	Ability to recover Phosphorus	9	9	9	10	9	9	10		8		9	9	9		9.09	3.64%	33.09
Option 4			6	6	6	6	5	6.7	5		6		5	4	5		5.52		20.09
Option 2													8	5	7	9	7.25		69.02
Option 3	16	Ease of maintenance											8	5	7	7	6.75	9.52%	64.26
Option 4													9	10	10	9	9.50		90.44
Option 2													9	7.60	8	8.60	8.30		44.16
Option 3	17	Operator safety											8	7.20	7	8	7.55	5.32%	40.17
Option 4													9	8	9	8.20	8.55		45.49

Table 110: Technical scoring results

Note: Not all scorers scored all criteria. The impact of this inconsistency in scoring is assessed in a sensitivity analysis of the scoring table provided in Appendix 8: Scoring table sensitivity analysis.

I.2.2 THE SPECIFIC CASE OF TRACK RECORDS IN SIMILAR CLIMATE

Biofilter technology is less well known to the CoW members of the scoring team than the standard activated sludge processes. A list of relevant references for biofilters is given in the Appendix 9: Biofilter list of references. These were made available to all scorers and discussed during the option review workshop. The EAP acknowledged during the review workshop that the process technologies of the three pre-selected options were all reliable with respect to the existence of a sufficient number of successful references around the world.

I.2.3 THE SPECIFIC CASE OF THE CONSTRUCTION DURATIONS

The construction durations of each option are assessed as follows:

- Option 2: 45 months
- Option 3: 46 months
- Option 4: 34 months

These values are indicative and comparative durations. The differences between the construction duration of the options come arise from:

1. Lead time for equipment
2. Extent of civil works
3. Extent and methods of erection
4. and complexity of commissionin

In particular, differences in the commissioning requirements of each option have a significant impact on the construction durations. A first draft commissioning plan for each option is presented in Appendix 10: Commissioning plans which illustrates this point. The global construction schedules are given in the Appendix 11: Construction schedules.

Note: the schedules presented in Appendix 11 are based on the business as usual procurement strategy which is a Design - Bid - Build process.

II. CAPEX AND OPEX ESTIMATIONS

-ooOoo-

II.1 CAPEX ESTIMATIONS

		OPTION 2	OPTION 3	OPTION 4
MECHANICAL EQUIPMENTS				
HEADWORKS	uc	3,862,587.51	3,862,587.51	3,862,587.51
PRIMARY CLARIFIERS	uc	842,169.07	842,169.07	905,885.81
BIOREACTORS (IFAS prop. Tech. not included)	uc	21,452,124.42	6,186,726.30	
BIOREACTORS (IFAS prop. Tech.)	uc	10,413,735.30		
Among which the following propriatary technology package		6,900,000.00		
BIOFILTERS	uc		25,911,911.71	36,634,859.92
Among which the following propriatary technology package			9,400,000.00	14,000,000.00
SECONDARY CLARIFIERS	uc	4,710,427.48	4,898,844.58	695,977.04
CSO BALLASTED PRIMARY CLARIFIERS	uc	9,308,613.61	9,308,613.61	9,308,613.61
Among which the following propriatary technology package		3,340,076.38	3,340,076.38	3,340,076.38
DISINFECTION - CHLORINATION	uc	87,076.56	87,076.56	87,076.56
OTHER MECHANICALS	uc	697,087.00	2,554,210.14	3,420,865.03
TOTAL M&E	uc	51,373,820.96	53,652,139.49	54,915,865.48
CIVIL WORKS COSTS		59,203,071.63	66,386,686.25	35,544,794.17
GENERAL CONTRACTING		9,065,202.32	9,795,683.69	7,419,386.73
SITE WORKS	uc	11,511,088.88	11,511,088.88	11,511,088.88
UV DISINFECTION	uc	2,344,045.00	2,344,045.00	2,344,045.00
UPGRADE COSTS	uc	11,680,924.61	11,680,924.61	9,198,709.99
BY-PASS AND OUTLET PIPES	uc	12,991,708.13	12,991,708.13	12,991,708.13
SLUDGE STORAGE	uc	7,257,937.50	7,257,937.50	7,257,937.50
ODOUR TREATMENT	uc	4,237,183.91	4,237,183.91	4,237,183.91
STANDBY EMERGENCY POWER UPGRADE	uc	3,440,262.38	3,440,262.38	3,440,262.38
DAF SLUDGE THICKENER	uc	7,257,937.50	7,257,937.50	0.00
SITE COSTS	uc	19,097,278.18	20,624,841.12	11,908,878.57
CONTINGENCIES FOR CONSTRUCTION CHANGE ORDERS	uc	19,946,046.10	21,118,043.85	16,076,986.07

Table 111: CAPEX of the 3 pre-selected options estimation w/o R&O

II.2 OPEX ESTIMATIONS

OPTION 2	2010	2015	2020	2025	2030	2035	2040	2045
OPEX elec (*)	481,500	532,551	583,601	634,651	685,702	736,752	787,803	838,853
OPEX chemical (*)	242,919	279,564	316,209	352,854	389,500	426,145	462,790	499,435
OPEX Sludge (*)	562,335	613,724	665,113	716,502	767,891	819,280	870,668	922,057
OPEX - others (*)	451,484	476,258	501,031	525,805	550,579	575,353	600,127	624,901
OPEX total (*)	1,738,238	1,902,096	2,065,955	2,229,813	2,393,671	2,557,530	2,721,388	2,885,247

(*) Expressed in cost unit

Table 112: OPEX evolution from 2010 to 2045 for option 2

OPTION 3	2010	2015	2020	2025	2030	2035	2040	2045
OPEX elec (*)	396,008	445,630	495,252	544,874	594,497	644,119	693,741	743,363
OPEX chemical (*)	248,949	286,503	324,058	361,613	399,168	436,723	474,278	511,832
OPEX Sludge (*)	594,535	648,867	703,198	757,530	811,861	866,193	920,524	974,856
OPEX - others (*)	457,784	482,558	507,332	532,105	556,879	581,653	606,427	631,201
OPEX total (*)	1,697,276	1,863,558	2,029,841	2,196,123	2,362,405	2,528,687	2,694,970	2,861,252

(*) Expressed in cost unit

Table 113: OPEX evolution from 2010 to 2045 for option 3

OPTION 4	2010	2015	2020	2025	2030	2035	2040	2045
OPEX elec (*)	363,026	403,526	444,025	484,524	525,024	565,523	606,022	646,522
OPEX chemical (*)	790,852	910,155	1,029,459	1,148,762	1,268,065	1,387,368	1,506,671	1,625,974
OPEX Sludge (*)	878,961	959,285	1,039,609	1,119,932	1,200,256	1,280,580	1,360,903	1,441,227
OPEX - others (*)	468,607	493,381	518,155	542,929	567,703	592,477	617,251	642,025
OPEX total (*)	2,501,447	2,766,347	3,031,247	3,296,147	3,561,047	3,825,947	4,090,847	4,355,747

(*) Expressed in cost unit

Table 114: OPEX evolution from 2010 to 2045 for option 4

II.3 R&O MATRIX

I. RISKS TABLE

Risk Description	Risk owner	Impact	Ranking	Likelihood	Severity	Risk Score	Action Plan & Expected Result	Risk Cost: Project Manager	Risk Cost: In budget
			Only for R&O owned by the Program						
Construction									
Geotechnics	Program	Additional cost + delays. The risk is assessed as follows : 20% increase on price of buildings x 50% occurrence of the risk		50%			Launching a geotechnical survey as soon as the process is selected and the localization of the main works is roughly known. Meanwhile the risk as to be considered in CAPEX estimation		
Option 2				50%	3,594,922			1,797,461	
Option 3				50%	3,574,604			1,787,302	
Option 4				50%	1,711,604			855,802	
Impact of winter on the CW	Program	Winter => 20% increase on price of concrete. 30 month duration will imply at least 2 winters (4 months each), 36 and 40 months duration will imply at least 3 winters							
Option 2				33%	3,882,337			1,294,112	
Option 3				30%	4,809,936			1,442,981	
Option 4				27%	2,777,650			740,707	
Intermediate pumping station	Program	we considered that intermediate pumping plants will be needed for options 3 and 4. For option 2 it is likely that we could do without one but it has to be checked.							
Option 2				50%	2,579,850			1,289,925	
Option 3					2,579,850				
Option 4					2,579,850				
Reuse of existing equipments for secondary clarifiers	Program								
Option 2		Equipements are upgraded							
Option 3		Equipements are upgraded							
Option 4		Equipments are reused		50%	551,603		Refurbishment cost assessed as 25% of eqt cost	275,802	

Total risks option 2	4,381,499
Total risks option 3	3,230,283
Total risks option 4	1,872,310

Table 115: Risks form

Note: for option 4, the risk that the Regulator doesn't approve the recourse to a chemicaly P removal process cannot be included in the R&O matric for the following reasons:

- Its approval (or not) will be given before any option 4 specific expenses is done and
- The flexibility and modularity of option 4 allows to turn the option into a bio-P process, as shown in Appendix 12: Assessment of options 2 and 4 possible delivery options.

II. OPPORTUNITIES TABLE

Description	Nature	Action Plan & Expected Result	Success Likelihood	Total Impact	Opportunity Gain: Project Manager	Opportunity Gain: In Budget
Interconnection piping and valves above ground						
Option 2		Option 2 shall have less interconnecting pipes and valves above ground than option 3				
Option 3						
Option 4		Option 4 shall have less interconnecting pipes and valves than options 2 and 3				
Odour treatment						
Option 2		The option with a smaller size will generate less air volume to treat				
Option 3						301,768
Option 4						2,049,965
Roads and external works						
Option 2		The different options don't have the same footprint thus the roads and external works won't be the same for all three options.				30,580
Option 3		Roads estimations : option 2 : 530 m new roads / option 3 : 750 m new roads / option 4 : 285 m new roads				24,080
Option 4		Fence estimations : option 2 : 1570 m / option 3 : 1500 m / option 4 : 1450 m				105,915

Total opportunities option 2	30,580
Total opportunities option 3	325,848
Total opportunities option 4	2,155,880

Table 116: Opportunity form

II.4 FINAL RESULTS

		OPTION 2	OPTION 3	OPTION 4
MECHANICAL EQUIPMENTS				
HEADWORKS	uc	3,862,587.51	3,862,587.51	3,862,587.51
PRIMARY CLARIFIERS	uc	842,169.07	842,169.07	905,885.81
BIOREACTORS (IFAS prop. Tech. not included)	uc	21,452,124.42	6,186,726.30	
BIOREACTORS (IFAS prop. Tech.)	uc	10,413,735.30		
Among which the following propriatary technology package		6,900,000.00		
BIOFILTERS	uc		25,911,911.71	36,634,859.92
Among which the following propriatary technology package			9,400,000.00	14,000,000.00
SECONDARY CLARIFIERS	uc	4,710,427.48	4,898,844.58	695,977.04
CSO BALLASTED PRIMARY CLARIFIERS	uc	9,308,613.61	9,308,613.61	9,308,613.61
Among which the following propriatary technology package		3,340,076.38	3,340,076.38	3,340,076.38
DISINFECTION - CHLORINATION	uc	87,076.56	87,076.56	87,076.56
OTHER MECHANICALS	uc	697,087.00	2,554,210.14	3,420,865.03
TOTAL M&E	uc	51,373,820.96	53,652,139.49	54,915,865.48
CIVIL WORKS COSTS		59,203,071.63	66,386,686.25	35,544,794.17
GENERAL CONTRACTING		9,065,202.32	9,795,683.69	7,419,386.73
SITE WORKS	uc	11,511,088.88	11,511,088.88	11,511,088.88
UV DISINFECTION	uc	2,344,045.00	2,344,045.00	2,344,045.00
UPGRADE COSTS	uc	11,680,924.61	11,680,924.61	9,198,709.99
BY-PASS AND OUTLET PIPES	uc	12,991,708.13	12,991,708.13	12,991,708.13
SLUDGE STORAGE	uc	7,257,937.50	7,257,937.50	7,257,937.50
ODOUR TREATMENT	uc	4,237,183.91	4,237,183.91	4,237,183.91
STANDBY EMERGENCY POWER UPGRADE	uc	3,440,262.38	3,440,262.38	3,440,262.38
DAF SLUDGE THICKENER	uc	7,257,937.50	7,257,937.50	0.00
SITE COSTS	uc	19,097,278.18	20,624,841.12	11,908,878.57
CONTINGENCIES FOR CONSTRUCTION CHANGE ORDERS	%	10%	10%	10%
CONTINGENCIES FOR CONSTRUCTION CHANGE ORDERS	uc	19,946,046.10	21,118,043.85	16,076,986.07
CAPEX RISKS & OPPORTUNITIES				
Risks	uc	4,381,498.58	3,230,282.50	1,872,310.40
Opportunities	uc	30,580.00	325,848.08	2,155,880.44
TOTAL CAPEX RISKS & OPPORTUNITIES	uc	4,350,918.58	2,904,434.42	-283,570.04
TOTAL CAPEX PROJECT VALUE	uc	223,757,425.00	235,202,916.00	176,563,276.00
OPEX RISKS & OPPORTUNITIES				
Risks	uc			
Opportunities	uc			
TOTAL OPEX RISKS & OPPORTUNITIES	uc			
TOTAL OPEX PROJECT VALUE (average 2010 - 2031)	uc	2,082,340.00	2,046,468.00	3,057,737.00
WHOLE LIFE COST (Construction + 30 year operation NPV with 6% discount rate)	uc	234,311,677.00	243,435,624.00	215,322,052.00

All solution CAPEX Excluding : decommissioning costs

OPEX including sludge hauling cost and excluding : HVAC on operation and human resources

Table 117: CAPEX and OPEX estimations for the 3 pre-selected options

Note: different delivery options have been assessed for the options 2 and 4 in order to check if their ranking could be impacted. These delivery options are presented in Appendix 12 and consist of:

- Assessment of construction phasing,
- Assessment of option 4 modularity (in regard to bio-P),
- Assessment of option 4 flexibility in regard to i) de-nitrification as a future option and ii) use of DAF to equalise the sludge volume between the two options.

III. CARBON FOOTPRINT ESTIMATIONS

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III.1 OPTIONS 2, 3 AND 4 RESULTS

Tons CO2-e on lifetime (30 years)			
	Option 2 - HYBAS	Option 3 - BioP + Biostyr	Option 4 - Biostyr
Construction	13,784	15,164	9,793
Operation - Electricity	2,067	1,791	1,604
Operation - Coagulant + methanol + polymer	8,758	9,208	30,263
Operation - Process CO2	191,478	104,904	100,269
Operation - Process N2O	58,003	58,003	58,003
Operation - Freight coagulant	1,178	1,095	3,924
Operation - Freight sludge	90,213	97,301	98,074
Operation - Other	-	-	-
Sub-total operation	351,696	272,302	292,136
Total construction	13,784	15,164	9,793
Total Operation	351,696	272,302	292,136
Total	**365,480**	**287,466**	**301,930**

Table 118: Carbon footprint results

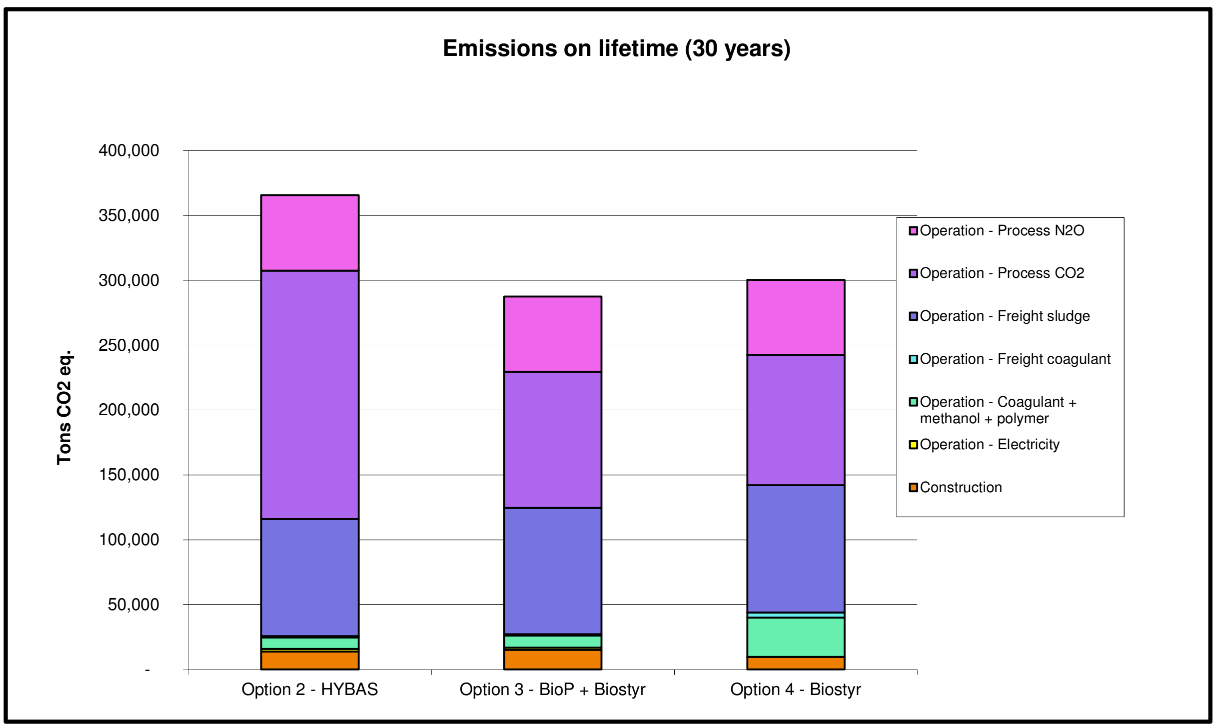

Chart 2: CO2 emissions on lifetime

III.2 INTERPRETATION

The analysis indicates that carbon footprint for construction is not significant compared to that of the operation (construction carbon footprint is less than 4% of the total footprint for all the options as shown in Chart 3: CO2 emissions in representative percentage below.

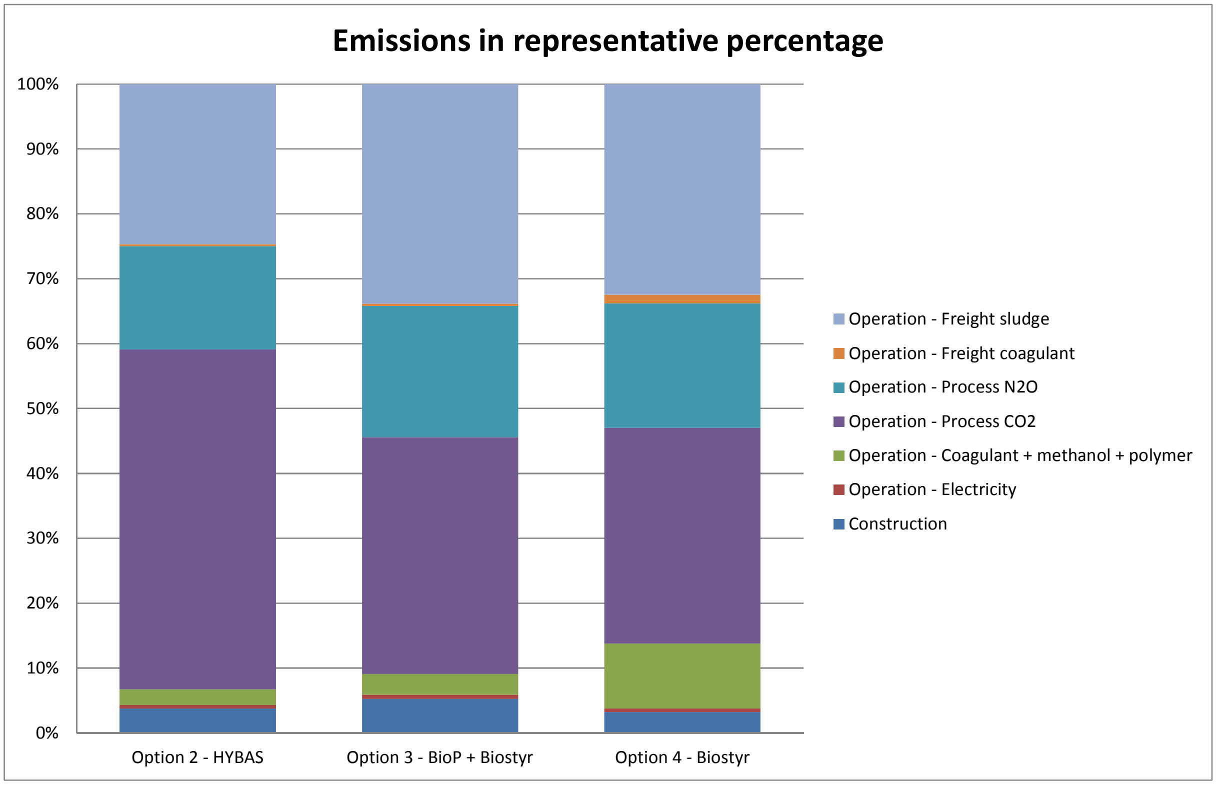

Chart 3: CO2 emissions in representative percentage

Although option 4 uses some chemicals, its global carbon footprint is lower than for options 2 and 3. The main reason is that, in this process, a significant part of the carbon is removed in the primary clarifiers and stored into the sludge when it is mostly oxidised and released as CO_2 in secondary's in the options 2 and 3. Consequently, to be complete and balanced, the carbon footprint calculation should also consider the sludge treatment process.

Since the sludge treatment is not chosen yet, there remain a large number of scenarios that cannot be assessed realistically. Nevertheless, there is for option 4 some significant opportunities for reducing its carbon footprint compared to the other options by chosing a sustainable sludge treatment process. Indeed, by using the carbon stored in the sludge in processes that generate whether bio-gas or fertilizers, option 4 will allow saving some fossil carbon resources.

To capitalize this opportunity which is specific to option 4, the results of the carbon footprint assessment described above are considred relevant.

IV. PROCESS OPTION SELECTION

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IV.1 GLOBAL SCORING OF THE PRE-SELECTED OPTIONS

The combination of the technical and financial scoring gives the following results:

			Average scores	Weight	Weighted scores
Option 2		TECHNICAL SCORING			660.28
Option 3					629.60
Option 4					728.60
Option 2	18	Carbon footprint	7.29	0.00%	0.00
Option 3			10.00		0.00
Option 4			9.50		0.00
Option 2	19	Capital cost	7.33	4.20%	30.77
Option 3			6.68		28.05
Option 4			10.00		42.00
Option 2	20	Operating cost	9.82	6.30%	61.90
Option 3			10.00		63.00
Option 4			5.06		31.87
Option 2	21	Whole life cost	9.12	10.50%	95.74
Option 3			8.69		91.29
Option 4			10.00		105.00

	GLOBAL SCORING
Option 2	848.69
Option 3	811.95
Option 4	**907.46**

Table 119: Global scoring of the 3 pre-selected options

Note: to complete the sensibility analysis already made on the technical results, if the weightings of the financial criteria were equal, the final ranking of the options wouldn't change, as shown hereunder.

WITHOUT WEIGHTING OF FINANCIAL CRITERIA

Option	#	Criterion	Average scores	Weight	Weighted scores
Option 2		TECHNICAL SCORING			660.28
Option 3					629.60
Option 4					728.60
Option 2	18	Carbon footprint	7.29	5.25%	38.25
Option 3			10.00		52.50
Option 4			9.50		49.86
Option 2	19	Capital cost	7.33	5.25%	38.47
Option 3			6.68		35.06
Option 4			10.00		52.50
Option 2	20	Operating cost	9.82	5.25%	51.58
Option 3			10.00		52.50
Option 4			5.06		26.56
Option 2	21	Whole life cost	9.12	5.25%	47.87
Option 3			8.69		45.65
Option 4			10.00		52.50

	GLOBAL SCORING
Option 2	798.20
Option 3	762.81
Option 4	**860.15**

Table 120: Sensitivity analysis to assess the impact of carbon footprint

IV.2 AUDIT OF THE SLUDGE IMPACT ISSUE

As previously discussed, in order to ascertain the validity of the ranking presented above, the Program has audited the impact that the pending sludge issue could have on this final option selection. The scoring in Table 119: Global scoring of the 3 pre-selected options was subject to a review of the practicable sludge options to determine if they would materially impact process selection for SEWPCC.

The treatability of the sludges produced by the 3 probable pre-selected options is deemed to be the same. Consequently, the two main differences between the pre-selected options with respect to sludge treatment are firstly, the importance of the potential for bioP recovery and secondly, the quantity of sludge produced.

The first issue has already been taken into account and scored in the technical evaluation of the main treatment process in each option (criterion #15). Any BioP recovery process required, whatever is the option selected, would be accomplished in an additional process separate from the main treatment. The bioP issue can therefore be considered as financial with respect to its impact on option selection. The second point is purely a financial issue.

Consequently, the Program considers that the type of sludge process selected will not be determined by the main treatment process options. However it is necessary to compare the whole life cost of the total treatment process (main treatment plus sludge treatment) to determine if the combined cost would make a difference to the selection of the main process treatment option. The Program therefore assessed the financial scores each option would receive if a full sludge treatment process was included in the scope of option selection.

To assess the financial impact of sludge treatment the Program assumed the following:

- The assessment can be made on options 2 and 4 only as they are the two extreme options in respect to the sludge production and
- That the sludge treatment process will be within the following alternatives:

ALTERNATIVES	A1	Pelletization	
	A2	Thermal oxidation	
	A3	Composting	
	A4	Landfilling	= sludge treatment in SEWPCC for SEWPCC sludge
	A5	Land application	= current sludge management : all treatment in NEWPCC

Table 121: Unit rates assumption for sludge hauling

In addition, for the numeric calculation we assume that:

- The current OPEX of the sludge treatment in 2010 is: **1.7 MCAD/year** (alternative A5)
- The current sludge production at NEWPCC in 2010 is: **13,000 Dtons/y** at **25%** dry solids
- The sludge hauled from SEWPCC and WEWPCC to NEWPCC are at **4%** dry solids and
- The unit rates for hauling are:

Hauling from SEWPCC to NEWPCC	130 $/truck
Hauling from WEWPCC to NEWPCC	87 $/truck
Hauling from WEWPCC to SEWPCC	43 $/truck

Table 122: Unit rates assumption for sludge hauling

For the capital costs of sludge treatment, the Programs retained the following figures from Stantec's PDR (SEWPCC Upgrading/Expansion Preliminary Design Report, March 31, 2008 – Section 16.6):

2006 values expressed in CAD		CAPEX	OPEX
A1	Pelletization	35,888,000	1,821,000
A2	Thermal oxidation	46,880,000	1,976,000
A3	Composting	29,305,000	3,091,000
A4	Landfilling	27,698,000	1,574,000
A5	Land application	10,430,000	2,056,000

Table 123: CAPEX and OPEX for sludge treatment alternatives from Stantec's PDR (2006)

These monetary assessments were based on a 27.57 Dtons/d sludge production by SEWPCC in 2006. The details of the calculation are given in Appendix 13: Details of calculation of the sludge issue impact.

The NPV calculations of the options 2 and 4 including the sludge treatment are:

		Water process option		
	Sludge alternative	Option 2	Option 4	Difference
NPV total (water + sludge treatments)	A1 - pelletization	267.03	257.99	-CAD 9.04
	A2 - thermal oxidation	274.80	261.01	-CAD 13.79
	A3 - composting	275.31	260.62	-CAD 14.69
	A4 - landfilling	257.90	246.04	-CAD 11.85
	A5 - land application	256.93	246.50	-CAD 10.43

Table 124: NPV results including the sludge treatment

Important note: compared to the NPV results presented in Table 117: CAPEX and OPEX estimations for the 3 pre-selected options, the sludge hauling has been removed from the "water NPV" calculation.

These results suggest that although it would reduce the gap between the whole life NPV for the options, the sludge issue won't change the monetary ranking nor the global one (refer to the tables herebelow).

A1 - Pelletization		GLOBAL SCORING
Option 2		859.31
Option 4		**913.05**

A2 - Thermal oxidation		GLOBAL SCORING
Option 2		857.08
Option 4		**918.81**

A3 - Composting		GLOBAL SCORING
Option 2		855.63
Option 4		**920.27**

A4 - Landfilling		GLOBAL SCORING
Option 2		857.21
Option 4		**910.81**

A5 - Land application		GLOBAL SCORING
Option 2		855.90
Option 4		**909.13**

Table 125: Global scoring with the sludge treatment alternatives

Consequently, the pending sludge issue can be considered not to have any significant impact on the process selection of SEWPCC.

IV.3 CONCLUSION AND RECOMMENDATION

Based on the results of the technical and financial assessment of the three pre-selected options and after having ascertained that the scoring procedure was relevant and comprehensive enough not to jeopardize in any way the best interest of the project, the Program recommends the following ranking of process options for SEWPCC to meet the Project objectives:

- Preferred option: **option 4** based on biofilter technology
- 2nd preferred option: **option 2** based on IFAS technology
- 3rd preferred option: **option 3** based on an hybrid technology (activated sludge + biofilters)

During the Process Selection Report presentation, some issues have been raised that will have to be addressed in the next steps. They are listed in Appendix 14: Issues to be addressed in the next steps.

APPENDICES

Appendix 1: Review workshop guideline

Appendix 2: Stantec's option G estimate

Appendix 3: EAP report

Appendix 4: Pre-scoring scan results

Appendix 5: Benchmark analysis details

Appendix 6: Civil works bill of quantities methodology

Appendix 7: CO_2 emission factors database

Appendix 8: Scoring table sensitivity analysis

Appendix 9: Biofilter list of references

Appendix 10: Commissioning plans

Appendix 11: Construction schedules

Appendix 12: Assessment of options 2 and 4 possible delivery options

Appendix 13: Details of calculation of the sludge issue impact

Appendix 14: Issues to be addressed in the next steps

Appendix 15: Presentation of January 24, 2011

Appendix 16: Presentation of January 27, 2011

Appendix 17: Presentation of April 29, 2011