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Chateh Water Treatment Plant

Category: Project Management

Client/Owner: Dene Tha’ First Nation

Subconsultants: Manasc Isaac Architects Ltd

Contractor: SKMG Construction Ltd.

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VOLVO

Chateh Water Treatment Plant: Getting the Right Fit for the Community

BACKGROUND

The community of Chateh (population 1500) is located in the far northwestern corner of Alberta in the boreal forest region of Canada. This is Dene Tha' reserve land. Like many First Nation communities, or indeed other small, remote communities, contending with water quality issues is a fact of life. As recently as May 2010, a ***Safe Drinking Water for First Nations Act*** was proposed in Parliament recognizing "the unique water challenges facing many First Nation communities" (Indian and Northern Affairs Canada website, April 20, 2011). As of March 31, 2011, there were 107 First Nations communities across Canada under a Drinking Water Advisory (INAC website). The problem is often more pronounced in First Nation communities, as they tend to be isolated; have inadequate water, wastewater and waste servicing; aging facilities and equipment; and due to isolation, find it difficult to find and retain experienced water treatment plant operators. In Chateh's case, the water appeared and tasted undrinkable. The community faced frequent boil water advisories, stemming largely from a turbidity problem. The old water treatment plant could no longer treat the high organic content of the raw source water to Health Canada's standards. The approach to working with these communities is very different from the conventional one: it is far more relationship-based and hands-on. The needs are greater. In this case, ISL's team went beyond normal project management scope for the client in seeking solutions that would solve the water quality issues and also fit with the community: from funding application assistance and bringing key stakeholders together to equipping the plant with basic tools and safety gear, training videos and a custom information and management system that also enables remote troubleshooting. The project even resulted in an additional asset of the community: housing for teachers for the local school.

Some of the Worst Water in Canada...

Drawn from Sousa Creek, the source water for the water treatment plant is particularly poor. The creek's drainage basin is dominated by muskeg and base flow levels are typically low, with the effect that water quality is very high in organics and murky in colour. This is some of the worst water to treat in Canada in terms of the levels of organic material or Total Organic Carbon (TOC), which is in the range of 14 mg/L to 30 mg/L with spikes to 40 mg/L. In comparison, the TOC level in the North Saskatchewan River at Edmonton is typically about 3.0 mg/L. Even the treated water samples from the former water treatment plant showed a range of 10mg/L to 28.5 mg/L, which is two to six times Alberta Environment's recommended limit (<4mg/L) for TOC content prior to adding chlorine.

In addition to the very high level of total organic carbon in the raw water, water monitoring consistently showed levels of aluminum, manganese, iron and colour above the limits of those in Canadian Drinking Water Quality standards. The iron and manganese problem is pretty rare in surface water. Even after treatment at the former plant, the levels of aluminum, manganese and colour in the drinking water remained excessive. This was also of concern as aluminum is regulated in drinking water as a potential neurotoxin.

The aluminum in the surface water compounded the problem of seeking an effective water treatment solution. In the past, and for the former treatment plant, the conventional way to reduce turbidity was to increase the dosage of alum (an aluminum-based coagulant). However, the previous process hadn't been able to remove the residual aluminum content in the treated water. Now, with the raw water in Chateh already having a high background level of aluminum, care had to be taken to not contribute to this problem and also to effectively remove the aluminum in the treated water.

There was an additional, more significant concern about the quality of the treated water from the former water treatment plant. Water quality monitoring samples of Chateh's treated water from the past 12 years showed continued excessively high levels of total trihalomethanes (TTHMs) that were two to three times Health Canada's maximum acceptable concentration of 0.100 mg/L – with occasional spikes to four times the limit. Trihalomethanes are a suspected carcinogen. In December 2008, Chief James Ahnassay of the Dene Tha' First Nation expressed the community's concern in a letter to INAC:

"Our biggest concern with our current plant is the high levels of disinfection byproducts in the drinking water at Chateh. Water samples have shown that the levels of these in the water – both of trihalomethanes (THMs) and haloacetic acids (HAAs) including bromodichloromethane, are significantly above the limits permitted by Health Canada in the Guidelines for Canadian Drinking Water Quality – 2008."

Trihalomethanes are generated when water high in organics comes into contact with chlorine during the normal disinfection process. This is why Alberta Environment has a recommended limit for the amount of Total Organic Carbon in the water prior to adding chlorine, and why the problem of THMs is so closely tied to the problem of water high in organic content. It was evident that the water treatment solution had to address this health risk.

Treated Water (Left) from the Former Water Treatment Plant and Raw Source Water (Right) from Sousa Creek (April 2010)

Building the Case for Better Treatment

The Dene Tha', along with assistance from ISL and Indian and Northern Affairs Canada (INAC), worked to ensure a treated water system that would provide their community with reliable, clean and safe drinking water. However a visit from a Health Canada official in 2005 concluded that the existing treatment processes were incapable of dealing with the poor source water quality.

"Given the challenging source water quality and the inability of the current treatment processes to effectively control chemical and physical parameters within the guideline limits, modifications to the current treatment process or implementation of new treatment technology is required."

(Letter from Health Canada, February 2005)

There was extensive corrosion in the pipes and pumps as well as spalling of concrete in the treated water storage reservoirs. Between 2005 and 2007, a number of upgrades to the raw water supply system were completed by ISL, including raw water reservoir expansion, raw water pumping upgrade, and a raw water transmission line. Two aerated raw water storage reservoirs were constructed to replace the old, small single unit reservoir in 2006. This last addition enabled the community to store more than one year of water demand and helped resolve the water supply issue of ensuring sufficient storage despite the relatively low flow of the creek for most of the year. To further reduce the turbidity problem of the source water, the water is drawn from the creek at the tail-end of the peak flows from spring run-off, when the creek is less turbid and cleaner water is available.

Bringing Stakeholders Together
(Representatives from Dene Tha' First Nation, Health Canada, ISL Engineering and Land Services and SKMG Construction)

The only component that was missing was a new water treatment plant. Unfortunately, the current plant site was too congested to allow for the additional piping and treatment process equipment needed for upgrades. A new site was identified as the most suitable location and set aside for the new water treatment plant in the community planning process. An environmental impact assessment and geotechnical investigation were completed for the new site. Now the community was ready for the new treatment plant.

In 2005, the same year as the Health Canada visit, the Dene Tha' First Nation identified the water treatment plant in Chateh as the highest priority project for the community in its 2006-2010 Capital Plan Submission to INAC. INAC gave the project its highest possible rating (30 points) for these capital projects, in terms of priority for funding. The community upped this to 33.2 points through their own contributions due to their extreme interest in the project going ahead as quickly as possible. Despite the expectation that funding would proceed for the project to proceed in early 2006, and the best efforts from all parties, a budget deficit in INAC meant funding was not forthcoming. Frustrated, but not put off, ISL worked closely with the community and regulatory authorities to press the urgent need for funding based on the water quality issues of the community. Finally, funding became available through INAC from Canada's Economic Action Plan infrastructure stimulus fund, supporting design in the 2008/09 fiscal year.

Finding the Right Fit for the Community

The challenge for ISL was how to provide effective and efficient water treatment for some of the worst source water in Canada and to do so in a manner that would incorporate community needs for this isolated community, including those relating to operability, chemicals, and lifecycle costs. This is believed to be the first dual-membrane water treatment system in a First Nation community in Canada. In addition, this project would also be one of the first to test INAC's first Design Guidelines for First Nations Water Works (2006) in the design and construction of the water treatment plant. Previously, ISL had designed water treatment plants for other First Nation communities based on Alberta Environment's and older federal guidelines for this infrastructure.

ISL'S DESIGN PHILOSOPHY

An appropriate water treatment process is usually selected based on its ability to treat the specific water quality issues of the raw water source. When it comes to securing funding for water treatment infrastructure projects, the capital cost, or initial design-to-construct capital outlay, is often the deciding factor for selecting a water treatment process. There is typically less consideration of how to minimize the cost of running the facility over its expected lifetime – an important consideration for the owner.

In the case of Chateh, a variety of factors informed the design of the water treatment system, including the needs of the owner, operating staff, and INAC. Consequently, the focus was on designing a water treatment system to:

- Produce treated water that meets the Guidelines for Canadian Drinking Water Quality (Health Canada requirements);
- Be as compact as possible;
- Be as efficient as possible;
- Be as operator-friendly as possible (additional client consideration);
- Consume the least amount of chemicals possible (additional client consideration);
- Enable optimal integration of all process equipment for an efficient system; and
- Have the lowest possible life cycle cost (an INAC and client consideration).

Solving the Source Water Quality Problem

ISL went through a number of evaluation measures in order to find the perfect treatment solution for the very poor source water and meet the community's needs for operability and reduced lifecycle costs. These included desktop analysis, pilot study, pre-selection of treatment process, extensive research into final system suppliers, and a progressive tendering process.

First, through desktop research and analysis, the team determined that only a few treatment technologies have the capacity to remove such high levels of organics and reduce the turbidity that was largely the cause of the boil water advisories. Based on this, two major treatment technologies were selected to treat the initial TOC problem of the water quality to Canadian Drinking Water standards: activated carbon (option 4 in the table below) and membrane filtration (options 2, 3, and 5 in Table 1).

Table 1: Comparison of Water Treatment Technologies

Option	Treatment Technology Description	Sufficient Removal?			Impact of Raw Water Quality Fluctuation	Ease of Operation	Estimated Capital Cost	Estimated Operating Cost	Where Installed (Alberta)
		TOC	Aluminum	Manganese					
1	Former Treatment Process	No	No	No	High	Somewhat Difficult	$$	$$	Chateh
2	Enhanced coagulation followed by micro membrane filtration	No	No	No	High	Moderate	$$$$	$$ 1/2	Sucker Creek
3	Conventional treatment process followed by ozone and granular activated carbon filter	Yes	No	No	High	Very Difficult	$$$$$	$$$$	High Level
4	Slow Sand and synthetic media filtration pretreatment followed by nano membrane filtration	Yes	Yes	Yes	Low	Moderate	$$$$	$$$	Driftpile
5	Microfiltration followed by nano membrane filtration	Yes	Yes	Yes	Low	Moderate	$$$$	$$$	Piloted in Chateh

Option 1 in Table 2 represents the former treatment process, which was simply not able to provide sufficient treatment for this source water to meet the current Canadian Drinking Water Quality standards, and is especially not suitable to deal with excessively high TOC levels.

Option 2, the enhanced coagulation followed by micro membrane filtration process, does not sufficiently resolve the water issues, relies heavily on coagulation chemistry and requires constant supervision and operational adjustments, making it more difficult to operate.

Two membrane-based processes were shown to be capable of sufficiently removing TOC, aluminum and manganese: Option 4) the slow sand and synthetic media filtration pre-treatment followed by nano membrane filtration; and Option 5) microfiltration followed by nano membrane filtration. Both were similar in terms of ease of operation, capital and operating costs, and that varying raw water quality would not much impact the effectiveness of the system.

Option 3 is conventional treatment process followed by ozonation and granular activated carbon (GAC) filtration. This system is very costly and complex to both implement and maintain. This treatment system, however, is not designed to deal the high aluminum, iron, and manganese levels. In addition, changes in raw water quality require close monitoring and operational adjustments to maintain consistent treated water quality.

Option 4, involves nano membrane filtration with pre-treatment steps of slow sand and Kinetico/ synthetic media filtration to protect the membranes and prolong the membrane service cycles. The nano membrane filtration is capable of removing 95% of TOC from a raw water source. The main benefit is that operators need not be too concerned about the varying raw water quality as the nano membrane filtration will consistently remove TOC to meet Guideline limits.

In **Option 5** is nano membrane filtration with micro membrane filtration as pretreatment. This is similar to Option 3 except that micro filtration is used to protect the nano membranes instead. The microfiltration will provide superior pre-treatment to remove most of the suspended solids and larger TOC molecules that would otherwise clog up the nano filtration equipment. The nano membrane filtration is very effective at removing most of the impurities from the source water, including colour, aluminum, iron, manganese, and the remaining soluble portion of TOC. This dual membrane system also provides superior protection against *Cryptosporidium* and *Giardia*. The microfiltration enables overall life of the nano membrane to be extended and this system is not subject to raw water quality fluctuations.

Based on this evaluation, it was clear that nano membrane filtration is the only practical and economical treatment technology to sufficiently and consistently remove TOC and other parameters from the raw source water to meet water quality standards. The only question was which pre-treatment technology to use to protect the nano membrane. While microfiltration seemed to be the preferred option from this cursory evaluation, ISL also considered a number of other options.

Pre-treatment Solutions

Because of the very fine pore size of the nanofiltration (NF) membrane, it requires pre-treatment to remove all the larger suspended solids and colloidal particles; otherwise the membrane would frequently be plugged and the operation become very inefficient.

While there were different options for pre-treatment, coagulation followed by microfiltration (MF) was deliberately selected for the following reasons:

- similar nature to the membrane technology;
- one system supplied by one manufacturer;
- reliability and ease of operation of the MF system;
- elimination of the need for conventional flocculation; and
- MF achieves similar levels of organic reduction (~25%) as the conventional enhanced coagulation practice.

An important consideration at this stage was eliminating the need for conventional flocculation as a pre-treatment method. Conventional flocculation requires a higher alum dosage as a coagulant, and would therefore contribute further to the aluminum problem in the water. It also requires more delicate adjustments to coagulant dosage, relying on the operator's experience to determine exactly the right quantity to suit water conditions. In addition it needs a longer flocculation time and a subsequent settling process (and would therefore require additional tankage, control, and maintenance).

As a viable alternative, microfiltration achieves similar levels of organic reduction (~25%) as this conventional practice – while reducing the alum need. In addition, microfiltration protects the nano membranes by reducing the required frequency of cleaning and minimizing the silt buildup, reducing the loading on the fragile nano membrane, and providing 4 Log-removal. It also acts to remove iron, manganese, aluminum and turbidity and the giardia parasite. Microfiltration was clearly the front-runner!

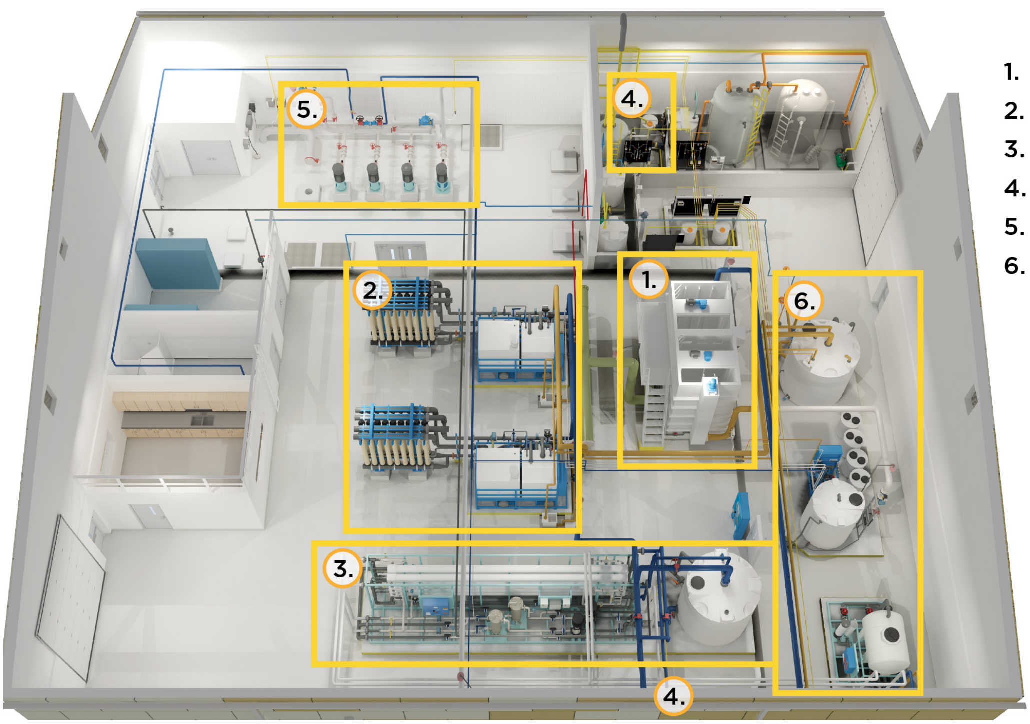
However, it was important to establish that this system would be a good fit for the community. Given the raw water characteristics and design considerations such as remote location and ease of operation, ISL arranged for a pilot study of the microfiltration-nanofiltration combination to be performed between August 2005 and March 2006 (by DWG Process Supply). The study demonstrated that this was indeed a feasible treatment system for the removal of aluminum, colour, iron, manganese and TOC. Specifically, it showed that micro filtration provides an excellent and consistent removal of iron and turbidity throughout the testing period. It also demonstrated that aluminum could consistently be removed to a very low level with the microfiltration portion of the treatment.

Close-up of Microfiltration Membrane Cut-off

A system is selected!

This dual membrane set-up, with micro and nano filtration, was considered a good conceptual design of a treatment system that can efficiently and effectively treat the poor source water. The final process includes micro filtration followed by nano filtration, with a coagulation pre-treatment step before the micro filtration membrane. There is also some further pre-treatment built in earlier in the treatment train with the aeration of the raw water storage to reduce TOC and remove iron and manganese. At the design stage, this was believed to be the first dual-membrane water treatment system in a First Nation community.

Given the complications involved in reducing TOC and aluminum simultaneously, the dual membrane system (micro and nano filtration) was the only way to efficiently and effectively treat the water without contributing to the problem of producing harmful chemical by-products in the water. At the same time, ISL resolved to tackle the TTHM problem at its source. By dramatically reducing the amount of colour and TOC in the water *before* the addition of the chlorine disinfectant, the formation of these harmful TTHMs is prevented.



1. **Coagulation**
2. **Microfiltration**
3. **Nanofiltration**
4. **Disinfection**
5. **Distribution Pumping**
6. **Chemical Cleaning**

Floor Plan View of Treatment Trains

UNIQUE EQUIPMENT SELECTION AND TENDER PROCESS

Now that the type of treatment system was selected, ISL needed to select the supplier(s). The team chose a unique progressive tendering process to select the best possible equipment to suit the remote location, the operators, and the client in the long-term. This was a three-step process from prequalification of the membrane suppliers to final selection.

STEP 1 Call for Proposals

A call for preliminary proposals was sent to the public tender system. The team took the unusual step of requiring only technical information (not pricing) with the goal of better understanding the proposed systems first. The evaluation criteria were developed collectively by the ISL design team and the client consulted as to what was important to them. The criteria included considerations of effectiveness, efficiency, maintenance requirement, chemical consumption, and the manufacturer's reputation. The overall evaluation was divided into the following major components:

- Pre-treatment Process (including need);
- Microfiltration/Ultrafiltration Process;
- Nanofiltration Process;
- Customer Service and Manufacturer Experiences; and
- Proposal Quality.

Seven suppliers expressed interest in submitting preliminary proposals and five submitted. The preliminary proposals were evaluated by the design team and the client.

STEP 2 Design Workshops with Manufacturers

The three manufacturers with the highest scores were each invited for a full-day design workshop. Each manufacturer brought their technical experts to present their system as well as to answer questions from the design team. Based on these workshops, the manufacturer with the highest initial score was actually eliminated as the material of their membranes was found to be not as reliable and more susceptible to damage.

STEP 3 Detailed Proposals

The request for bid proposals went to the last two manufacturers. They were evaluated by the design team and the client based on the following criteria:

- Life cycle cost;
- Chemical cleaning requirements and frequency;
- Chemical usage and power consumption;
- System efficiency and effectiveness;
- Ease of Operation; and
- Performance Guarantee and Warranty.

This final stage of evaluation resulted in the manufacturer with the lowest capital cost *not* being selected. The selected manufacturer had clearly shown that even though they had the highest capital cost, they had the lowest overall Net Present Value (NPV) when chemical and operational costs are considered over 20 years.

The owner benefited from this unique, rigorous approach to selecting equipment by the reduction in risk from construction to operation over the design life of the water treatment system. The selection of the best possible equipment for the community and, in particular, the choice of one single manufacturer for the system, resulted in numerous efficiencies for the job and risk reduction in the long-term. Were this not the case, the owner could be faced with a higher risk of problems due to treatment processes not working well together and loss of the performance guarantee; plus the risk of a communication break-down between multiple suppliers/manufacturer, and construction scheduling issues that could result in further delays. Ultimately, this unusual approach to equipment selection and tendering helps reduce the level of risk at the design, construction and operation/maintenance stages.

INNOVATIVE BUILDING DESIGN

Compact

The building structure also had to fulfil certain requirements to suit the operator/staff, INAC and the northern climate. The Chateh facility would be one of the first to put into practice INAC's new design requirement of solutions to enable lower lifecycle costs. One way to achieve this was with a compact building design, which would lower operational costs for heating and other aspects. A compact building was also important given the new water treatment plant's location in the downtown core.

ISL's assessment of the former site and talks with the WTP operator confirmed this conclusion. A significant factor in improving the overall efficiency of the water system was the construction of a single new building that would contain all the associated water treatment and distribution processes on one level, complete with a new treated water reservoir below. This way, it would far easier for the operator to access all equipment quickly. This was a big improvement on the former WTP layout, which had involved three separate buildings, making it relatively inefficient to manage/maintain from the operator's perspective, as he had to go back and forth from building to building. With a compact design for the building in mind, this meant that throughout the design stage ISL sought very efficient use of space and compact design solutions for the equipment it housed. The result was a much smaller building footprint than the conventional plant set-up.

One of these unique space-saving design solutions was a custom-designed nano 2-in-1 skid. Now the nano filtration system and its standard back-up are housed on one frame instead of the conventional two, and therefore use half the space.

Nanofiltration Skid

Energy Efficient

Incorporating energy efficiency into the building design and features was a clear way to make this facility suitable for the cold winters and also enable a reduction in the lifecycle cost associated with running the facility. Instead of the usual cold, poorly insulated, brick building for a water treatment facility, the building envelope was architecturally designed with a number of innovative features that enable the building to be energy efficient for the life of the facility, and also to help make the building become an aesthetically-pleasing anchor for the downtown core.

Using the principle that the simplest energy efficiency approach is the best and most reliable one for a simple building, the architects chose four energy efficiency strategies that do not require maintenance or operating knowledge to sustain and allow continuous energy-saving over the life of the facility.

Four key strategies for energy efficiency were used in the building design: reduce energy demand and emissions from heating, cooling and lighting; replace lighting energy with a renewable supply; reduce the embodied energy of the building structure and shell; and reduce the materials needed to maintain the building throughout its life.

STRATEGY 1

Reduce energy demand. Extensive thermal insulation in windows (R12), walls (R36) and roofs (R60) serves to reduce heat flow through the building envelope and reduces the associated heating and cooling loads. A full air barrier in the building envelope and good air seals at the doors minimize air and moisture movement through the envelope and the associated heating and cooling loads. Keeping the process and equipment spaces at a lower operating temperature also reduces energy demand. Only the operator's control room is kept at a shirt-sleeve comfortable temperature throughout the year.

STRATEGY 2

Replace energy with renewable supply. The insulated glazing placed high above the Process Room is very effective at bringing daylight into the plant *(see photos: Kalwal)*. The sloped shape of the ceiling helps distribute the light evenly throughout the principal working area, permitting safe use of the space without unnecessary use of electric lights. A design change to the original form of the building, to allow daylight deep into the building, also had the effect of raising the roof profile and making the plant more visible in the community. Along with the lively colour and pattern of the exterior cladding materials, the new roof gives the facility a more significant place in the community. Care was also taken to consider the relationship of the adjacent health care facility when designing the building's appearance.

Kalwal "windows" allow natural lighting of the Process Room (in construction in this photo)

Close up of Kalwal Insulated Glazing

STRATEGY 3

Reduce embodied energy of building materials. Making the building structure and sheathing of wood achieves two important environmental tasks. Wood has a significantly lower embodied energy and water demand during manufacturing than alternate components using concrete and steel, and wood sequesters carbon when growing. This 'capture' of carbon will offset emissions from equipment use during construction. Wood materials can be supplied more locally than the alternates, reducing the transportation energy needed to bring them to site.

STRATEGY 4

Reduce maintenance energy and material use. Cladding the exterior with properly vented and galvanized metal roof and wall surfaces, and the interior with moisture resistant finishes, allows the building to function with little operator attention and effort. The durability of the building enables a reduction in the both maintenance material and energy use.

None of these strategies relies on a high level of building operator' knowledge or attention and each will perform reliably throughout the life of the building. All will result in significant cost savings for operations and maintenance over the life of the facility. All are particularly appropriate for use in remote communities where simple, robust, economical and well-performing infrastructure facilities are needed.

Further, basic energy modeling of the building indicates that it will operate (excluding process energy loads) using 62% less energy and 65% less cost than a comparable building using Model National Energy Code for Buildings (MNECB) standards for construction. This represents an annual GHG emission reduction of 24 tonnes of CO_2. These savings will, with a minimum amount of care of the building, last for the life of the building shell, 50 years or more, and future cost savings will increase, as the cost of future energy use increases. The overall result of the strategies is a safe, warm (or cool) and well-lit plant that is durable, economical and easy to operate. It will allow the operators to do their work of running the plant effectively.

DESIGN CONSIDERATIONS

Safety First!

In terms of chemical storage, INAC mandates chemicals to be stored in a separate room (although ISL uses this in all projects anyway). However an additional safety feature in the design was to have a chemical transfer pump accessed from the outside of the facility that could be hooked up to the shipping container. Using this pump hook-up, chemicals could now be directly transferred from truck/shipping container into the permanent chemical storage tank inside the building, mitigating the environmental and health risks of spillage that were forever present in the practice of wheeling the carts through the site in the old system.

Another issue had been how to safeguard all-weather access to clean water for the seventy-five percent of the community dependent on truck water delivery from the plant. Now, the site was raised to avoid past flooding problems, and the area, including the treatment plant and neighbouring community health centre, benefited from the community's first ever stormwater management plan and outlet, helping mitigate flooding in the downtown core. Moreover, in winter the driver can now park on a heated pad, effectively removing a previous safety hazard caused by water spillages at the site, which had made it virtually inaccessible in the winter.

Minimizing Chemicals and Reducing Supply Risk

Water treatment solutions were sought that would minimize the use of chemicals due to their difficult delivery to the isolated location, lifecycle cost considerations, and potential effects on the effluent and final drinking water. The membrane system enabled use of less chemical coagulants (i.e. less alum) for example. This served to reduce the risk of supply issues.

In particular, there was a deliberate choice not to select membrane systems that would require use of proprietary chemicals (a lot of membrane suppliers force the client to use proprietary chemicals). This would have made the client dependent on a particular supply source and would therefore incur all the risks of that dependency over the lifecycle of the water treatment system - such as if the supplier was to go out of business or stop making that particular chemical. Instead the team chose a water treatment system that could use generic chemicals so these could be bought from any chemical supplier. Choosing *not* to use proprietary chemicals also means a reduction in the carbon footprint associated with operation of the facility. Generic chemicals could also be more locally sourced.

Anticipating Future Growth and Regulation Change

With just a quarter of the community on piped water, it was clear that flexibility needed to be built into the design such that the piped water distribution network could be expanded at a future date. The Community Development Plan identified the need for the plant design to have the flexibility to support an increase in capacity in order to meet a future surge in piped water demand - both quality and quantity of drinking water. The system was therefore designed with the flexibility to be able to expand service capacity in the future.

In terms of wastewater disposal, the reject water from the treatment system and operator facilities needed to be designed to fit into the existing sewer system while at the same time being careful not to overload this system. Consequently, allowance was built into the design to anticipate future regulation change, including control of the flow of reject water by its diversion to a reject water tank either for further treatment before release into the water source or to allow for possible wetland discharge.

Chateh Water Treatment Plant, June 2010 (in construction)

FROM CONSTRUCTION TO OPERATION & MAINTENANCE

Both the community's remoteness and the high water table in the muskeg-dominated area presented a number of challenges for the construction stage. Exactly the right elevation had to be selected for the foundation of the facility to avoid hitting the high water table of the area. To add greater security to concerns of managing drainage and water in the area, both the building and the equipment within were built on raised ground/concrete pads.

In general, the facility foundation and underground treated water reservoir required a huge amount of concrete (about 940 m^3) and the contractor had to deal with the logistics of organizing large concrete pours while ensuring a consistently good quality product, despite the hour and a half lag time in delivery from the nearest concrete supplier 105 km away. The contractor solved this issue with truck staging.

LSL Timber Close up

LSL manufactured timber is straight and true for "Amazing Construction Quality"

In addition, an innovative construction material was used for construction of the frames of the water treatment facility. Laminated Structural Lumber (LSL) is a manufactured timber with a high density that helps improve insulation, and being straight and true it also enabled a high quality fit and finish for the building. As the contractor pointed out, this had the benefit of providing very sound framing and making the building that much easier to erect.

A Housing Solution for the Job and for the Community

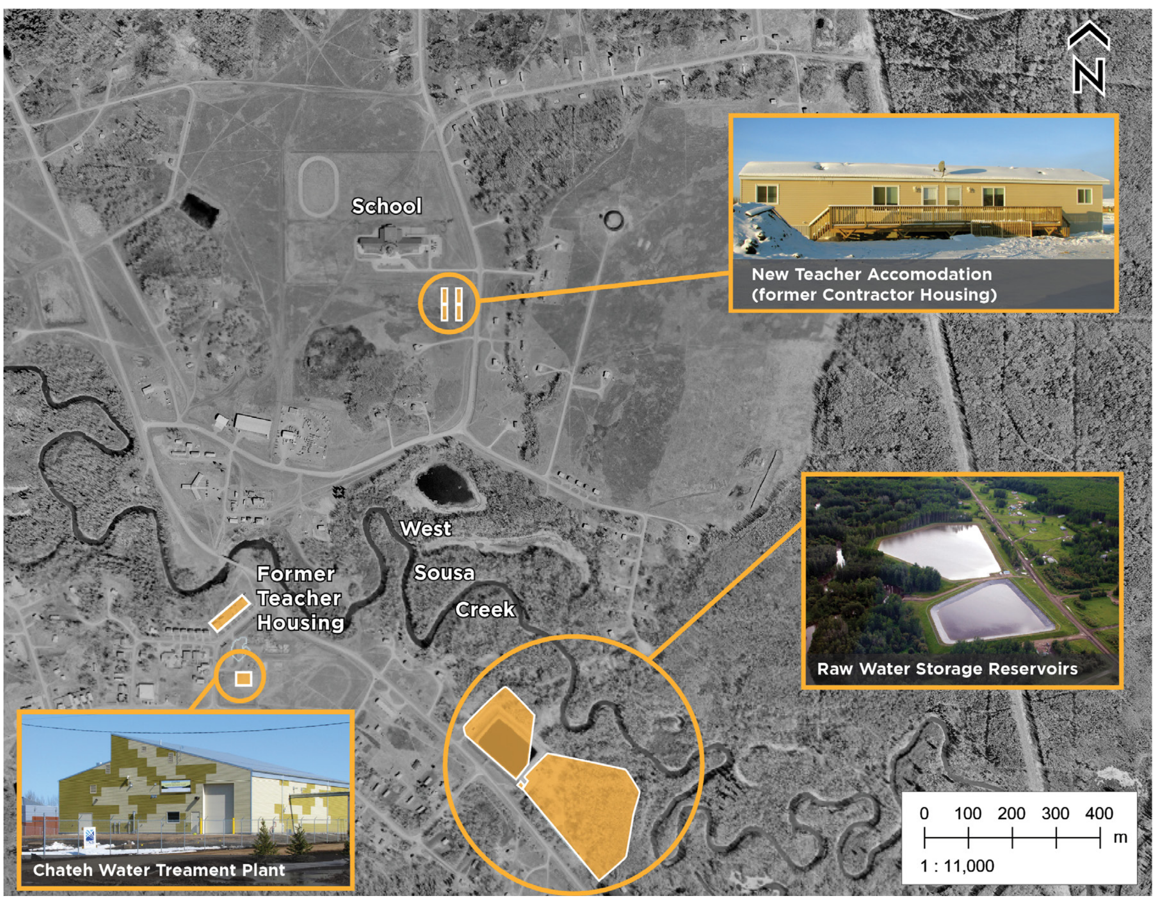
The remote location added another point of complexity to the construction of the water treatment facility. While local labour and equipment were used on the project (also an INAC requirement), there was still the question of how to mobilize the specialised contractors to the remote location while keeping the costs down. The cost for the construction stage would normally have to factor in hotel accommodation and commuting to and from the remote site for the specialised labour - an estimated cost of about $1,000,000 for the required duration, or 10% of the contract. In addition, there would have been about a one to two month loss in productivity because of the time required for commuting to the site during the project.

Instead the design team and client chose a solution that would enable the contractors to stay on site, resulting in a gain in productivity, and also leaving the community with an additional infrastructure asset that would solve another accommodation problem in the community. The solution was to provide housing. The criteria for the design included that the housing would be easy to manufacture and deliver to the site in rapid time so as not to delay the project, and also be well-insulated and generally designed for the northern climate.

New Teacher Accommodation (former Contractor Housing)

Once the WTP project was completed, these sturdy, well-insulated, fully-serviced, duplex trailers would be turned over to the school. Teachers for Chateh often come from outside the community and the existing teacher accommodation was dilapidated and several kilometres from the school. Everything about the housing was designed with the end use in mind. The site selected for the housing means the teachers only have to walk about 100 m to the school. Each fully-furnished mobile home has two separate living units with a large shared deck. The decks of each mobile home face each other to invite social gatherings and the site has proper stormwater drainage. They have water and sewer servicing tied into the nearby subdivision, with the capacity to expand to 10 units (currently eight teacher units, or four duplex trailers).

The housing decision contributed to the successful completion of the water treatment plant project on schedule and budget, and ultimately benefited the whole community, and the environment. Housing the contractors in the community had the additional benefit of helping reduce the carbon footprint of the construction stage by reducing the commute. The use of local labour and equipment for construction helped build capacity in the community for future construction work, through on-the-job training in carpentry, electrical, roofing, and siding. At the end of the project, the community was left with not only excellent water quality but $800,000 of infrastructure asset for use by the community to support local education.



Overview of Project Components

Solutions to Support Operation and Maintenance

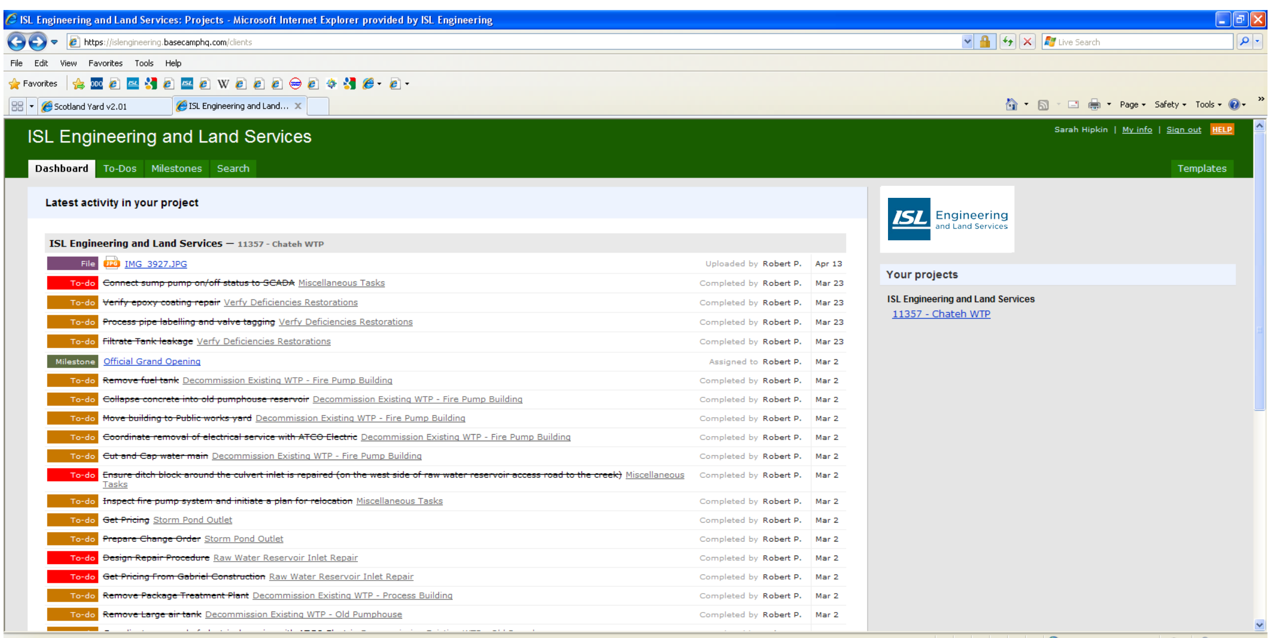
Ease of operation of the treatment process was considered throughout. Earlier on, ISL even included a design review trip with the plant's circuit rider trainer and operator to review a potential equipment and plant design for ease of operation.

The final water treatment plant includes a number of operational supports and training materials. ISL worked with the staff to prepare Standard Operating Procedures, and installed the custom 3D Operation and Maintenance Information System (3DOM-IS) at the plant for quick, one-stop visual access to all the information needed to run the plant. Linked to a custom-made 3D model of the actual plant, this innovative information management system is easy to use and the system can be copied to a laptop to enable remote troubleshooting if needed, and provides other benefits to the operator such as simplifying the ordering of new equipment components. Other materials included a series of training videos to support new staff – the potential for high turnover of staff is a constant risk in these remote locations.

An allowance was also built into the budget that enabled the plant to start-up fully equipped. ISL worked with the operator staff and First Nations (Alberta) Technical Services Advisory Group (FN-TSAG) to determine purchase needs, which included safety gear and tools the operating staff didn't have before.

FN-TSAG are now considering using the plant as a training facility for other water treatment plant operators based on all the design considerations to suit this First Nation community, its fit with the INAC design standards and the multitude of training tools available at the site from 3DOM-IS to videos.

The Supervisory Control And Data Acquisition (SCADA) system is a vital component for all such facilities, as it enables the monitoring, control and alarming of the plant from a central location. Since the backbone of the SCADA system is an internet service, ISL had a tower installed so the plant's communication could be linked into the band's internet. This gives the operator access to remote trouble-shooting assistance and allows check-ups of the working of the plant.



Sample: Basecamp Dashboard

TRANSPARENT, FULL SERVICE PROJECT DELIVERY

The approach to working with these communities is very different from the conventional one: it is far more relationship-based and hands-on. The needs are greater. In this case, ISL's team went beyond normal project management scope for the client in seeking solutions that would solve the water quality issues and also fit with the community: from funding application assistance to bringing key stakeholders together, equipping the plant with basic tools and safety gear, training videos, and a remote troubleshooting information and management system - even providing a housing solution for teachers in the community. The focus is on delivering the excellent water treatment solutions on time and on budget, but also on taking the time to develop excellent relationships with clients and working with them as part of the project team throughout the process. This recognizes that they are the key to identifying workable solutions to suit their particular circumstances. The approach benefits the project as a whole by preventing or reducing risks later on. This hands-on, relationship and trust-based approach is even more relevant for the First Nation communities that ISL works with. In this case, ISL's had been engaged with the community on various upgrade projects since 2002, which had helped build a relationship of trust and mutual respect with the Chateh community.

Building on involvement with the community over the years, the team spent time with the administration, plant staff and community, specifically to identify other needs and issues beyond the technical assessment of the water treatment system. Throughout the WTP project, ISL facilitated meetings and ongoing communication between representatives from INAC, Health Canada, FN-TSAG and members of the Dene Tha'. This helped keep critical momentum for the project and, most importantly, ensure all understood the chronic water problems faced by the community and the work that had gone into identifying a solution that was workable for the raw water issues, the council, community, and plant operation staff. Tendering proceeded in April 2009, with a tight construction timeline to meet the need for completion of concrete works before freeze-up. The plant was commissioned in mid-December 2010.

Another part of going the extra mile for the client was that ISL worked with the community on funding applications, and assisted in tendering and funding accounting. Overall, ISL's general services included project management, infrastructure assessment/ conducting a feasibility study, preliminary and detail design, contract document preparation, construction administration, facility commissioning and post construction services.

A number of decisions were made by the project management team at the pre-design and design stage that helped keep costs down for the project and keep the project on track for completion of concrete works before freeze-up. The rigorous approach to selecting appropriate treatment processes and system equipment reduced the risks to the owner over the design life of the system. In addition, the pre-selection of the system and equipment helped keep construction costs down by reducing risk for the contractor. ISL either quantified the risks to the contractor or removed them altogether from the contractor's list, e.g. contractor housing eliminated the need for mobilization, while the pre-selected process and equipment meant it was a fixed price. The contractor didn't have to add much contingency because the contract already included clear specifications and accounted for local considerations. ISL also built a cash allowance in at the front end to allow for a suitable mobilization solution for the contractor team: the housing near the work site. This reduced downtime and the risk of delay as the contractor and project management could be located on site. Housing them reduced costs by about 10% and saved time. Doing so served to keep the project budget down and removed risks to the budget and delivery timeline such that despite the complexity of the project, the anticipated budget was practically spot-on and the project delivered on time.

The use of Base Camp software allowed the client in Chateh and INAC staff in Ottawa to log in and check progress or share project documents at any time. This solution achieved project transparency both for the First Nation community and INAC as the latter could be fully informed as to how the dollars were being spent and project progress. This also added further efficiencies to project management, through such features as document sharing, and a dashboard 'to-do' list that the design and contractor team used to track progress, including milestones. This was the first project for which ISL has used this software and has been so well-received by client and INAC that it is being touted for use and is being used for several more ISL projects.

Representatives from Dene Tha' at Breaking-Ground Ceremony Chateh, August 2009, including Chief James Ahnassay (fourth from left), Mr. Stephen Ahnassay (Director of Capital Projects, second from left) and Councilor Andrea Denechoan (fifth from left).

A PERFECT FIT FOR THE COMMUNITY!

Commissioned in mid-December 2010, the water treatment facility is operating as intended. From the worst source water it now produces excellent water quality that exceeds both Health Canada and INAC's standards and is superior in taste and look, resolving the long-standing problem of poor, unreliable water quality. The community no longer has to suffer the chronic problem of boil water advisories and, with access to reliable high quality water, the residents are less likely to feel the need to purchase bottled water. The treatment processes removes the THM issue at the source by reducing the potential for its formation. The new water treatment building is also a prominent, attractive feature that helps anchor and revitalize Chateh's downtown core. The teachers now have new accommodation, serviced with water and sewer and located just 100 m from the school. The client and INAC were pleased with the approach to project delivery and the end result, and FN-TSAG is making plans to use the facility for training other First Nation water treatment plant operators in Alberta.

Sign commissioned from local artist Josh Kolay

CHATEH WATER TREATMENT PLANT AT A GLANCE

Complexity	• **Treating some of worst water in Canada** (turbidity, high TOC and aluminum/ TTHM issues) in a remote northern community • **Testing INAC's new design guidelines** for new water treatment plants • **Bringing all stakeholders together** for a treatment solution to suit the particular water quality issues and needs of this First Nation community • **Managing complex construction issues** due to high water table, remote location, and the logistics of large concrete pours
Meeting and Exceeding Client's Needs	• **Selected a water treatment system** that produces reliable, excellent quality water with relative ease of operation and reduced lifecycle costs to suit this isolated First Nation community • **ISL kept costs down and the project on schedule** by quantifying risks at the design outset, and including provisions for these in contracts • **Extensive solutions to support operation and maintenance**, including purchase of tools and safety gear; preparation of SOPs; and training videos to help mitigate any future problems with staff turnover due to remote location • **Custom, easy-to-operate, O & M Information System** based on 3D model of the treatment plant, that also allows remote troubleshooting • **Compact building design solutions** give the operator more efficient access to all equipment needed to run the plant • **Safety solutions** such as chemical transfer pump, heated truck-fill pad • **Achieved project transparency** by using Basecamp software in management • **Helping find funding** - assisted with funding applications and transparent funding accounting, going above and beyond to ensure project success
Environmental Impact	• **Energy efficiency of building** - uses 62% less energy and operate at 65% less cost than a comparable building (MNECB energy modelling) • **Estimated annual GHG emission reduction** of 24 tonnes of CO_2 • **Reduction in carbon footprint** with treatment system that can use generic chemicals bought from a more local supplier • **Less use of chemical coagulants** (alum) with selected treatment system
Innovation	• **The first water treatment plant in a First Nation community using dual membrane system** (micro and nano filtration) • **Use of a unique equipment selection / tender process** helped mitigate risks with very difficult raw source water *and* targeted lower life cycle cost • **Contractor housing** - an innovative solution to mobilizing contractors for this remote location and giving the community something they needed. • **Tested the first ever Design Guidelines** for First Nations Water Works from Indian and Northern Affairs Canada
Social and Economic Impact	• **Resolved issue of chronic boil water advisories** providing reliable water that exceeds regulatory requirements; reducing bottled water dependency • **Dual purpose housing solution** for contractors and then later for teachers (approx $800,000 worth of infrastructure asset left in the community) • **Being considered for use as a Training Facility** for other water treatment plant' operators in First Nation communities in Alberta • **Revitalizes the downtown core -** the unique, attractive architectural design of the building anchors and revitalizes the downtown core

Chateh Water Treatment Plant
2 PAGE SUMMARY

Unique client needs spurred ISL to innovate every component of the Chateh Water Treatment Plant project. The first dual-membrane water treatment system for a First Nation in Canada, it addresses the complexities of water treatment in a remote area, has an easy to operate system with a lower lifecycle cost and is housed in an energy-efficient building.

BACKGROUND

The community of Chateh is located in the far northwestern corner of Alberta in the boreal forest region of Canada. This is Dene Tha' reserve land. Like many First Nation communities or other small, remote communities, contending with water quality issues is a fact of life. The problem is often more pronounced in First Nation communities, as they tend to have inadequate water, wastewater and waste servicing; aging facilities and equipment; and due to isolation, find it difficult to find and retain experienced water treatment plant operators. In Chateh's case, the water appeared and tasted undrinkable and came from some of the worst source water in Canada. The community faced frequent boil water advisories, stemming largely from a turbidity problem. Drawn from Sousa Creek, the source water is some of the worst water to treat in Canada in terms of the extremely high levels of organic material or Total Organic Carbon (TOC), and levels consistently above the Canadian Drinking Water Quality standards for aluminum (potential neurotoxin), manganese, iron and colour. The aluminum in the surface water compounded the problem of seeking an effective water treatment solution. Chateh's treated water also showed excessively high levels of total trihalomethanes (TTHMs), suspected carcinogens formed when water high in organic content comes into contact with chlorine during the normal disinfection process.

The challenge for ISL was how to provide effective and efficient water treatment for some of the worst source water in Canada in one of the most remote northern communities in Alberta, and to do so in a manner that would incorporate the community needs of this First Nation. These needs include those relating to operability, chemicals, and reduced lifecycle costs. The remote location and the high water table in the area added a further level of complexity to the construction stage.

FINDING THE RIGHT FIT FOR THE WATER AND THE COMMUNITY

The approach to working with these communities is very different from the conventional one: it is far more relationship-based and hands-on. The needs are greater. ISL's team went beyond normal project management scope for the client in seeking solutions that would solve the water quality issues and also fit with the community: from funding application assistance and bringing key stakeholders together, to equipping the plant with basic tools and safety gear, and providing training videos, standard operating procedures, and a custom information and management system that also enables remote troubleshooting. To keep critical momentum going on the project, ISL facilitated meetings and ongoing communication between representatives from Indian and Northern Affairs Canada (INAC), Health Canada, First Nations-Technical Services Advisory Group (FN-TSAG) and members of the Dene Tha'. The use of Basecamp project software provided project transparency with funders, INAC.

ISL went through a number of evaluation measures in order to find the perfect treatment solution for the very poor source water and to fit the needs of the owner, operating staff, and Indian and Northern Affairs Canada. The focus was on designing a water treatment system to produce treated water that: meets the Canadian Drinking Water Quality standards; is as compact, efficient and operator-friendly as possible; consumes the least amount of chemicals possible; enables optimal integration of all process equipment; and has the lowest possible life cycle cost.

Extensive solutions to support operation and maintenance

The final water treatment plant includes a number of operational supports and training materials. ISL worked with the staff to prepare Standard Operating Procedures, and installed the custom 3D Operation and Maintenance Information System (3DOM-IS) at the plant for quick, one-stop access to all the information needed to run the plant. Other materials included a series of training videos to support new staff – the potential for high turnover of staff is a constant risk in these remote locations. An allowance was also built into the budget that enabled the plant to start-up fully equipped, and ISL worked with the operator staff and FN-TSAG to determine purchase needs, which included safety gear and tools the operating staff didn't have before.

Energy efficient, compact building

Incorporating energy efficiency into the building design and features was a clear way to make this facility suitable for the cold winters and enabled a reduction in the lifecycle cost associated with running the facility. Four key strategies for energy efficiency were used in the design: reducing energy demand and emissions from heating, cooling and lighting; replacing lighting energy with a renewable supply (Kalwal insulated glazing and building design); reduce the embodied energy of the building structure and shell; and reducing the materials needed to maintain the building throughout its life. Basic energy modeling of the building indicates that it will operate (excluding process energy loads) using 62% less energy and 65% less cost than a comparable building using Model National EnergyCode for Buildings (MNECB) standards for construction. This represents an annual GHG emission reduction of 24 tonnes of CO2. These savings will, with a minimum amount of care of the building, last for the life of the building shell, 50 years or more, and future cost savings will increase as the cost of future energy use increases. The overall result of the strategies is a safe, warm (or cool) and well-lit plant that is durable, economical and easy to operate.

INNOVATIONS

Some of the firsts!

In the end, this is the first dual-membrane water treatment system in a First Nation community in Canada. It uses micro and nano filtration for 100% treatment of water quality issues for some of worst raw water in Canada - removing TOC, aluminum, colour, iron, manganese and effectively preventing the generation of harmful disinfection by-products (THMs). In addition, this project would also be one of the first to test the entirely new Design Guidelines for First Nations Water Works from INAC (2006) in the design and construction of the water treatment plant.

A unique solution to contractor mobilization...

Considering the problem of mobilizing contractors to the remote location, the team pursued a solution that would meet this need and another one of the community's own. Choosing to construct accommodation so that the contractors could be housed in the community saved two months of otherwise lost productivity from commuting. It also left the community with about $800,000 worth of additional infrastructure asset, and the teachers (largely coming from outside the community) now have well-insulated, fully-serviced new accommodation located just 100 m from the school.

Selecting the right manufacturers – unique equipment selection / tender process

The team chose a unique progressive tendering process to select the best possible equipment. The three-step process included proposal call, design workshops with manufacturers, and detailed proposals.

The evaluation criteria were developed collectively by the ISL design team and the client consulted as to what was important to them. The chosen manufacturer had clearly shown they had the lowest overall Net Present Value (NPV), considering chemical and operational costs over 20 years. This resulted in numerous efficiencies for the job and reduced the level of risk to the owner. Overall, ISL was able to keep the costs down for the project and keep the project on track by using knowledge of local area/client to quantify risks at the design outset, and including provisions for these in contract work.

A Perfect Fit for the Community!

Commissioned in mid-December 2010, the water treatment facility is operating as intended. From the worst source water it now produces excellent water quality that exceeds standards and resolves the long-standing problem of boil water advisories. The new water treatment building is also an attractive design feature, revitalizing Chateh's downtown core. The client and INAC were pleased with the approach to project delivery and the end result, and FN-TSAG is making plans to use the facility for training other First Nation water treatment plant operators in Alberta.