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Technical Memorandum

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CC	File		
Subject	Iqaluit Wastewater Treatment Plant (WWTP) Technical Overview of 2005 Secondary Sewage Treatment Design		
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INTRODUCTION

The basis for the overview originates primarily from the Earth Tech report entitled, *Final Conceptual Design Report – Iqaluit WWTP Conversion & Expansion* (July 2004). The review also draws upon the information provided in the *Iqaluit WWTP – Phase 2 Issued for Tender* drawings and specifications.

In order to have a complete context of the wastewater treatment project, a brief timeline of the project development over the past 14 years is presented as follows:

- 1997 – design/build tender issued by the City of Iqaluit for a complete WWTP
- 1998 – design/build tender awarded to Hill-Murray for membrane bioreactor (MBR) facility (GE - Zenon ZeeWeed process)
- 2000 – problems with the project became apparent when commissioning began; in particular, the structural integrity of concrete aeration basins
- 2000 – CH2M-Hill (no relation to Hill-Murray) retained to review structural integrity of concrete aeration basis; review concluded that design and construction were deficient
- 2000 – UMA (Ken Johnson, P.Eng.) retained for review of contract management (as part of overall review of Iqaluit contract management); review concluded that the contractual framework executed by Iqaluit and contract management applied by Iqaluit were deficient
- 2001 – work executed to improve structural integrity of aeration basins; during this time contractual relationship with Hill-Murray was terminated
- 2002 – Earth Tech (Glenn Prosko, P.Eng., project manager) retained to undertake a complete review of facility; the review concluded that there are major deficiencies on all aspects of the project, and that the current facility, as it was designed and constructed by Hill-Murray, could not be commissioned
- 2003 – Earth Tech retained to provide engineering for upgrading of facility to provide functional secondary treatment system; a decision was made to abandon MBR process and advance conventional activated sludge process making use of existing infrastructure wherever possible
- 2004 – Earth Tech directed to prepare a three phase design for tender and construction; Phase 1 to provide primary treatment for a population equivalent of 12,000 and Phase 2 to provide secondary treatment for a population equivalent of 8,000 (Phase 3 to provide secondary treatment for a population equivalent of 12,000)

- 2005 – Phase 1 of project commissioned; work included a building and an addition to the existing structure, which houses a lift station, manual inlet screens, two mechanical auger screens, and Salsnes Filter (primary filter); the remainder of the facility remains unused
- 2005 – Earth Tech advanced the detailed design of Phase 2 of the facility with 90% complete tender documents; Earth Tech directed by the City not to advance the tender because capital funding of $7 million not available for Phase 2
- 2006 – Iqaluit water license renewal (Ken Johnson, P.Eng., technical advisor) ; stakeholders to water license "encouraged" City to advance the secondary treatment phase of the project
- 2011 – Iqaluit preparing for water license renewal and, as part of this process, engaged AECOM (formerly Earth Tech) to prepare a technical overview of the 2005 design documentation as a benchmark for advancing the completion of secondary sewage treatment in the future.

PROCESS REVIEW

Background

The intent of this process review is to establish whether or not the proposed wastewater treatment plant design remains valid from both a regulatory and a technology perspective.

The challenge presented in the 2004 design (Earth Tech now AECOM) of the Iqaluit WWTP was to incorporate existing elements from the abandoned 2000 MBR plant design into a more practical configuration. This was achieved with the development of a nitrifying/denitrifying activated sludge process. Utilizing this process allowed for the re-use of the existing concrete tankage and the majority of the process equipment already on site. The design also provided sufficient flexibility for future expansion to accompany population growth.

Regulatory Considerations

At the time of design, the City of Iqaluit was operating under a water license that stipulated effluent BOD and TSS concentrations of 120 and 180 mg/L, respectively. Earth Tech developed a design that would be capable of meeting requirements more in keeping with those typically used for secondary wastewater treatment plants. In addition to BOD and TSS reduction, it was further determined that ammonia reduction would be beneficial to eliminate the likelihood of effluent toxicity. The 2004 design report presented the effluent requirements and design objectives outlined below in Table 1. The requirements were based upon discussions and consideration of the regulatory responsibilities of Environment Canada, Indian and Northern Affairs, Fisheries and Oceans, Nunavut Department of Health and Social Services, and the Nunavut Water Board.

Table 1 – Effluent Requirements

Effluent Requirement	Effluent Criteria[1]	Design Objective
BOD	45 mg/L	20 mg/L
TSS	45 mg/L	20 mg/L
Ammonia	10 mg/L	10 mg/L

[1] *Based on monthly averages of 24-hour daily composite samples.*

Although Nunavut is not a signatory to the Canadian Council of the Ministers of the Environment's (CCME's) *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* that forms the basis for the proposed national *Wastewater Systems Effluent Regulations*, it is assumed that a plant being designed for secondary treatment in the territory would use the regulations as a guiding objective. As such, we assume that the plant would be required to meet the objectives outlined below in Table 2.

Table 2 – Proposed Effluent Requirements

Effluent Requirement	Effluent Criteria[2]
BOD	25 mg/L
TSS	25 mg/L
Un-Ionized Ammonia	1.25 mg/L

Comparing the design objectives in Table 1 to the proposed effluent criteria noted in Table 2, it appears that the plant design is still valid in this emerging regulatory environment.

To relate the un-ionized ammonia noted in Table 2 to the ammonia concentration noted in Table 1, a relationship is used that is a function of pH (at a temperature of 15°C). This relationship is as follows:

$$\text{Un-Ionized Ammonia} = \text{Total Ammonia} \div (1 + 10^{(9.56\text{-pH})})$$

Based on a typical wastewater pH and an effluent total ammonia concentration of 10 mg/L, an un-ionized ammonia concentration greater than 1.25 is virtually impossible to attain. For example, at an effluent pH of 7.5 and a total ammonia concentration of 10 mg/L, the resulting un-ionized ammonia concentration would be 0.09 mg/L.

Technology Considerations

Design Basis

The 2004 plant design report considers two phases of design based on two population horizons – 8,000 and 12,000 persons. The current baseline census population (2006) according to Iqaluit's General Plan is set at 6,520. At a medium growth rate of 2.87% per year, the population is anticipated to reach 8,000 persons by the year 2014 and 12,000 persons by the year 2028.

The initial intent of the design was to implement two phases of secondary treatment at the two population horizons. However, as project funding became a limiting issue, a three phased approach was developed. This approach is as follows:

- Phase 1 – implementation of equivalent to primary treatment (Salsnes Filter) for a population up to 12,000;
- Phase 2 – addition of secondary treatment for a population up to 8,000 and solids handling processes for a population up to 12,000; and
- Phase 3 – expansion of the secondary treatment for a population up to 12,000.

[2] *Based on defined averages (monthly or quarterly; depending on plant size).*

While this phasing approach was valid in 2004/05, it may not be prudent in 2011/12. If the population projections are accurate, by the time the plant is built for the Phase 2 secondary treatment addition, it will already be at its design horizon. For this reason, it may be more practical to add the secondary treatment and solids handling processes for the 12,000 build out population as part of a single phase. This assumes that the phasing strategy and the re-use of existing infrastructure outlined in the 2004 report is still the desired way to proceed. If not, a new purpose-built facility could be considered that can be phased more appropriately, rather than basing the phasing on existing infrastructure. A life cycle cost analysis comparing the two approaches should be undertaken if this project is to be advanced further.

Another area to be considered further is the per capita loads used in the 2004 report for BOD, TSS and TKN. In the absence of plant influent data, typical North American values were applied for these constituents. It is recommended that the City undertake an influent sampling program in advance of additional design work to help to confirm the validity of that proposed in the 2004 report. A similar approach would involve the examination of any available plant flow data. This would be useful in helping to identify the true peaking factors for maximum month, day and peak hour flows.

Technology

Aside from the potential challenges noted above regarding the phasing strategy and the current population projections, the design approach itself remains valid in today's context. The secondary treatment process has been designed to meet the proposed national effluent guidelines, while producing a non-toxic effluent. The overall design presented (secondary treatment and solids handling) also provides for a relatively straightforward operation, with modest maintenance requirements.

From a technology perspective, assuming the phasing approach matches that in the 2004 design report, there may be issues revolving around the Salsnes Filter. The recommended approach to secondary treatment presented in the 2004 design report is predicated on the presence of an equivalent to primary treatment process. It is the availability of this process that allows for a reduced organic and solids load entering the secondary treatment process. This process is capable of reducing the organic load by as much as 30% and the solids load by as much as 50%. However, by having this singular unit with no redundancy, the additional load would have to be fully treated by the secondary process were the sole unit to be out of service. This would be acceptable in the near term, when the secondary plant is under loaded, but would become a problem as the plant neared its design capacity.

It is our understanding that since it has been installed, the Salsnes Filter has not proven itself to be a completely reliable unit process. On certain occasions, the process has to be bypassed with preliminary screened wastewater being directed to an existing lagoon. Going forward, it would be preferable to add a redundant unit, or proceed with a purpose-built facility that would accommodate the additional loads that would be present in the absence of primary treatment.

TECHNICAL DISCIPLINE REVIEW

General

The deferral of a project in the detailed design phase of the work creates a need to validate the design and tender documentation at the time when the documentation is brought "off the shelf." The validation effort required depends upon the time elapsed. If the time lapse is reasonably short, say two years or less, then the validation process may be a reasonably simple review by the engineers of record and a "resealing" of the design drawings. The simplicity ultimately depends upon the availability of the engineer of record, and the level of comfort the engineer may have on executing the design after the elapsed time.

If the elapsed time is over two years, then a significant review may be required to validate the design and tender documentation. The reasoning for the review are threefold – firstly, the in situ conditions of the site, which directly influence the design, may have changed, therefore the engineer of record is obliged to ascertain the nature and extent of any site changes and revise the design accordingly; secondly, the technology influencing the design may have changed, therefore the engineer of record is obliged to ascertain the nature and extent of the technology changes and revise the design accordingly; and thirdly, the regulatory framework influencing the design may have change, therefore the engineer of record is obliged to ascertain the nature and extend of the regulatory changes and revise the design accordingly. In addition, the engineer of record may not be available at the time of the validation of design and tender documentation; therefore, a new engineer of record must review and validate the design and tender documentation.

Process Mechanical

The process and instrumentation drawings (P&ID's) are estimated to be in an 80% stage of completion and would require the new engineer of record to examine the line/pipe sizes to ensure they are adequate. The process mechanical drawings are also estimated to be in an 80% stage of completion and would require the new engineer of record to complete a review.

The technical specifications have not evolved a great deal over the past seven years; the Division 11 specifications are still relevant. The new engineer of record would need to check the capacities of each unit process and whether the named acceptable vendors are still applicable. There is no specification for the polymer system, which will have to be developed.

As this equipment has been on site in excess of 10 years, it is necessary for a process mechanical engineer to go to the site and undertake a condition assessment. This would also involve some preliminary liaison with the equipment vendors to determine if there are any pitfalls with re-using this equipment.

Building Mechanical

The building mechanical drawings are estimated to be in an 80% stage of completion. The review suggests that there may be an opportunity to improve the constructability of the building mechanical installations given the available limited space in the existing WWTP. This would require a reworking of the heating and ventilation drawings. The location for the oil boilers may also be too tight for current design practices, which may require a reworking of the facility layout.

The heating and ventilation drawings appear to have been completed to a commercial standard, which does not provide as "robust" a system as an industrial standard. An industrial standard would incorporate design changes to provide an increased degree of redundancy, such as a third boiler and a larger air handling unit.

The current design documentation does not include any heating and ventilation commissioning, which places the commissioning burden on the Owner (and Consultant) as opposed to the Contractor. Section 15999 - Mechanical in the technical specifications includes equipment schedules; some of the equipment manufacturers selected in the schedule are no longer in business, so the equipment will need to be reselected.

Structural

The structural drawings are estimated to be in an 80% stage of completion. Some of the details still need to be coordinated, and a considerable effort will be required to re-orient the engineer of record to the existing conditions of the plant given that the project is renovation and not new-build.

Structural specific items that should be noted are:

- Specifications are substantially complete, but more comprehensive and coordinated specifications have been developed over the last five years; therefore, specifications would be completely redone prior to going to Tender.
- The current design was completed to NBC 1995 and the current code in effect is NBC 2010. Some significant changes to Part 4 (structural design) have been made since NBC 1995 and critical infrastructure (such as sewage treatment plants) is now required to be designed as a post-disaster structure. That is, the NBC will require this building to be designed to greater snow and wind loads than typical structures; therefore, design review and revision of the building shell structural members will be required.
- The structural drawing presentation does not match current AECOM standards; drawing reorganization and clarification of details will be required.
- Structural design of the clarifier tanks will need to be reviewed and possibly modified; the arrangement of support piles and base slab reinforcing could be optimized.
- The wall framing design of the clarifier building addition will need to be reviewed and modified. Not all of the framing is clearly shown and what is shown can likely be simplified from a constructability perspective.

Electrical

The electrical drawings are estimated to be in an 80% stage of completion. The work required should include a separate section (typically using Section 16015 of the technical specification) to describe the electrical scope of work. It should briefly describe what the electrical contractor is required to do. It could also describe the construction sequence, especially if this is a plant upgrade.

A revision to Section 16405 of the technical specification is required (coordination and short circuit study) to include Arc Flash Study. Text describing the requirements of the Arc Flash Study should be added.

Instrumentation and Controls

The instrumentation and controls drawings are estimated to be in at a 20% stage of completion. It appears that that some PLC (programmable logic controller) and HMI (human machine interface) equipment was installed and has been operational at the plant. Also, it appears that some I&C (instrument and controls) equipment is installed but has not been operational. The existing controls equipment and software have been at the site for at least seven years, and it is anticipated that the software and computer hardware is obsolete.

In order to complete the design, the following activities need to be completed:

- Revision of Division 17 Specifications including Instrument Index; Instrument list; Instrumentation and Controls Standard Details; and PLCs I/O Lists.
- Revisions of Division 11 (Process) Specifications to include I&C requirements in package supplied equipment.
- Preparation of a drawing which shows: the Control System Architecture; the Bioreactor Local Control Panel layouts and wiring diagrams; and the Clarifiers Local Control Panel layouts and wiring diagrams.
- Revisions to drawings including: P&ID drawings and Instrument Layout drawings.
- Coordinate with Division 15 (HVAC) to include the HVAC major alarms into the SCADA system. HVAC controls will be by a dedicated Building Automation System.

BUDGETARY ESTIMATE FOR VALIDATION OF DESIGN AND TENDER DOCUMENTATION PREPARATION

Advisory.....$50,000

Liaison with City Council / Government of Nunavut / Nunavut Water Board / Regulators on proposed Phase 2 work to obtain an understanding on the overall framework for the design.

Preliminary Engineering $200,000

Site inspections by all technical disciplines to ascertain if site conditions have changed from inspections completed by previous design team in 2003. Observations by all technical disciplines on performance of Phase 1 (primary treatment) process to ascertain opportunities for process modifications as part of Phase 2 project. As well, the operating condition of the equipment installed

during Phase 1 would be inspected to ascertain the maintenance or replacement opportunities or need. Liaison / presentations / submissions to City Council / Government of Nunavut / Nunavut Water Board / Regulators on proposed Phase 2 work. Preparation of preliminary engineering report presenting summary of all preliminary engineering activities, and design criteria for detailed design update phase of project. Engineers of record for previous detailed design work are no longer available to this project; therefore, a considerable effort will be needed for new engineers of record to become familiar with the project and technical information in order to be in a comfortable position to sign off on the design.

Detailed Design $350,000

Updating / revisions / detailing of technical disciplines (process mechanical, building mechanical, structural, electrical and instrumentation and controls) to prepare tender ready drawings and technical specifications. Liaison / presentations / submissions to City Council / Government of Nunavut / Nunavut Water Board / Regulators on finalized Phase 2 work.

LIMITATIONS ON THIS REVIEW

This review was based upon a limited review of the existing background information available on the Iqaluit Wastewater Treatment Project by the technical disciplines stated in the review. The intent of this information is to provide a framework for advancing the detailed design of the project once project funding is available. The work did not include the generation of any new technical or cost information, or any environmental or public health and safety related reviews associated with the existing wastewater treatment system, or the proposed wastewater treatment system.

Sincerely,

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Project Manager

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