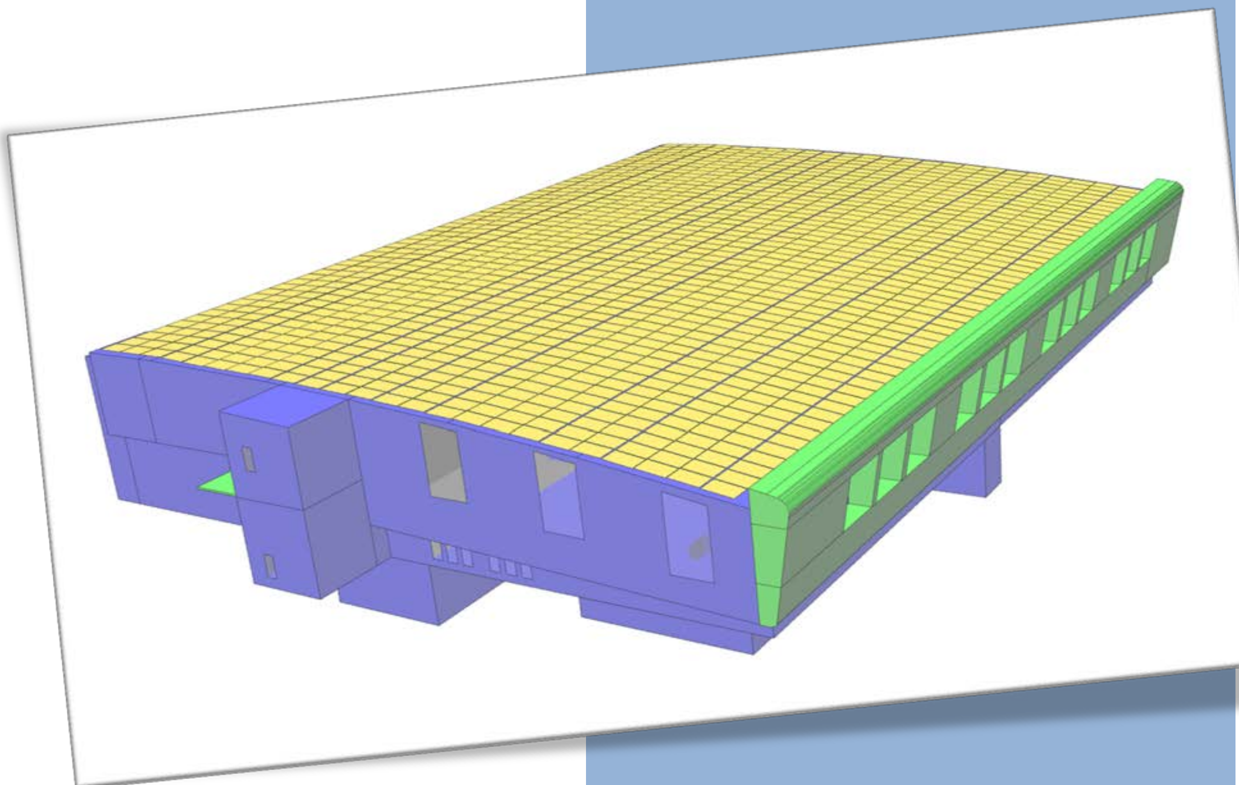
Drayton Valley Aquatic Centre – Net Zero Study



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DRAYTON VALLEY AQUATIC CENTRE NET ZERO STUDY

PREPARED FOR:

THE TOWN OF DRAYTON VALLEY

MAY 24, 2017

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WITH CONTRIBUTIONS FROM:
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1.0 INTRODUCTION

1.1 BACKGROUND

Revolve Engineering Inc. has been engaged by the Town of Drayton Valley to study the feasibility of building a Net Zero Aquatic Facility in Drayton Valley or Brazeau County. The scope of the project was to determine whether it is feasible to build a Net Zero or Near Net Zero Aquatic Facility to replace the existing Aquatic Facility which is due for replacement.

The broad scope of the study also included the following items:

1. Define the values and space/program requirements of the community for an aquatic facility
2. Develop concept plans for the space and pool layout
3. Develop architectural concepts that will meet those needs
4. Develop mechanical and electrical concepts that will achieve energy goals of projects
5. Develop renewable energy strategies
6. Develop recommendations on pool and other technologies that will help achieve energy goals
7. Compare energy use to code compliant and traditional buildings
8. Provide capital cost estimates for the entire net zero concept building

To deliver this scope of work, Revolve Engineering Inc. has hired expert sub-consultants including program, architectural, mechanical and electrical consultants, as well as construction/cost consultants, and renewable system experts.

1.2 VALUES ALIGNMENT

Before any work was completed on the project, the team felt it was valuable to determine the exact needs of the community in terms of values and space requirements. There is no use in performing a net zero study on a building that is either too big, too small, or doesn't meet the requirements of the community. The team examined previous work done by Barr Ryder (Aquatic Facility Concept Design Report from January of 2012) which engaged the community and key stakeholders in determining the key requirements for an aquatic facility. In addition, a "values analysis" workshop was done on April 4th, 2016 with key stakeholders and community members to determine the real needs of the community. The feedback and values gathered from this workshop was compared to the previous stakeholder consultations identified in the Barr Ryder report and formed the basis of the program and space design. Appendix A identifies the key values the team has identified for this facility.

1.3 NET ZERO DEFINITION AND METHODOLOGY

For the purposes of this study, Net Zero Energy is defined as the difference between the *yearly* site energy use and energy consumption. Thus, Net Zero Energy is achieved if:

$$\textit{Site Energy Production}_{YEARLY} - \textit{Site Energy Consumption}_{YEARLY} = 0$$

This study does not address the source of power or carbon neutrality. The intent is for the proposed concept design to produce as much energy (over the course of each year) as is consumed at the site. There will clearly be an energy production deficit during the winter months, but the intent is to make up for this shortfall during the summer months. In addition to the above definition, the study has assumed that no fossil fuels will be burned on site (except for possible backup purposes). All of the energy for the building will be electrical energy.

The team has approached the project with a typical Net Zero methodology for achieving Net Zero. This includes the following key broad steps:

1. Reduce or eliminate energy consumption from equipment and plug loads as much as possible
2. Reduce lighting energy use as much as possible
3. Reduce building heat loss using a high performing envelope
4. Reuse and recover energy wherever possible
5. Use the most efficient mechanical system available
6. Produce energy on site to cover any remainder of energy after performing steps 1-5.

In addition, the team has considered non-energy items as well, including building durability and lifespan, equipment longevity, as well as maintenance and other items, as these items also impact the embodied energy of the building.

1.4 NET ZERO CONSIDERATIONS

Net Zero energy is an ambitious goal for any building let alone an aquatic facility. Reaching this target requires commitment to the target by all parties involved, especially the users of the building, as the *use* of the building needs to align with the energy goals. Firstly, the *needs* of the users need to be carefully balanced with the *wants.* The easiest approach to building a Net Zero aquatic facility is to build a dark box with 2 lanes and no other amenities. This would clearly not meet the *needs* of the community for an open, inviting, usable and fun space. However, when going through the energy budget for each piece of equipment in the building, the goal of net zero needs to be kept in mind throughout the process. Some items might fall more into the "wants" category and could possibly be eliminated. It is not the goal of this study to determine which items are the "wants" or "needs", but simply to illustrate that such an ambitious goal requires a type of "soul searching" to determine where reasonable compromises can be made.

For example, the values analysis showed that the preference would be to have 8 lanes in the lap pool. How important is this requirement in the context of the energy goals? If the extra 2 lanes are simply to be able to hold swim competitions once or twice a year (but would go unused the rest of the year), is this something still worth keeping? The added volume of water increases the energy, capital and maintenance costs significantly; is this a need or a want?

We use this only as an example of the type of conversations that we believe need to happen if the goal of net zero is to truly be achieved. Technology will only get you so far. A home or building can be designed for net zero, but if the users are wasteful in their energy habits (leaving lights and equipment on etc...), the net zero target could be missed badly. Net Zero requires a type of cultural change; it would be remiss for us to not acknowledge that fact here.

2.0 EXECUTIVE SUMMARY

This report summarizes the results of an extensive study into the feasibility of building a Net Zero Aquatic Centre in or near Drayton Valley. The study established key values in a values alignment workshop, and developed design concepts during site investigations, design charettes and big room meetings with some of the most experienced pool designers and installers in the province. Using extensive energy modelling and analysis to verify and refine the design, the team has developed a concept which would use approximately 45% less energy than a traditional Aquatic Facility.

The proposed concept relies on waste heat recovery from a nearby hockey arena (the Omniplex) which would serve as the heat source for the building's heat pump loop. By capturing waste heat and storing it in a ground heat exchanger, the proposed system would use heat pumps to heat and cool the building as well as provide all of the hot water requirements for the building. Even though the proposed system is estimated to use approximately 80% less energy for heating and hot water demands, the significant energy consumption associated with pool pumping (for filtration) limits the ability of the building to reach Net Zero solely with a rooftop mounted solar photovoltaic (PV) system. To reach Net Zero, significant additional solar PV capacity would be required to be installed as a ground mounted system or on neighbouring rooftops. The report also analyses an alternative design should waste heat from the ice plant not be available (at an alternate site).

Aside from the proposed concept, this report also recommends many systems, technologies and strategies for not only reducing energy use, but also minimizing maintenance and operation costs. Furthermore, risks and considerations are given throughout relevant sections, including recommendations on the suggested project delivery method.

A capital cost estimate was developed through input from key contractors and trades and is estimated to be $24,052,000 for this 3000 m² facility. This cost includes all proposed systems but does not include the land based PV system (the PV on the roof of the facility is included, but additional PV to reach Net Zero is not).

3.0 SITE SELECTION

3.1 SITE OPTIONS

This study was originally intended to consider two possible locations for the aquatic facility, the first is within the Town of Drayton Valley near the existing Omniplex, as shown in Figure 1 below.

Figure 1 - Site Location 1

The second possible location is just outside of the Town across from the Brazeau County Office, as shown in Figure 2.

Figure 2 - Site Location 2

The team has also identified a third possible site location which is also near the existing Omniplex but is located in between the existing school and curling rink, as shown in Figure 3 below. This option was added because of its proximity to the existing ice plant (discussed in more detail below).

Figure 3 - Site Option 3

3.2 SITE SELECTION CONSIDERATIONS

While there are obvious financial, political and practical considerations in choosing a site, the goal of this study was to focus simply on the energy goals of the facility; while also keeping in mind the values identified in the values analysis. Our recommendations therefore are based almost solely on the energy needs of the project, not other factors which might include land ownership, cost etc…

3.3 SITE RECOMMENDATION

As discussed in the Executive Summary, the most important energy opportunity of this project is the potential waste heat recovery from the existing Omniplex ice plant. It is for this main reason that the project team recommends Site Option 1 or 3 for the location of the aquatic facility. The ice plant waste heat is, in our opinion, too valuable a resource to pass up. As will be discussed later in this report, not having the ice plant waste heat creates big challenges in achieving the goals of the project.

While Site Option 2 was also considered throughout the report, the following will focus on the advantages and disadvantages of Site Options 1 and 3.

3.3.1 SITE OPTION 1 – ADVANTAGES AND DISADVANTAGES

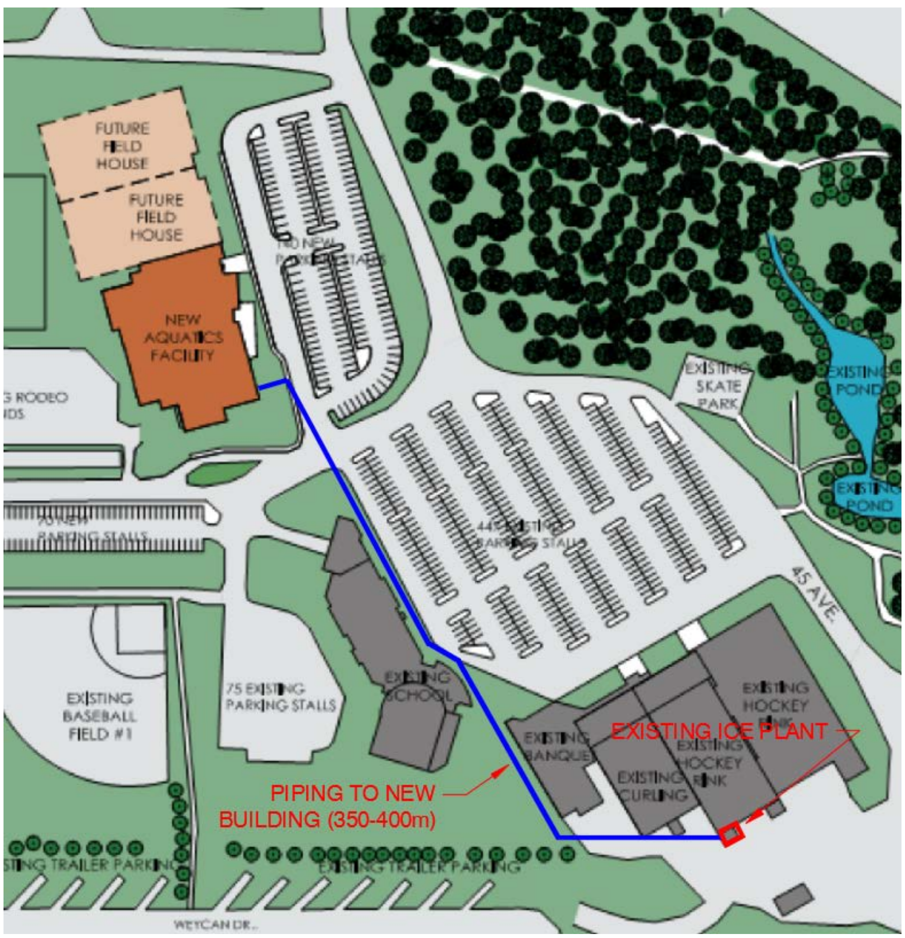


Figure 4 - Site Opton 1

As seen in Figure 4 above (taken from the Barr Ryder conceptual report), the first possible site location is on the north west corner of the existing parking lot which currently houses a baseball field and rodeo grounds. Also shown is the location of the existing ice plant in the Omniplex, as well as the piping connection that would be required to connect the two buildings (the length of piping would be approximately 200-400 metres in length). Please note that the route shown for the piping is only one of many possible options; the best option would likely be a straight line directionally drilled underneath the parking lot. The estimated cost to install two 8" HDPE pipes with this method is $60,000.

There are advantages and disadvantages to this site and they are listed below:

Advantages:

- Easy access for construction purposes
- Easy access during operation
- Autonomous operation
- More prominent location
- Better ability to expand
- Flexibility in site planning, building location and layout

Disadvantages:

- Non-optimal land use
- Less ability to consolidate maintenance/programs etc…
- Large distance from ice plant requires long runs of piping
- Larger heating loads means increased first cost and operational costs (minimal)

3.3.2 SITE OPTION 3 – ADVANTAGES AND DISADVANTAGES

As shown in Figure 3 above, the second possible location for the aquatic facility is in between the existing school and conference centre. There are two important reasons why this site was identified as a potential site. First, the shared walls between the existing buildings would decrease the heating demands of not just the aquatic facility, but also the heating demands of the existing buildings; reducing operating costs for all three (realistically, the impact is not significant compared to the overall energy use of the project, as discussed in detail later in this report). Furthermore, the remaining exposed walls would be mostly south facing, which is again favourable from a heat loss standpoint. Secondly, this location would significantly decrease the distance between the aquatic facility and the ice plant, dramatically reducing the amount of trenching and piping required. Some additional advantages (as well as disadvantages) are listed below:

Advantages

- Energy benefits of shared internal walls which minimizes heat loss (minimal)
- Reduced costs of exterior cladding
- Shorter and less costly connection to ice plant (less heat loss)
- Better utilization of land (leaves other site open for development of field house)
- Better potential for sharing and optimizing parking
- A connected building might increase usage and feeling of community
- Ability to optimize programming to share spaces (ie. Meetings/parties after swim meets)
- Increased room for solar PV panels (by utilizing neighbouring roof space)
- Relocating fitness space to aquatic facility could open up existing fitness location for other uses without moving the fitness centre far away
- Potential to create a community hub

- Aligns well with sustainability goals around walkability, community connection etc…
- Could reduce maintenance and operation staffing

Disadvantages

- Disruptive construction to adjacent buildings
- Perceived parking and drop off shortfall when multiple events occur (additional space for parking would be available at the back so this is only perception)
- Fieldhouse expansion would likely not be linked to aquatic centre (however, locker rooms would not be shared anyways; the field house is totally stand alone)
- Limited flexibility in building plan and layout (existing buildings will influence a preferred plan)

3.3.3 COST DIFFERENCE BETWEEN SITES

The total cost is provided in the Executive Summary as well as Section 14.0 which refers to Site Option 1. This price includes the connection to the existing ice plant and the installation of connecting pipe between the two buildings. Selecting other sites will have only minor impacts on the total budget and are discussed below:

Site Option 2

As discussed further in the report, locating the building at the County site requires the addition of solar thermal collectors with an estimated cost of $400,000. However, the costs associated with the connection to the Ice Plant could be removed, which includes $200,000 for the ice plant heat exchanger and upgrades, as well as $60,000 for the piping connections. This means that the premium for locating the building at Site 2 is approximately $140,000.

It should also be noted that with this option there is less room for Solar PV panels on the roof but to keep the comparison the same (in terms of saved energy), it is assumed that this PV would be relocated somewhere else on site (perhaps over the parking lot).

Site Option 3

While the differences in architectural cost between the proposed building and one that would need to be designed to fit between the existing buildings is not within the scope of this study, the costs should be very similar assuming the size of the building is the same. In terms of mechanical costs, the piping between buildings would be significantly reduced, potentially saving $20-40k in costs. In the context of the overall budget however, this is not a significant cost savings.

4.0 ARCHITECTURAL CONCEPT

4.1 PROGRAM AND SPACE DESIGN

A planning and program expert was hired to develop a space program and sample floor plan for the facility. Based on the values and anticipated needs of the facility, the proposed size of the building was reduced significantly from the recommendations in the Barr Ryder report. The proposed facility is approximately 3,000 m^2 (32,000 ft^2) in size and would include the following key features:

- 8 lane, 25m lap pool
- Leisure pool
- Lazy River resistance pool
- Whirlpool with 15-20 person capacity
- Viewing gallery (50 person capacity)
- Lifeguard office

- Staff unisex change room and lockers
- Partial basement pool equipment room
- Men's, Women's and Universal Change Rooms
- 2nd Floor fitness centre
- Multi-purpose room

Based on the program and space-list created by David Hewko, a conceptual floor plan was created by Gibbs Gage Architects as seen below in Figure 5 and Figure 6. All of the floor plans (including partial basement) can be seen in Appendix B. It should be noted that David Hewko has previously worked with the town in developing the space-list and preferred floor plans; this study has borrowed that work and expanded on it. As mentioned above, the floor space is about half of that recommended in the Barr Ryder report but aligns very closely with the values and needs of the community.

It should be noted that the layout and floorplan design proposed in this report can be modified by the town as needed. The energy aspect of this study is not sensitive to changes in room layout, size of rooms etc.... These can be shuffled as much as needed. The big items that do affect energy is the size, type and quantity of pools.

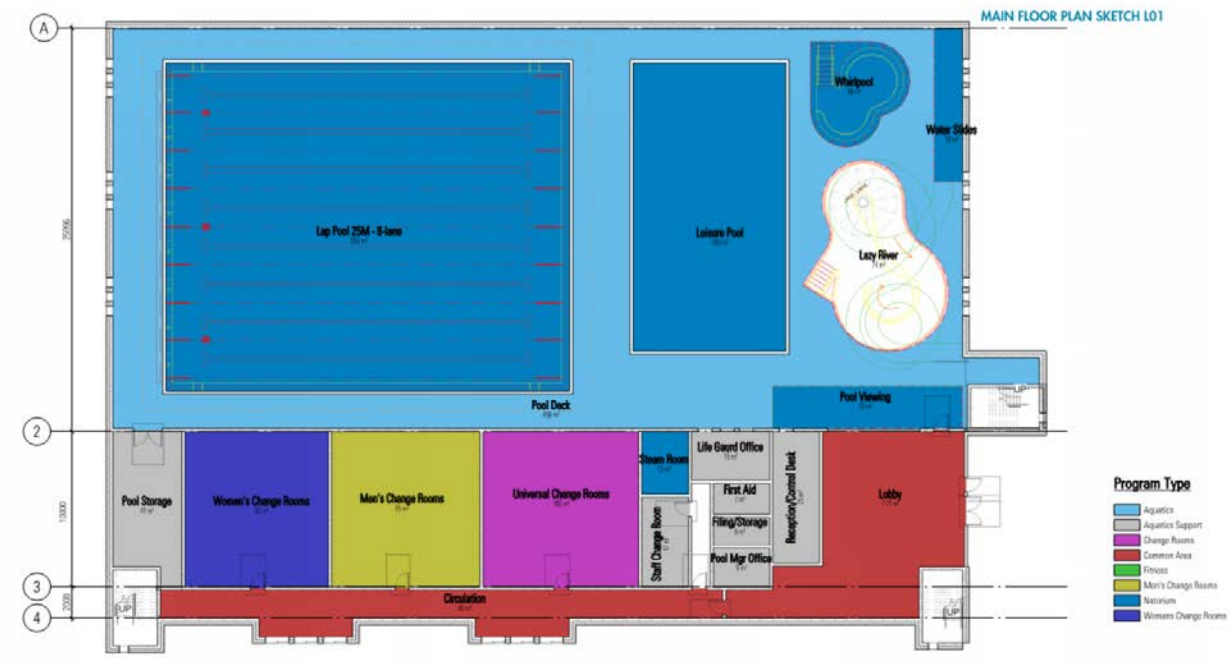


Figure 5 - Main Floor Plan – Concept

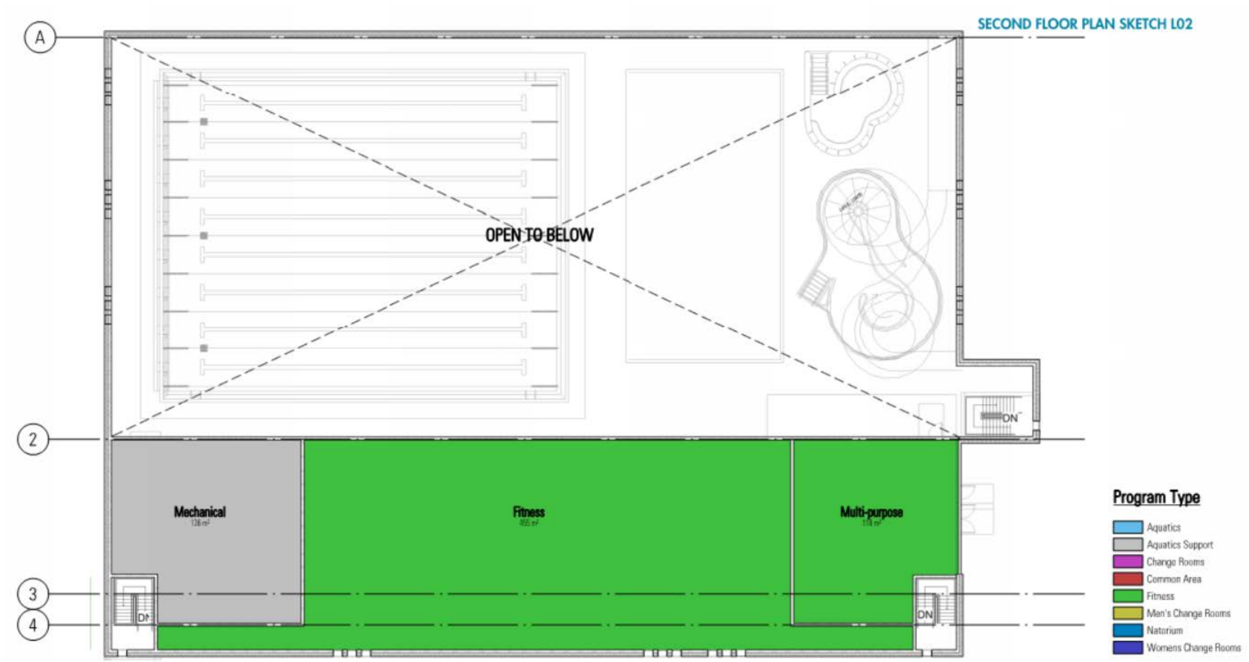


Figure 6 - Second Floor Plan

4.2 BUILDING CONCEPT

The building concept created by Gibbs Gage Architects can be seen below in Figure 7 and Figure 8 as well as Appendix B. This building concept served as the architectural basis for the entire study including mechanical, electrical, energy modelling and costing. Similarly to the floor plan above, this concept is simply an architectural basis for this study. It does not and likely will not represent the final building when built.

Figure 7 - Architectural Concept North

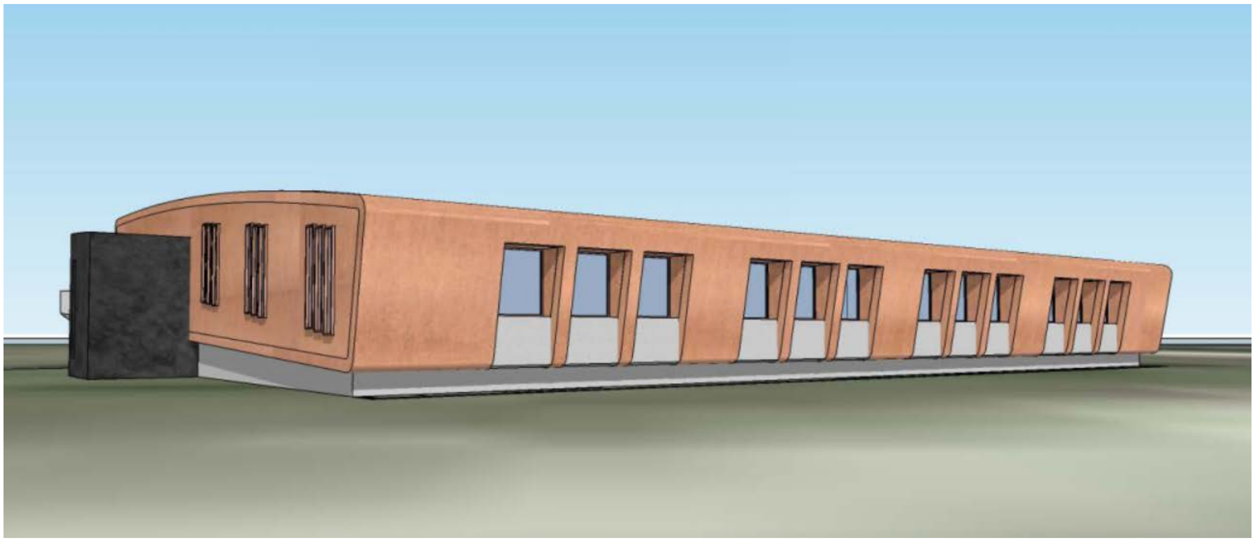


Figure 8 - Architectural Concept South

4.3 ARCHITECTURAL CONSIDERATIONS

In developing the architectural concept, the project team considered all aspects of the building design. The team visited the possible site locations and held a workshop meeting to discuss all critical features of the building, especially those that would impact energy use. The following represents some of the key discussions and features considered in developing the architectural concept.

4.3.1 Windows, Daylighting and Orientation

One of the values identified in the values alignment is that the community wants a bright, open and inviting space. The team therefore attempted to provide as much daylighting and openness as possible without creating other issues. In a pool environment, daylighting can cause glare issues on the pool surface which creates big challenges for lifeguards. For this reason, the window area in the pool space attempts to balance the advantages of daylighting with the potential glare concerns. Furthermore, glass is a bad insulator and increases the heat loss from the building significantly; this was another reason to not add too much glass in the pool areas.

The building was orientated with the large glassed wall area of the pool facing south. This allows the capture of energy from the sun during the winter and shoulder months which reduces the heating loads of the building. The overhangs on the south windows provide shading in the summer to help reduce cooling loads and overheating.

4.3.2 Roof Design

The current architectural design shows a roof that is slightly sloped to the south. This was a deliberate decision to allow for easy and cost efficient mounting of solar photovoltaic (PV) panels to the roof. The most cost effective and efficient spacing of the PV system will be flat on the roof, with the slight slope allowing for dirt runoff (fully flat solar panels tend to accumulate dirt).

For costing purposes, the team ignored the curvature in the current concept roof design as this would increase roofing costs. Since the future design will evolve anyway, the decision was made to cost a straight sloping roof. The following represents the recommended roof design.

Roof Construction (inside to outside) (RSI 7.92, R-45 effective)

13mm gypsum sheathing
Self-adhering vapour barrier membrane
RSI 7.92 (R45) poly ISO insulation applied in 2 layers
Coverboard
2 ply SBS membrane

Note: Roof assembly is all mechanically fastened due to the slope of the roof

4.3.3 Envelope Design

As discussed in Section 8.2.8 later in the report, the suggested envelope should have an effective R-value of R-25 to R-30 for the walls, R-40 to R-45 for roof and utilize triple pane fibreglass frames. This recommendation is based on the optimization analysis performed and the fact that the envelope does not have a big effect on the overall energy use of the building. The suggested envelope values were chosen for the right balance between efficiency, cost, and thermal comfort.

One important recommendation in terms of envelope is durability. While a steel framed wall assembly might be slightly cheaper, it will not last nearly as long. Since a long-lasting building is part of what makes a sustainable building, the suggested wall type is a concrete block wall as follows:

Wall Construction (from outside to inside) (RSI 5.28 , R-30 effective)

Metal or other siding
25 mm Air Space with IsoClip (thermally broken girt system)
150mm Rigid Insulation (or less depending on insulation value desired)
Air / Vapour Barrier Membrane
290 mm Concrete Block
Interior Finish

4.3.4 Basement Mechanical Room

Maintenance of pool equipment is a critical aspect of building operations in an aquatic facility and from the feedback the project team received from all interested parties including the Town, it was highly recommended to include at least a partial basement mechanical room for pool equipment. While the increase in cost is not insignificant, the ease of maintenance and serviceability is considered well worth it. Furthermore, a partial basement allows for the recovery of heat from the showers using drain water heat recovery; as discussed in Section 8.2.10 below. The partial basement can be seen in Appendix B and C.

4.4 Items for Consideration

4.4.1 Reduce Lap Pool to 6 Lanes

While the values analysis clearly identified 8 lanes as a big want in the facility, it is again important to note that reducing the lap pool to 6 lanes would have a significant impact on the total building energy use. This would reduce the lap pool volume by approximately 25% and thus reduce the pool heat loss, circulation rates, chemicals required, as well as makeup water requirements. Lap pools tend to be under utilized in most pools yet represent one of the largest portions of energy use and cost. While hosting swimming competitions is not possible with 6 lanes, we believe this needs to be balanced with the energy goals of the project and realistic needs of the community.

4.4.2 Space Optimization

The current floor plan includes 3 separate locker rooms, one for men, one for women, and one universal change room. An innovative idea is to eliminate the three different locker rooms and replace them with only one larger universal change room. The big advantage of this is that it would only take up the 2/3s of the space of the three locker rooms. This means that a large portion of space can be used for other uses, including possibly commercial space used for income purposes (Booster Juice etc…).

4.4.3 Building Operation Optimization

Depending on the use of the building, and the preference of users, there is significant ability to reduce energy use, decrease cost and improve the efficiency of the building operation. For example, depending on the pool hours, there is often a gap from the early morning lap swimmers to the leisure swimmers later in the morning. There might be an opportunity to change operating hours (open later in the morning) to improve efficiency and reduce energy use. It might be a worthwhile exercise to engage the community in optimizing the building hours and operation while taking into consideration the energy goals of the project.

5.0 Pool Concept

5.1 Pool Design

The design of aquatic facilities is strictly governed by the Alberta Building Code and Alberta Health Services (AHS) Pool Standards thus the design will obviously follow all of those standards. As discussed above, the building would include an 8-lane lap pool, a whirlpool and a combined leisure pool and lazy river. While the main floor plan in Figure 5 shows the leisure pool and lazy river as standalone pools (shown diagrammatically), they would actually be combined into one pool to combine filtration systems and improve efficiency and reduce installation cost.

The pool mechanical design would include individual filtration systems for the lap pool and whirlpool, as well as a combined system for the leisure pool and lazy river (as mentioned above). Each filtration system would include its own circulation pumps, filters, water treatment systems and level controls. The filtration rate for each pool is mandated by the Alberta Building Code and enforced by AHS and is referred to as the "turnover" rate. The turnover rate refers to the number of hours it would take to circulate the entire volume of pool water through the filtration system. The turnover rates are as follows:

- 4 hours for public swimming pools (lap pool and leisure pool)
- 15-20 minutes for whirlpools depending on pool volume

Based on this strict requirement, there is a direct relationship with the size of the pool and the size of the circulation pumps and associated systems. The larger the pool area is, the larger the circulation pump and thus energy use. It should be noted that the Code mandates these turnover rates to be continuous even when the pool is unoccupied which means that the circulation pumps run essentially non-stop (this will be evident when considering the building's total energy consumption later in the report). The lazy river and whirlpool would also include additional jet pumps for occupant enjoyment; these would not run continuously.

It is recommended that the main lap pool and leisure pool have a gutter type drain that would provide excellent skimming to remove contaminants from the water's surface. The whirlpool and lazy river could use traditional skimmers. The skimmers/gutters in conjunction with the pool main drains on the bottom of the pool would return the water back to the system filtration pumps. The supply jets for the pools would be located to ensure effective turn-over of the entire pool.

5.2 DESIGN CONSIDERATIONS FOR OPTIMAL POOL EFFICIENCY

As mentioned earlier, since much of the design for aquatic facilities is strictly governed by the Alberta Building Code and Alberta Health Services Pool Standards, the amount of "flexibility" in terms of design are quite limited. The elements of design where design discretion is possible to minimize space requirements, consumption of power, water, heat, and chemicals include the following:

5.2.1 FILTER SELECTION

It is highly recommended to utilize "regenerative" filters in the pool filtration system. Regenerative filters use perlite (volcanic ash) as the filter medium which has huge benefits over traditional sand filters:

Efficient use of space

Regenerative filters have the capacity to filter large flow rates in a very small space footprint. An example is that it is possible to flow 1000 gpm (gallons per minute) through a regenerative filter occupying less than 10 m^2 of space, while to do the same flow rate with vertical sand filters would require roughly four times the space. There is a significant impact on building size.

Effective Filtration without Supplementary Filter Aid

Regenerative filters can filter down to about 4 microns without supplementary filter aids such as flocculants. Sand filter typically would normally filter down to about 17 microns and require supplementary filter aids to improve this performance. This has a large impact on operational cost.

Efficient Water use

Regenerative filters are very water efficient. Conventional sand filters must be backwashed frequently (about every 8-10 days) at flow rates equal to or greater than the turnover flow rate. Therefore, a filter system flowing at 1000 gpm would have to be backwashed at a minimum of 1000 gpm for up to 5 minutes. This results in the discharge to "waste" of about 5000 gallons of heated and treated pool water. In contrast, a regenerative filter is typically backwashed about every six weeks and the water loss during backwash is only about equal to the volume of the filter tank (nominal 500 gallons). There can be some debate about the value of "dilution" of water (such as would occur after the backwash of sand filters) but in pools that are not used to the maximum bather loads the dilution factor is not a major consideration. This has a major impact on the consumption of water as well as the utilities used to heat and treat the water up to the pool standards.

Operational Range

The filtration rate (flow per unit of filter area) for regenerative filters allows for greater flexibility in operations. The minimum filtration rate is about 0.6 gpm/ft^2 and it can go up to 1.2gpm/ft^2. The nominal usual design is for about 1.0gpm/ft^2 so if the filtration rate needed to be ramped up or down the operator does have considerable flexibility to do so.

Automation

Even the very basic regenerative systems are highly automated with very user friendly software programs. The functions of the filters are integrated with the variable frequency drives, the chemical controllers, the heating systems, and the UV systems to make the system operations very efficient and accurate. These features save operators time and ensure the systems interface with each other to prevent operator error.

5.2.2 PUMP SELECTION AND CONTROL

As will be evident later in the report, the circulation pumps for the filtration system represent the majority of the building's energy consumption. While this energy use cannot be eliminated because of pool safety requirements, there are ways to minimize the pump power through smart design and control. While virtually all pumps are now equipped with premium efficiency motors for optimal efficiency in terms of power consumption, if a pump is not selected or sized correctly, it might not run close to its best efficiency point (BEP). For this reason consideration must be given to the following items when selecting pumps and pump controls:

- Different pump manufacturers have different performance curves so when selecting pumps it is necessary to evaluate the pump performance from a variety of manufacturers and choose the most efficient ones.
- Carefully calculate the required flow rates and accurately calculate the resistance (pressure drop) in the system to select the performance point (flow/head); then choose the pumps that are most efficient. Most mechanical engineers will use spreadsheets or rough estimates which tend to over simplify and over estimate the required head. Sophisticated pipe flow software should be used to model the piping system accurately as per as-built conditions.
- Use variable frequency drives to control the pump speed and optimize the performance at the lowest possible electrical consumption. A very minor reduction in the speed of a motor has a magnified effect in terms of reducing power consumption.

5.2.3 PRIMARY AND SECONDARY WATER SANITATION

It is necessary to have a residual of a "halogen" (in the case of Alberta it must be chlorine) in the pool water. There are various ways to introduce the chlorine (primary sanitizer) to the pool water including gas chlorine, liquid chlorine (sodium hypochlorite), salt water chlorine generators, erosion type calcium hypochlorite feeds, etc.... The most common types of "secondary" sanitizers include specialized chemicals, UV, and ozone. Each type of system has certain benefits and certain drawbacks so the selection is discretionary.

The most efficient way of feeding chlorine into a pool is to use gas chlorine. It is 100% pure, it is cost effective, and it does not add "by-products" to the pool water. The largest issue with gas chlorine is the perceived danger of having chlorine gas at a site. There is no doubt that handling gas chlorine does require special staff training and specialized equipment (demand breathing apparatus) so in many cases this is a deterrent to the use of gas chlorine. This is especially the case where facilities employ lifeguards to maintain their operations (as opposed to professional building operators). Local policies with respect to the use of gas chlorine (or not) will govern whether gas chlorine is an option or not.

Regardless of the method of introducing chlorine into the pool water it is a fact that when swimmers use the pools they do introduce "organics" into the pool water and the active chlorine does oxidize these organics and produce a nitrogen based "waste" commonly referred to chloramines. Chloramines are noticeable in that they are the "chlorine smell" often associated with aquatic facilities. These chloramines can be detrimental to swimmer comfort (burning eyes, breathing problems) and contribute to pool indoor air quality that affects customer comfort and corrosion to the building structures and accessories. Chloramines control is very important to the health of swimmers and staff and to prevent corrosion within the natatorium. Chloramines control can be accomplished with chemicals or ozone but Medium Pressure UV systems have largely been adopted as a very clean and efficient way to control chloramines and provide some secondary sanitation. Some of the main benefits of including UV for swimming pool application are the following:

- The intensity of the light does have the effect of destroying the various chloramines; typically, they can be controlled to approximately 0.2ppm.
- The UV light has the effect of damaging the DNA of viruses and bacteria to prevent them from reproducing. Some of the viruses and/or bacteria cannot be destroyed by chlorine at all or requiring high concentrations of chlorine for long periods of time. The time lines and chlorine concentrations would be very disruptive to facility function.
- The intensity of the UV can be changed from 100% to 50% or shut off completely during non-peak hours to save on electrical consumption.
- The UV systems require minimal amounts of maintenance; annual lamp replacement and bi-annual wiper service is typically all that is required.
- UV systems are very compact and typically do not require any separate rooms (like ozone) and safety protocols like chemicals do.

5.2.4 FUNCTIONAL DESIGN

We are aware that there are many "pressures" that are brought to bear on facility designers and of course these are to be respected by the design team. However, there is always a "balance" that must respect the elements of capital cost, energy efficiency, operating cost, and the "visit experience" of the patrons. Clearly the goal is to optimize the "visit experience" while at the same time respecting the more practical considerations for finance and cost of operations. Some of the guidelines we believe need to be respected include the following:

- Determine the "program priorities" of the Owner and ensure they are realistic for the size of community. In other words, determine the anticipated number of potential facility patrons per day for various times of the year and time of day. Avoid building and operating a facility based on usage numbers that may only be achieved a few days a year.
- Include as many activities as possible into as few as possible bodies of water. For example, a Leisure Pool could and likely should include a "beach entry", lazy river, sufficient shallow water for teaching small children, interactive water features that provide play/entertainment value, etc.... The cost of operating an intensely used pool is not much higher than operating a low usage pool but having extra under-utilized bodies of water are expensive to build and maintain. An example of creating additional usage for a 25M pool is to use floating devices such as "obstacle courses" to enhance the play value of a pool that ordinarily could be under-utilized. Counter-current swim-jets are also an effective way of enhancing the use of lap pools.
- Effective selection of water features and play features. There are now many very creative options for this including using bases that can be used to inter-change water features from time to time to provide continued interest and entertainment valve. The use of floating play devices that are tethered to lap pools (for special events, promotions, or regular programing) is a way to helping to utilize lap pools.

5.2.5 Operational Planning

Sometimes facility operators implement "scheduled" operational task schedules on a "time-based" routine. This often includes frequency of backwashing filters and draining/refilling pools. Backwashing and draining/filling of the pools more frequently than necessary can be very expensive in terms of wasting water, heat, and chemicals. Backwashing more frequently than necessary does not enhance filter performance (it can vary depending on the type of filters used) but generally it does not. Draining/filling pools (usually whirlpools are the most common example) should only be done when the water quality parameters dictate that it is necessary to do so. There are objective testable measures that an operator can use to determine the frequency. Things related to this that can be put into practice to minimize resource consumption could include the following:

- Where possible use heated/treated water (assuming it is useable) from a larger body of water (eg. Lap Pool) to re-fill a smaller body of water (like a whirlpool) by use of a cross-connect. To do this will not reduce the total amount of energy required in total but it would reduce the momentary "demand" and thus it may be possible to re-heat the smaller pool in a short period of time with a relatively small heat supply. This is the preferred method especially with a ground connected heat exchanger which does not respond well to huge surges in demand.
- When backwashing (like in the case of sand filters) experiment with the backwash process to determine the "optimal" backwash time for each system and stay within this. Just because the Operator's Manual says it is necessary to backwash for 5 minutes it may only be necessary to backwash for 2-3 minutes.
- Test water frequently for all the usual things water is tested for including the chloramines. If the chloramines levels are low (due to low bather loads or whatever other reason) the UV system can be programmed to cycle on/off only when it is necessary to be operational. It can be programmed to go into reduced output mode or even shut down for significant periods of the day.

5.2.6 Pool Cover

The best method to control water evaporation in a body of water is to employ a traditional pool cover to insulate the pool water surface from the pool environment (this reduces latent heat loss from the pool's surface and thus hot water makeup). The challenges with the traditional cover are the cost and logistics associated with storing and operating the cover. Manual covers are the least expensive but most troublesome to operate. Automatic covers are very expensive but less troublesome to operate. Automatic covers are very expensive both from a capital standpoint and for maintenance. There is also a safety risk with the cover depending on the design. If a manual pool cover is not desired, a liquid pool cover is an innovation that utilizes a liquid that floats on the surface and minimizes evaporation. The liquid forms a microscopic layer that does not evaporate and reduces both the energy to heat the make-up water but also the amount of water treatment.

5.2.7 Code Variance

If the Authority Having Jurisdiction (AHJ) and Alberta Health Services (AHS) have a desire to embrace the net zero approach it would be helpful to challenge the continuous requirement for a 4 hour turnover rate on the main pool. AHS mandates that pool turnover rates are set and maintained at all times which means that the main filter pumps run continuously at high speed. Since there are many hours of the day when the facility is closed and the pools are not used, lowering the turnover rates would drastically reduce the building's energy consumption. This suggestion is not unprecedented as there are other jurisdictions that allow this. AHS has been reluctant in the past to allow any code variances on turn-over rates due to user safety concerns but based on the goals of this project it might be worth pursuing. It is not likely that this variance would be allowed but it could be a part of a larger discussion with the province and local AHJs. Compromises could be made in terms of additional testing or other mitigating strategies that would appease their concerns.

6.0 MECHANICAL CONCEPT

6.1 CONCEPT DESCRIPTION

The mechanical system for heating and cooling of the building is similar to that of a typical high performance net zero building. Appendix C shows the preliminary mechanical design and is described as follows:

6.1.1 NON-POOL AREA HEATING AND COOLING

Non pool areas are heated and cooled with water-to-air heat pumps (which create hot and cold air) as shown on drawing M1.1 in Appendix C. Each zone would include one heat pump which would give individual heating and cooling space temperature control. The recommended heat pumps used in the proposed design and costing include the most efficient heat pumps on the market which feature variable compressors and fans (typical minimum efficiencies are 380% in heating and over 600% in cooling).

The water-to air heat pumps would be connected to the main building heat pump loop as shown in Figure 9 as well as drawing M2.0 in Appendix C. Based on the energy modelling performed, these heat pumps would spend most of the time cooling the space, which means they would reject heat into the heat pump loop.

6.1.2 HOT WATER GENERATION

As seen in Figure 9, water-to-water heat pumps would upgrade the heat in the heat pump loop and generate hot water for showers, pool heating as well as space heating in the air handling units. HP-1/2 would handle hot water for domestic hot water (DHW) use which would be stored in a separate storage tank. Depending on the loop temperature and delivery temperature of these heat pumps, an electric heating coil might be required to flush the storage tank above 60°C once per week (to prevent legionnaires disease). It is not necessary to store water at this temperature the entire time. Heat pumps 3 and 4 would generate hot water for use in the pool ventilation unit (discussed below) as well as the reheat coils on the energy recovery ventilators (ERVs). Heat pumps 5 and 6 would be dedicated to pool heating through the pool heat exchangers.

6.1.3 HEAT PUMP LOOP

Figure 9 shows how the main heat pump loop would be configured. The heat pump loop essentially acts as the heat delivery mechanism for the entire building. Waste heat from the ice plant maintains the temperature in the loop, the ground heat exchanger is used for temporary energy storage and to prevent the heat pump loop from overheating, and the heat pumps described above extract energy from the loop as needed. The waste heat and geothermal portions of the loop are described in Sections 6.3 and 6.4.

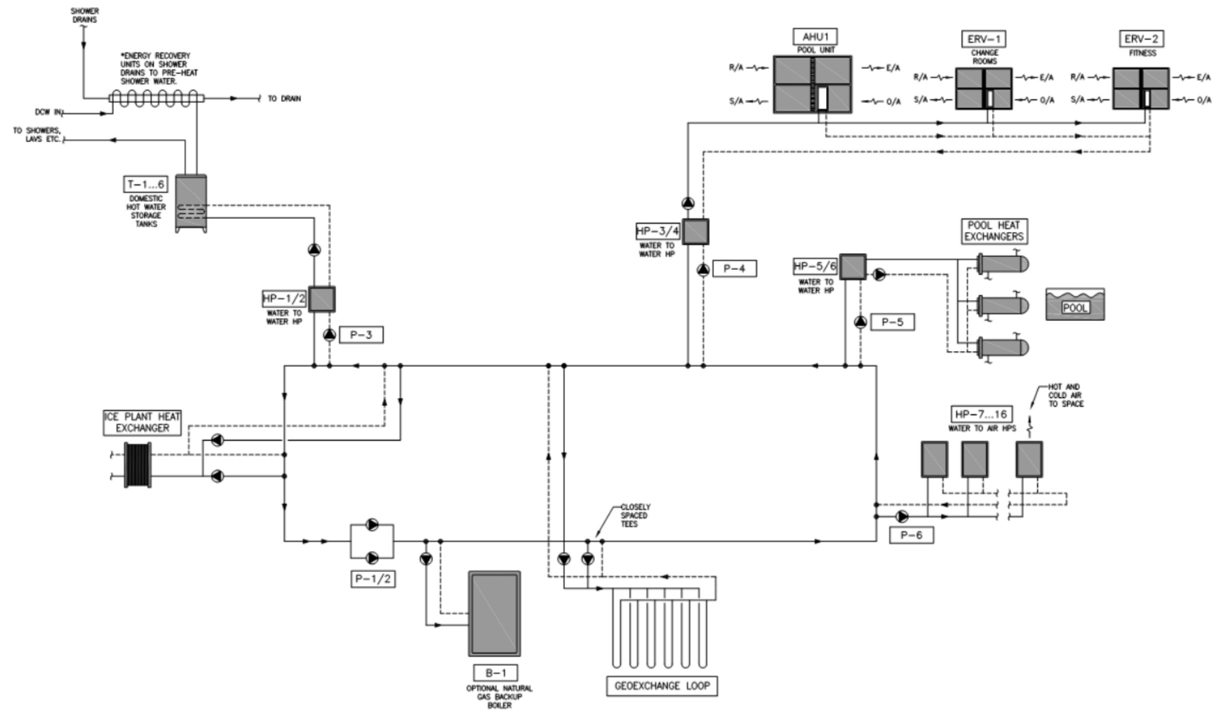


Figure 9 - Mechanical System Schematic

6.1.4 Energy Recovery Ventilators (ERV)

A critical component of the building design is energy recovery on all air systems. The pool unit should utilize heat recovery (discussed below) and the non-pool areas should utilize dual-core energy recovery ventilators which recover up to 90% of the energy from the exhaust stream. Each floor was modelled with its own energy recovery ventilator. These systems are discussed in more detail below.

6.1.5 Pool Ventilation

The ventilation for a natatorium is challenging to ensure occupant comfort, humidity control and high quality of air for the environment. The natatoriums have various bodies of water each with their own unique operating temperatures and activity levels that affect the amount of moisture that is evaporated into the pool environment. It is recommended by ASHRAE (American Society of Heating Refrigeration Engineers) to keep natatorium humidity between 40-60% RH and allow for 4-6 air changes based on the space volume. The humidity control is very important in the cold winter climate of Alberta as reducing high humidity levels, good envelope design and proper ventilation design strategies are very critical to minimize condensation on the windows of the space.

Typically the dehumidification process can be quite energy intensive as the moisture needs to be removed from the space while maintaining warm space conditions. The dry ambient conditions of Alberta does allow for outdoor air to be used to dehumidify the space thus reducing the energy required for dehumidification and allowing additional fresh air to be supplied to the space (increasing the air quality). The greater the dehumidification load, the more outdoor air is used to dehumidify the space. The challenge from an energy standpoint is heating the cold outdoor air up to space temperatures. The proposed design uses a sensible only energy recovery wheel to capture the heat from the pool exhaust air to preheat the incoming outdoor air to the space. Whenever possible, only delivering the least amount of outdoor air to satisfy the dehumidification load while meeting the occupant requirements would be the best approach from an energy efficiency standpoint.

Space and pool temperatures also play a critical role in the dehumidification process. The cooler the space temperature in relation to the bodies of water, the greater the amount of evaporation and the higher the dehumidification load. It is suggested that the space temperature be kept one degree Celsius above the water temperature of the lap pool to minimize evaporation from the pool surface (the lap pool being the largest body of water). Often this is much warmer than operational staff like the space temperature and it is reduced to the detriment of the energy efficiency (staff should be educated to this point). The air handling will have a glycol preheat coil to warm the winter outdoor air above the frost point on the wheel to avoid defrost mode on the energy wheel. The selection of the air handling unit, wheel control strategy and its internal components are critical to ensure proper heat recovery and avoid maintenance and operational pitfalls.

Consideration in the ventilation design for supply and return air locations is also crucial in the pool space to ensure air quality and minimize condensation. Supply air must be used to sweep both the envelope and the pool surfaces. The envelope supply is used to minimize the chance for cool surface temperatures that would drop below the dew point of the warm moist pool air and cause condensation. In addition to condensing on the windows and losing the nature views to the outdoors, condensation can lead to building envelope concerns with standing moisture and mold growth. The supply air must also remove the airborne contaminants released from the chemical reactions taking place with the sanitation of the water (organics introduced into the pool water are oxidized by the chlorine and produce the nitrogen based waste called chloramines). These airborne chloramines cause occupant discomfort and are known to induce asthma related breathing issues. The chloramines also produce the pool "chlorine smell" and lead to building corrosion issues. Return air locations are also very critical in the removal of these chloramines. Pool deck level returns in conjunction with high level returns would be recommended. Pool gutter return air systems could also be explored that remove the chloramines at the source of their generation. The construction of these combination pool gutters/return air systems requires an early adoption by the design team as there are multiple disciplines involved in their successful integration. There are commercially available products that can be sourced but typically public projects run into challenges with using sole sourced solutions.

Pool pressurization control is also a very important and dynamic load that is critical to control properly. The general building pressure should be slightly positive to both the outdoors and pool space to avoid the odors from the pool to permeate into the other building spaces. The change rooms should also have slight positive pressure in relation to the pool space for the same reason but a negative pressure to building so their odors are also contained. The pool space will have a varying outdoor air load for dehumidification purpose as will the fitness and other general areas so the proper pressure controls are critical. Education of the operation staff is very important on this control sequence as altering it can result in very problematic pressure problems that hinder many other similar recreation facilities.

6.1.6 Change Rooms and Fitness Area

The change rooms will have shower areas that have warm moist air that needs to be exhausted from the building. The proposed design uses an energy recovery ventilator for recovering both the sensible and latent heat from this exhaust air (the ERV can recover up to 90% of the energy from the exhaust stream).

The preheated outdoor air is supplied in directly to water-to-air heat pumps serving these spaces. A similar approach will be used for the ventilation air requirements for the fitness areas on the second floor. The fitness areas should also employ a demand control ventilation strategy (DCV) that will only provide the amount of exhaust/outdoor air as required for the occupants. The DCV system relies on CO_2 sensors in the space to adjust the outdoor air requirements, thus reducing the amount of outdoor air that will need to be conditioned. The change rooms will not be able to take advantage of the DCV strategy as there are mandated exhaust rates for the space that would not be advisable to reduce.

6.2 PLUMBING DESIGN AND CONSIDERATIONS

The plumbing design for this facility would be typical to any other aquatic facility with a few notable exceptions. Since reducing hot water flows is a huge energy savings opportunity it is highly recommended to utilize the lowest flow fixtures available on the market. In particular, the following are some recommendations for reducing water and energy use in the building:

- Implement drain water heat recovery (DWHR) from all showers. DWHR uses a copper heat exchanger to extract heat from warm drain water (a running shower) and passes it to the incoming cold water. The DWHR units need to be located below the floor level and luckily the partial basement included in the proposed design leaves plenty of room for the DWHR units. DWHR can reduce energy use by 10-35% depending on building use.
- Utilize the lowest flow fixtures available for lavatory faucets (including shut off or push timers to discourage use).
- Showers should use no more than 5-5.7 Lpm of water and should also have push timers or other mechanisms to discourage use. While this may be "annoying" for users, the intent is to discourage long showers and waste.
- Urinals and toilets should be ultra low flow units.

6.3 ICE PLANT WASTE HEAT INTEGRATION

The project team has identified the integration of waste heat from the ice plant as the biggest potential energy opportunity of the project, which could make or break not only the viability of achieving Net Zero, but also the financial viability of the proposed mechanical systems. The following sections will discuss the details around this system, the integration, challenges and opportunities.

6.3.1 WASTE HEAT FROM AN ICE PLANT

Based on NRCan research, a typical community hockey arena has to reject 120,000 to 170,000 kWh of heat monthly. The amount of waste heat available is dependent on many factors including:

- Number of hours the ice rink is used on a daily, weekly and annual basis.
- Number of times the ice is resurfaced per day
- Air temperature in the ice shed
- Ice temperature
- Thickness of the ice (refrigeration plant has to run more if the ice is thicker)
- Construction of the ice shed (insulation values, low-emissivity ceiling, type and quantity of lighting; some rinks have the capability to operate with low-med-high lighting levels)
- Rink floor construction (whether the floor is insulated)
- Size of refrigeration system pump
- Heating of spectator area (gas radiant heaters are common, and if they are not properly set up they can heat the ice surface itself and add to the refrigeration load).
- Dehumidification of the ice area. Moisture in the air will condense on the coldest surface. If moisture is removed with a dehumidification unit in the ice area, that will reduce the load on the refrigeration plant.
- Ventilation in the ice area. If a natural gas or propane ice resurfacer is used in the facility it will require higher ventilation rates than battery powered equipment.

Based on these many factors it is clear that estimating the amount of waste heat available is no small task. However, a rough estimate based on the NRCan research would dictate that the existing Omniplex facility, which has two hockey rinks and a curling rink, has to reject more than 3.0 million kWh of heat per year.

Currently, all of this heat is rejected through an air cooled condenser which rejects the heat to the outside air. The existing facility does recover some of this heat through heat exchangers which send heat to the snow melt system, as well as the main air handler (144 kW peak) for the hockey arena. How these systems are controlled, whether they are working at all, and how much heat they are using is unknown at this time but based on estimates of usage, the amount of heat available for rejection is still expected to be significant. The total capacity of the ice plant is 527 kW (150 tons) which includes three 50 ton compressors (one standby).

6.3.2 ESTIMATING AVAILABLE WASTE HEAT

It is challenging to estimate the waste heat available from the ice plant without direct measurements (or access to the building BMS), but for the purposes of this study, the team created a detailed spreadsheet to not only quantify the available waste heat, but also to convert this to an hourly load profile for every hour of the year, which would be used in sizing of the geothermal heat exchanger. A snapshot of this spreadsheet is shown in Figure 10, which shows how the operation of a typical ice plant was approximated using past experience as well as feedback from the builder operators.

Adj	Adj		1-yes,0-no				1-yes,0-no	Enter 0, 1 or 2 to activate refrigeration plant in NO LOAD, PART LOAD or FULL LOAD for hours of operation																						
kBtu	kW	Month	Operating	% Runtime	Beginning	Week	Operating		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0	0	Jan	1	60%	01-Jan	1	1	Mon	0	0	0	1	0	0	1	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0	Feb	1	65%	08-Jan	2	1	Tue	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0	Mar	1	75%	15-Jan	3	1	Wed	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0	Apr	0	85%	22-Jan	4	1	Thu	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
276	81	May	0	90%	29-Jan	5	1	Fri	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0	Jun	0	95%	05-Feb	6	1	Sat	0	0	0	1	0	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	1	1
276	81	Jul	0	100%	12-Feb	7	1	Sun	0	0	0	0	1	0	1	0	1	1	0	0	0	2	2	2	2	1	1	1	2	1
0	0	Aug	0	100%	19-Feb	8	1	Hol	0	0	0	0	1	0	1	0	1	1	0	0	0	2	2	2	2	1	1	1	2	1
276	81	Sep	1	95%	26-Feb	9	1																							
276	81	Oct	1	80%	05-Mar	10	1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0	0	Nov	1	70%	12-Mar	11	1	Mon	0	0	0	460	0	0	460	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
0	0	Dec	1	65%	19-Mar	12	1	Tue	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
0	0				26-Mar	13	1	Wed	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
480	141				02-Apr	14	1	Thu	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
480	141	Apr	0	85%	09-Apr	15	1	Fri	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
480	141	Aug	0	100%	16-Apr	16	1	Sat	0	0	0	460	0	800	800	800	800	800	800	800	800	800	800	460	460	800	800	800	460	460
480	141	Dec	1	65%	23-Apr	17	1	Sun	0	0	0	0	460	0	460	0	460	460	0	0	0	800	800	800	800	460	460	460	800	460
276	81	Feb	1	65%	30-Apr	18	1	Hol	0	0	0	0	460	0	460	0	460	460	0	0	0	800	800	800	800	460	460	460	800	460
276	81	Jan	1	60%	07-May	19	1																							
276	81	Jul	0	100%	14-May	20	1																							
480	141	Jun	0	95%	21-May	21	1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
276	81	Mar	1	75%	28-May	22	1	Fri	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
276	81	May	0	90%	04-Jun	23	1	Hol	0	0	0	0	1	0	1	0	1	1	0	0	0	2	2	2	2	1	1	1	2	1
0	0	Nov	1	70%	11-Jun	24	1	Mon	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0	Oct	1	80%	18-Jun	25	1	Sat	0	0	0	1	0	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	1	1
0	0	Sep	1	95%	25-Jun	26	1	Sun	0	0	0	0	1	0	1	0	1	1	0	0	0	2	2	2	2	1	1	1	2	1
0	0				02-Jul	27	0	Thu	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0				09-Jul	28	0	Tue	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
276	81	Enter plant capacity in kBtu			16-Jul	29	0	Wed	0	0	0	1	0	0	2	2	1	1	1	2	2	1	1	2	2	2	2	2	2	1
0	0		kBtu		23-Jul	30	0																							
276	81	No load	0	0	31-Jul	31	0		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0	0	Part load	460	1	07-Aug	32	0	Fri	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460
276	81	Full load	800	2	14-Aug	33	0	Hol	0	0	0	0	460	0	460	0	460	460	0	0	0	800	800	800	800	460	460	460	800	460
276	81				21-Aug	34	0	Mon	0	0	0	460	0	0	800	800	460	460	460	800	800	460	460	800	800	800	800	800	800	460

Figure 10 - Quantifying Available Waste Heat

In addition to the waste heat available from the compressors, pump heat from a 25 horsepower circulation pump was also added to the available waste heat, as this heat goes directly into the loop. Three estimates were created for the available ice plant heat (for use in geo system sizing; discussed below). They are summarized below:

1. High Ice Plant Heat – 600 Mbh (176 kW) part load and 1200 Mbh (352 kW) full load
2. Medium Ice Plant Heat – 460 Mbh (135 kW) part load and 800 Mbh (234 kW) full load
3. Low Ice Plant Heat – 300 Mbh (88 kW) part load and 600 Mbh (176 kW) full load

These three estimates were used for the sizing of the geothermal system (discussed below) in a sensitivity analysis on the impact that ice heat recovery has on the size of the geothermal storage system.

6.3.3 CAPTURING WASTE HEAT

Capturing waste heat from the Omniplex Ice Plant will require the installation of an ammonia to water heat exchanger (essentially a water cooled condenser) in parallel with the existing air cooled condenser (seen in Figure 11 below). This heat exchanger would be located within the Omniplex Ice Plant mechanical room. High pressure ammonia lines would be connected to the water cooled condenser (heat exchanger) and high density polyethylene (HDPE) plastic pipes would be run to the new Aquatic facility. The easiest and most cost effective way to route the HDPE piping to the aquatic facility (for Site Option 1), would be to directionally drill underneath the existing parkade.

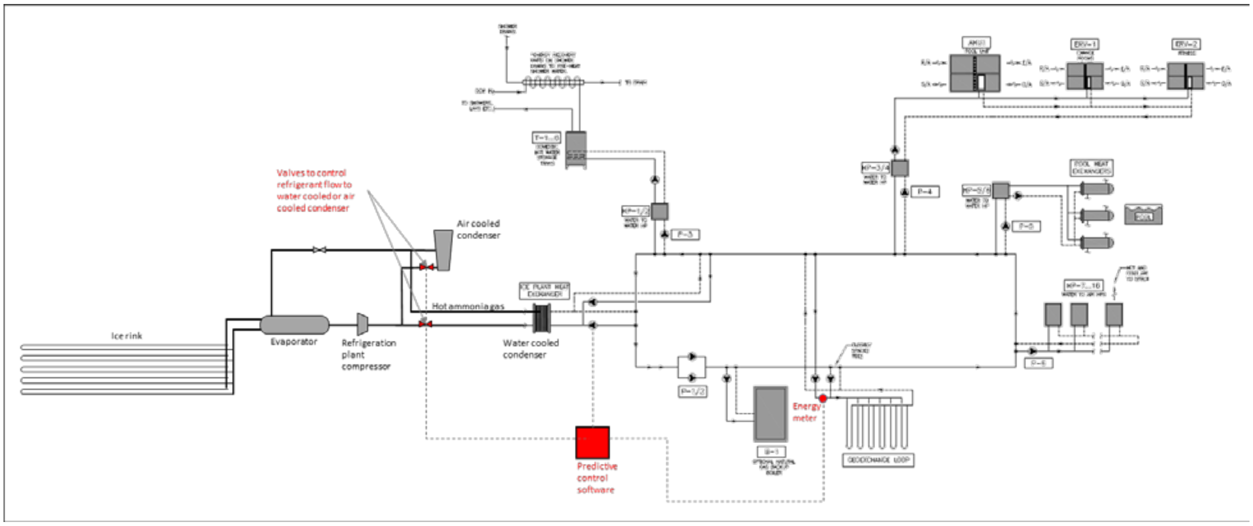


Figure 11 – Schematic Showing the Installation of an Ammonia to Water Heat Exchanger

The water cooled condenser should be installed in parallel with the existing air cooled condenser to allow a percentage of the heat to be used in the Aquatic Centre and the remainder dissipated to the atmosphere. Valves would be installed to control the refrigerant to either the air or water cooled condenser (or both). A predictive control system would likely be employed which would anticipate the heating demands of the Aquatic facility and adjust heat output accordingly. It should be noted that a firm with experience in ammonia refrigeration system design should be closely involved in the design and installation of the water cooled condenser and be familiar with the intent of the system design.

Once connected, the water cooled condenser should provide warm water with a temperature between 21°C-32°C. Depending on the length of pipe required to get to the Aquatic Facility, there will be some heat loss through the uninsulated piping. For the purposes of this study, a delivery temperature of 19°C was assumed at the Aquatic Facility. This warm water is the waste heat from the ice plant and is essentially free heat that simply needs to be upgraded to a usable temperature using heat pumps. Compared to a typical geothermal system, the higher entering water temperature improves the heating efficiency of the heat pumps by 30-35%.

6.3.4 USING WASTE HEAT AT THE AQUATIC FACILITY

While there is a large amount of waste heat available at the Ice Plant, *when* this heat is available does not always coincide with when the heat is needed in the aquatic facility. In order to maximize the usage of waste heat, heat storage in the form of a geothermal heat exchanger would be implemented at the Aquatic Facility. As seen in Figure 11 above, the aquatic facility uses many ground source heat pumps (GSHPs) for upgrading the low temperature waste heat to a usable temperature. GSHP equipment is designed to operate within a fairly specific set of temperatures. Delivering water temperature to the heat pumps outside of the temperature range they are designed to operate at will reduce operating efficiency and can shorten the life of the compressors. If entering water temperature is too high, the heat pumps will shut off on high pressure because of built in safety controls. Most heat pumps are designed with a high entering water temperature limit of approximately 27-32°C when they are in heating mode. For this reason, it is important to not simply bring in waste heat that will overheat the heat pump loop but to store the waste heat for future use. The geothermal or ground heat exchanger (GHX) is ideal for this purpose. When waste heat is available from the ice plant but is not needed at the Aquatic facility, it can be pumped into the GHX and withdrawn when needed. The waste heat will warm the ground around the heat exchanger and hold it for later extraction. When the heat is needed, this heat can be extracted from the ground heat exchanger.

A sophisticated control system will need to be developed that will control when heat is extracted from the ice plant, when it should be rejected through the ice plant air cooled condenser, and when it should be stored in the GHX for later use. There already exist control systems that can accomplish this task. Some predictive controls systems available on the market would employ a predictive strategy to control the control valves in the ice plant mechanical room. An energy meter on the GHX would monitor real time energy loads to the GHX, and by comparing the current GHX temperature to the predicted temperature (uploaded from an energy model), the software would adjust the waste heat extraction from the ice plant. The control system will be a critical component in the successful operation of such a system. While it is not in the scope of this study to develop the control system in more detail, it is highly recommended to employ experienced and knowledgeable companies to design such a system who have experience with such projects.

6.3.5 Opportunities

Snow Melt

As there will likely be too much heat available at the ice plant, some unique opportunities exist to use this heat in innovative ways to reduce operation costs. For example, a snow melt system could be employed in the side walks and entrance areas of the Aquatic Facility. When waste heat is available, it could be used to melt snow and ice around the facility and reduce or eliminate the need for shoveling, sanding and salting. The snow melt system would essentially act as another air cooled chiller; instead of rejecting heat through the ice plant's air cooled condenser, it could be rejected into the sidewalks (whether snow is present or not). This approach has been used successfully on several larger ground source heat pump projects with abundant amounts of available waste heat energy.

Omniplex Energy Savings

It should be noted that any energy extracted from the ice plant is energy that does not have to be rejected to the outdoors using the air cooled condenser. This will reduce run time of the air cooled condenser and therefore energy, which will reduce the operation costs for the Omniplex.

6.3.6 Challenges

While the waste heat from the ice plant presents an enormous opportunity, it also demonstrates some challenges as well. The following is a list of potential challenges in implementing waste heat from the Omniplex ice plant.

Quantity of Waste Heat

While this study has attempted to quantify the amount of waste heat available as best possible, it is still an unknown that should be quantified. As will be shown in the proceeding sections, the viability of the Aquatic Facility mechanical system is sensitive to the amount of waste heat available. Our opinion is that there is plenty of heat available, but this should be quantified before final design occurs.

Our recommendation would be to install energy meters and tracking on the existing air cooled condenser. This would quantify how much heat is currently being rejected. Furthermore, monitoring the contribution from the refrigeration plant provides valuable information about the amount of energy that might be available for other buildings that might be considered in the future. It will also help quantify the amount and value of waste energy from other facilities that might be owned or built by the community in the future.

Long Term Availability

One consideration is how long will the waste heat plant be available. Are there plans to move the ice plant? Or are there plans to use the waste heat for other purposes (within the Omniplex itself)? These are things that should be considered in the long term plan for the facility.

Dependent System

It should be noted that the proposed waste heat design inextricably links the operation of the two facilities. The aquatic facility will depend almost entirely on the Omniplex for heat energy. This can obviously be remedied through backup systems (as is shown in our design) but the design needs to consider potential shutdowns in the ice plant or other events which would prevent the waste heat from reaching the facility.

6.4 GEOTHERMAL HEAT EXCHANGER (GHX)

In a typical application of a geothermal or ground heat exchanger (GHX), the GHX would serve as a heat source and sink for the heat pumps in the building. The heat pumps would extract heat from the ground during the heating season, and reject heat to the ground in the cooling season. A proper design would ensure that the GHX does not overheat, or cool down over time. The GHX for the Aquatic facility serves a slightly different purpose. Because so much waste heat is available that provides the heat source, the GHX's main role is to function as an energy storage system for the building. Because of the differing schedules of the building, the waste heat from the Ice Plant will be available at times when it is not needed, or not available when needed. The GHX serves as a storage system for the waste heat, so that if waste heat is not needed at that exact moment, it can be stored in the ground for later use. In essence, this "syncs" the two buildings and allows greater use of the waste heat than would otherwise be possible.

6.4.1 SITE THERMAL PROPERTIES

In order to estimate the thermal conductivity of the soil available at the site, a water well log was pulled up from the nearby Omniplex. Using the data from the well log, the thermal conductivity was estimated using known thermal properties for different types of materials. The thermal conductivity was estimated to be 1.87 W/m·K. It should be noted that based on the actual measured thermal conductivity, the results below might differ by 10-20%.

6.4.2 GEOTHERMAL SYSTEM SIZING

Since the GHX for this facility acts as a sort of "storage tank", the proper sizing of the system needs to ensure that there is enough "refill" of the tank to meet the demands of the building; which withdraws energy from the "tank". In this sense, the waste heat from the ice plant recharges the heat within the ground heat exchanger, and the heating demands of the building (for heating and hot water) pull that heat back out. It is critical to quantify how much energy is being extracted, and to ensure that there is enough waste heat available when needed to always satisfy the building heat pumps.

As was discussed in Section 6.3.2 the amount of waste heat available from the ice plant was quantified using a detailed estimate of the anticipated plant operation. The resulting heat gains were extracted to an hourly spreadsheet which included every hour of the year. This represents the amount of heat rejected into the GHX and when it is available.

The detailed energy model (described in Section 8.0) establishes the hourly loads, or demands of the building. This includes the heating and cooling loads of the water-to-air heat pumps (which heat and cool the non-pool sections of the building), as well as the heating demands of the water-to-water heat pumps which create hot water for pool heating, domestic hot water, as well as the heating coils in the pool air handler and energy recovery ventilators. The cooling demands of the building were added to the waste heat generated from the plant as both represent heat rejection to the ground heat exchanger (cooling loads). The heating demands represent the energy extracted (heating loads). Figure 12 shows the heating and cooling loads for one of the scenarios modelled.

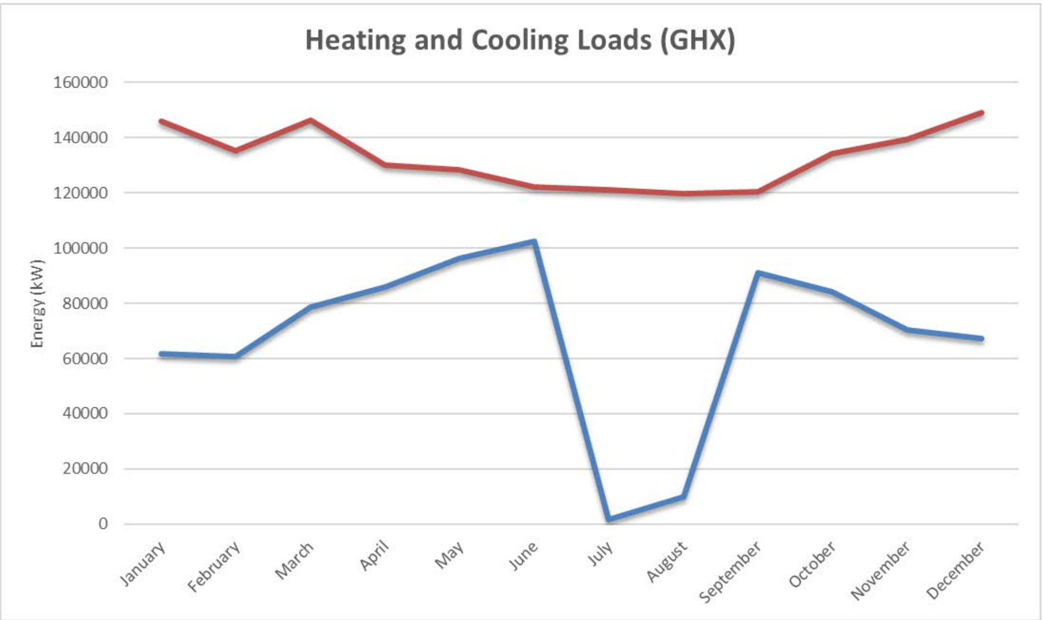


Figure 12 - Heating and Cooling Loads to/from GHX

As can be seen in the above chart, the heating demands for the building are relatively consistent. This is not surprising considering that the largest energy demand in the building is hot water for pool reheat and showers; this remains fairly consistent regardless of the outdoor temperature. The cooling demand however (which includes waste heat from the ice plant) shows a rapid decline during the summer months when the Ice Plant is not operational. Since there is less rejected energy than extracted energy, the GHX must be sized to compensate. A system that is too small would not be able to keep up with the heating demands (since the waste heat is insufficient) and would freeze over time. For this reason, sophisticated ground loop sizing software was used to model the GHX over a 30 year period, to ensure long term stability.

6.4.3 RESULTS OF GHX SYSTEM SIZING

To determine the size of the GHX system and the impact that waste heat has on the system sizing, several scenarios were modelled (with different quantities of waste heat) with a GHX size calculated for each scenario. The scenarios included the three mentioned in Section 6.3.2 in addition to some blended and hybrid scenarios. The results are summarized below.

<u>Scenario 1 - High Plant Heat</u>

When the waste heat from the ice plant was estimated to be almost all of the heat available at the refrigeration plant (176 kW part load, 352 kW full load), as seen in Figure 13 below, the GHX was sized at approximately 66 boreholes with a depth 150 m (approximate drilling cost of $600,000). Seen in a screenshot from the geothermal sizing software (Figure 14).

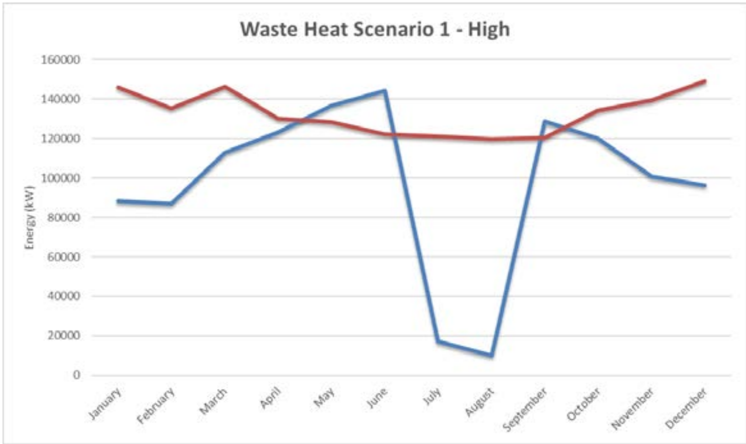


Figure 13 - Waste Heat Scenario 1 - High Plant Heat

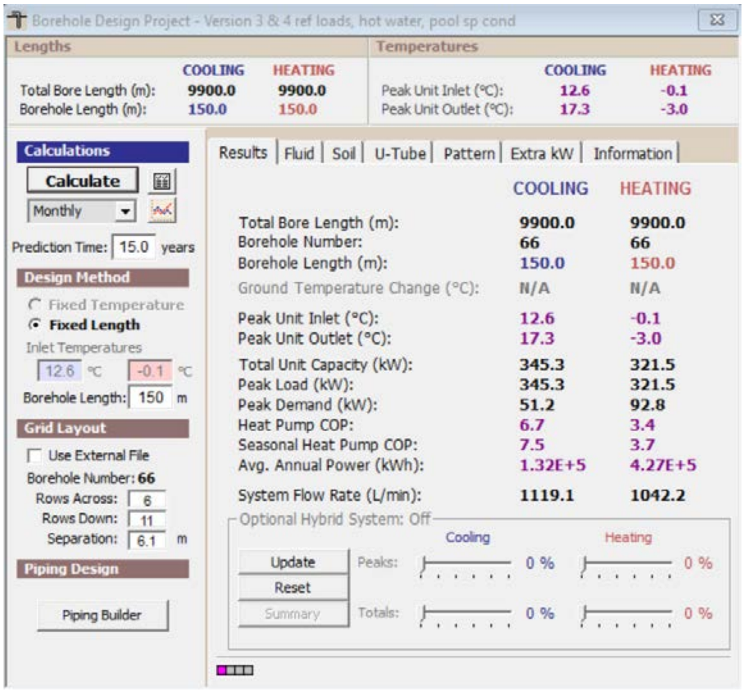


Figure 14 - Geothermal System Size for Scenario 1

The model shows that in this scenario, the long term ground temperature would actually increase, as seen below in Figure 15.

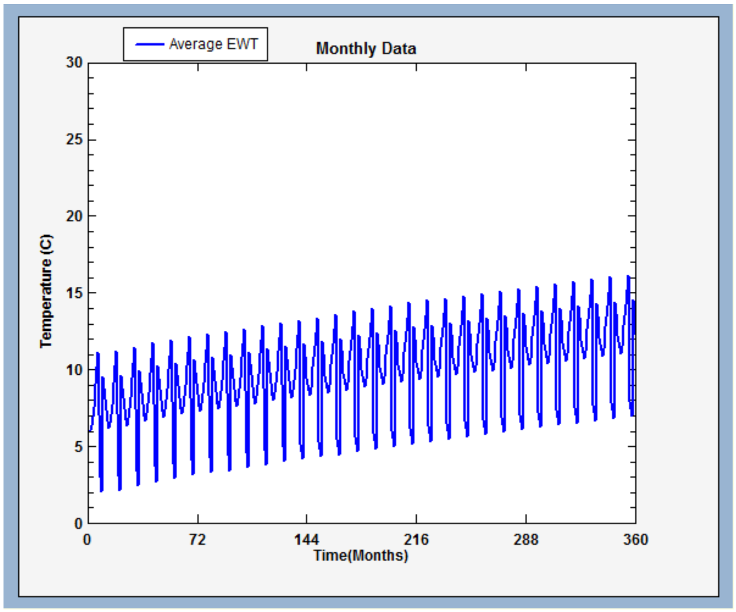


Figure 15 - Scenario 1 Ground Temperature over 30 Years

<u>Scenario 2 - Medium Heat Scenarios</u>

When the ice plant heat was estimated to be in the "medium" range, namely, 460 Mbh (135 kW) part load and 800 Mbh (234 kW) full load, the geothermal system size increased to approximately 100 Boreholes at 150m (approximate cost of $885,000). This represents an increase of approximately 30-35 boreholes over Scenario 1. The heating and cooling loads for this scenario can be seen in Figure 12. As seen in Figure 16 below, the ground temperature is slowly but steadily dropping over time. This is not expected to be a concern over 30 years, but mitigating design changes could be implemented to ensure long term performance.

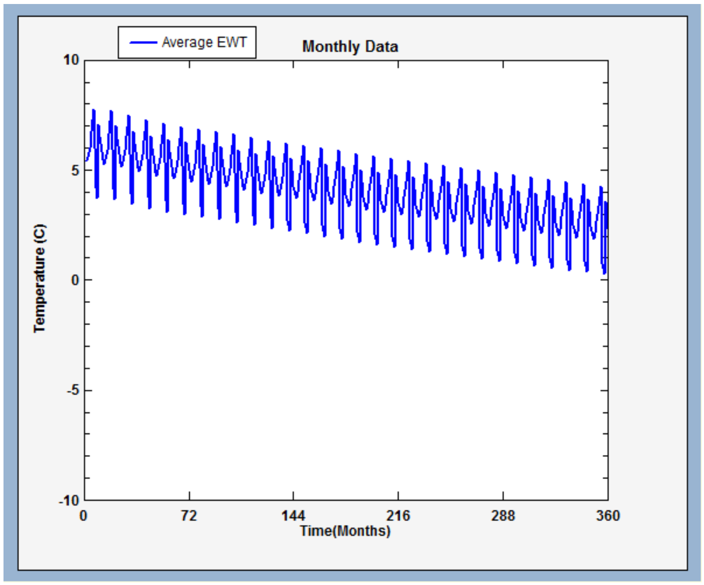


Figure 16 – Scenario 2 Ground Temperature Over 30 Years

Scenario 3 – Low Heat

When the waste heat from the ice plant was estimated at only 300 Mbh (88 kW) part load and 600 Mbh (176 kW) full load, the size of the GHX system increased significantly. In this scenario, the system was sized at 200-220 Boreholes at 150m ($1.7-1.9 million) which is double the size of the previous scenario. Furthermore, ground temperature degradation (seen in Figure 17) is significant which would likely require the use of a secondary backup or peaking system.

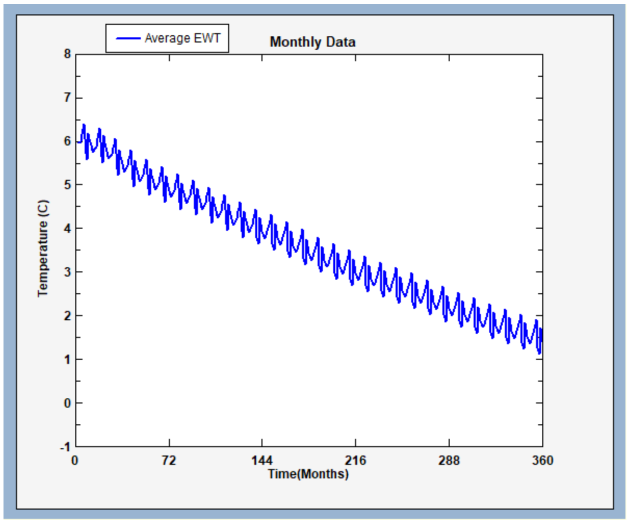


Figure 17 - Scenario 3 Ground Temperature Over 30 Years

Scenario 4 – No Waste Heat

For comparison, the calculations were also completed on a scenario where no ice plant heat is available (as would be the case at the county site (Site 2)). This system was sized at over 500 boreholes at 150m and experiences detrimental temperature degradation (Figure 18). This system is exceedingly large, and would not operate as needed without significant peaking/backup heat.

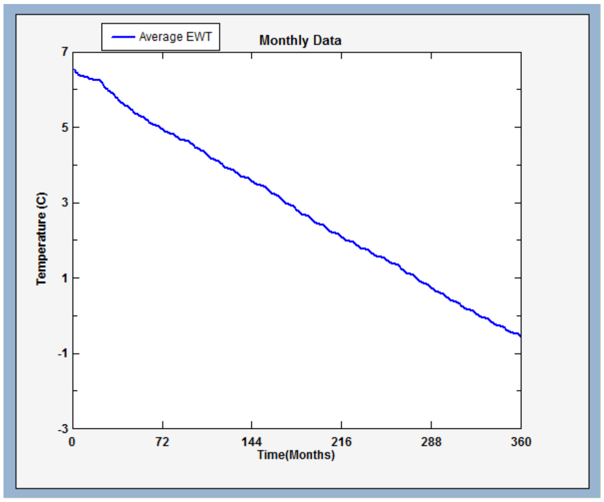


Figure 18 - Scenario 4 Ground Temperature Over 30 Years

6.4.4 CONCLUSION

It is quite evident from this analysis that the geothermal system size is very sensitive to the amount of waste heat available from the Ice Plant. It is the professional opinion of the authors that the waste heat available is closer to the High scenario, or somewhere in between High and Medium, but it is still clear that deeper analysis into the available waste heat is necessary. We recommend that energy meters be installed in the existing ice plant to quantify the available waste energy.

Furthermore, it is also evident from this analysis that absent of a secondary heat source, heating the building solely off a geothermal system is not possible. The heating loads of the building are simply too great. In order to make this type of system feasible at Site 2 (county site), an alternate heating system would need to be implemented. This will be the focus of the next section.

6.5 SOLAR THERMAL HEATING SYSTEM

Based on the above analysis of the sizing of the geothermal system, it became clear that if the building was to be built on Site 2 (county site) or at Site 1 without a connection to the ice plant, an alternate heat source would need to be provided. Since the intent of this study is to examine a net zero solution, a hybrid natural gas boiler solution was not considered. Instead an analysis was completed on the implementation and sizing of a solar thermal heating system. Two systems were considered. The first, is a traditional solar thermal collector (flat plate or evacuated tubes), the second, is a nano technology collector which captures daylight instead of sunlight.

The design of the mechanical system would change only slightly as seen in Figure 19. The hot water from the solar thermal system would feed a large solar storage tank which would distribute hot water to all systems requiring heat. The tank would also be connected to the geothermal system which would allow the storage of excess energy in the GHX. All other systems would remain the same.

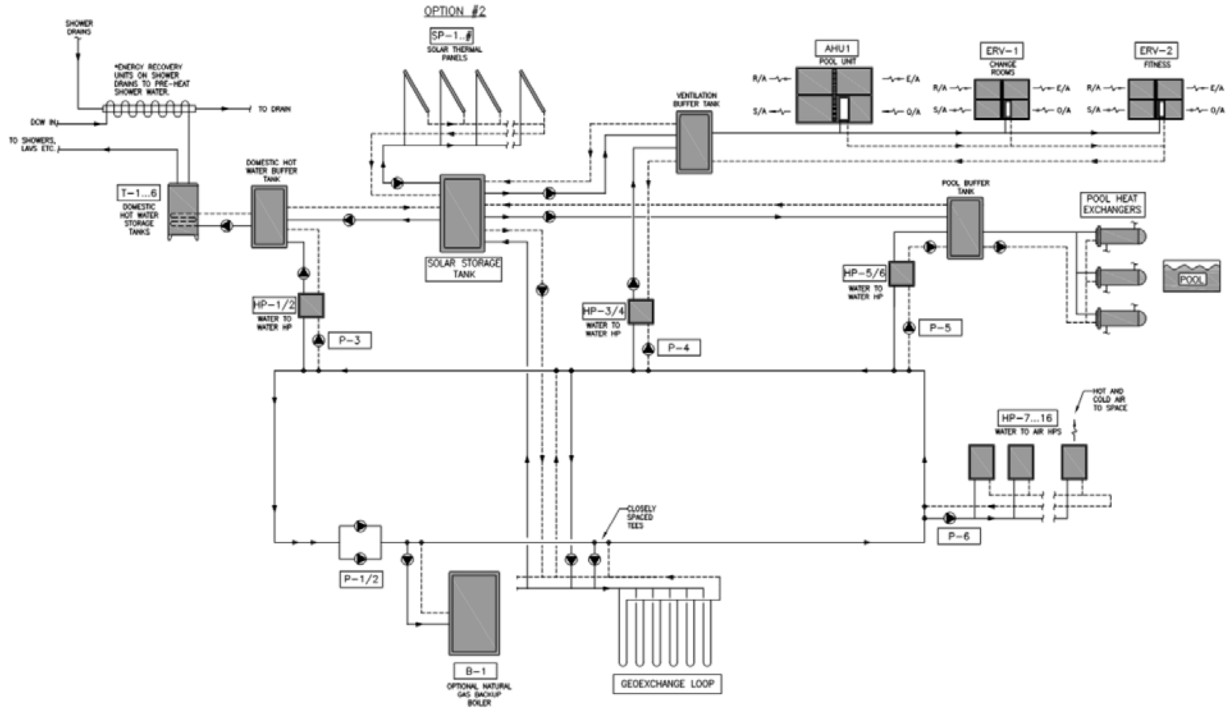


Figure 19 - System Schematic with Solar Thermal Option

6.5.1 Traditional Solar Thermal Collector

A traditional solar thermal system converts solar radiation to heat through a collector mounted on the roof that heats up water by absorbing sunlight. Since the hot water demands of the building are so large, almost every single kWh of energy could be used throughout the year, without needing to dump excess heat. The problem with traditional solar thermal collectors however, is that they require a significant amount of roof space and can also be costly. Also, any roof space that is devoted to solar thermal, takes away roof space available for electricity generation (through solar PV).

The estimated hot water load for the building was estimated at approximately 947,000 kWh. Using a solar thermal modelling package (Polysun), it was estimated that to achieve this energy production would require more than 600 solar thermal collectors covering the entire roof area. This is not considered a practical solution simply in terms of size, cost ($1.5-2 million) and complexity. Furthermore, there would not be any room left for Solar PV modules on the roof, eliminating any potential for electricity generation on site.

6.5.2 Hone Nano Daylight Collector

Because of the unpracticality of a traditional solar thermal collector, a more efficient collector was considered which has only recently entered the market in Canada. It should be clearly noted that this technology ventures a little bit into the unknown. Because this technology comes from the UK and hasn't really gotten a foothold in North America yet, there is only one installation in Canada (currently ongoing at the University of Ontario). However, the technology is so promising that we wanted to include it in this study. There are many installs in the UK including a major one for the National Health Service so we don't consider this an unfeasible proposition.

Unlike a traditional solar thermal collector which uses sunlight to create heat, a Hone solar thermal collector (www.hone.world) uses daylight to drive a "molecular high temperature heat engine" which is based on nano technology. Because the system harnesses daylight not sunlight, the production hours are increased dramatically; the system can produce heat as soon as daylight is available, even on a northern exposure. Because of the proprietary nature of the technology, further detail into its operation is not available. However, based on the performance of the system, including the fact that it can also generate electricity in addition to heat, makes it very exciting. For this study, we have only considered the water heating aspect of the collectors (certain models create heat only, certain models include energy generation).

Working with the Canadian distributor for the Hone Collectors we have estimated the heat production as well as cost of the collectors. Based on production estimates, the building would require only 100 collectors on the roof which would represent only 172.8 m^2 of roof area. These 100 collectors would generate approximately 933,000 kWh of heat per year, equivalent to almost the entire DHW heating demand, as seen in Figure 20 below (blue line is heat production, red is building DHW heat demand).

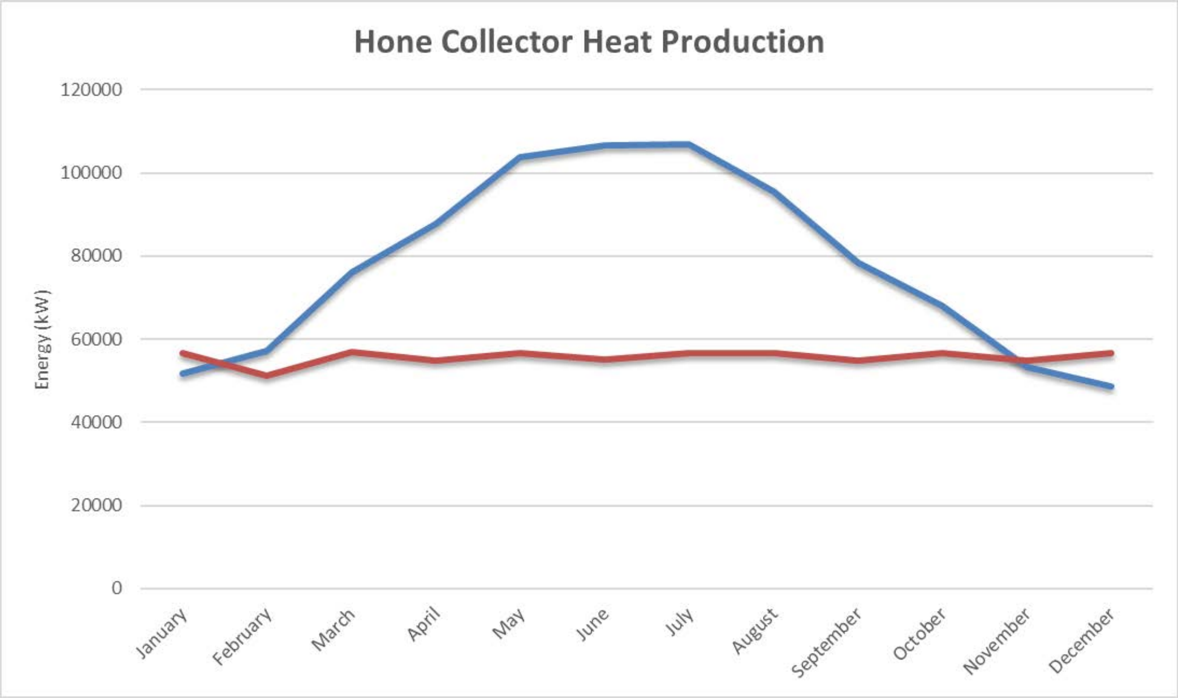


Figure 20 - Hone Collector Energy Production (Blue Line) vs DHW Demand (Red Line)

The cost of the systems installed was estimated to be just under $400,000, which compared to the solar thermal collectors and the energy production is significantly cheaper.

6.5.3 ENERGY SAVINGS

As seen in the Figure above, the estimated heat production from the Hone solar thermal collectors meet or exceed the required DHW demand for the building for almost every single month. It should be noted that this production not only replaces the heat energy that would otherwise come from the Ice Plant, but because this heat is provided at a higher and more usable temperature without the need to upgrade it (unlike the Ice Plant option), there is some additional savings in heat pump energy for upgrading this heat. The total DHW heat pump plant energy (for the ice plant option) was estimated to be 137.6 MWh. While this would not be eliminated entirely, it is possible that up to 90% of this energy could be eliminated which represents 123.8 MWh of electricity, or approximately $8,000 per year in energy costs.

6.5.4 Geothermal System Sizing with Hone Collectors

The geothermal system size was also calculated for the Hone Solar Thermal collector scenario. Because of the large energy production of the Hone collectors, the geothermal system size is actually reduced from the waste heat plant scenarios. It was calculated that only 45 boreholes at 150 m (approximately $400,000) would be required for this scenario which reduces the geothermal system size by approximately 20-60 boreholes depending on the amount of waste heat available. It should be noted that this represents a savings of approximately $170,000-$500,000 in geothermal drilling costs which offsets much of the installation cost of the collectors.

6.5.5 Conclusion

Based on the analysis performed above, there is a way to meet the energy goals of the project with an alternate system (should waste heat not be available). However, it should again be stressed that there are unknowns with these collectors and the authors would themselves need a lot more research and education on the product before fully recommending it. That being said, we felt it was worth including in the study as it solved a potential problem and has some added benefits including reduced energy use and smaller geothermal system size.

6.6 Controls and Optimization

A dedicated Energy Management Control System (EMCS) that would incorporate an intelligent and user friendly method to analyze the energy consumption and control major mechanical equipment would be essential for the operation of the facility. While the building mechanical system is not overly complicated, the addition of waste heat energy and the geothermal storage system definitely add to the complexity of the control system. Compared to a traditional building, the control system will be more advanced and will have a bigger impact on performance. The EMCS would need to accurately analyze the following to determine the best control strategy:

- Waste Heat from Omniplex
- Geothermal energy input and output
- Geothermal entering/leaving temperatures
- Heat pump loop temperatures
- Facility outdoor air requirements (Pool and Occupant load)

The control system would be much more complex and therefore would require a savvy operation staff to ensure the control strategies are operating properly. The system would also have a measurement and verification component (discussed in Section 7.3) that would be able to present information and results to not only the staff of the facility but the building patrons and ideally the community at large. We would also recommend a strong building commissioning agent for the project to ensure the systems are installed and operating properly from the first day of operation. The owner's training is also another critical component to ensure proper operation. It is highly recommended that this training be video-taped and well documented so future new staff is educated in the same manner as the original staff which tend to turn over at many similar facilities.

7.0 Electrical Concept

7.1 Lighting

While seemingly simple, indoor pool lighting can be a complex undertaking when considering the many unique variables and challenges that a pool environment creates. The goal of the lighting design is to provide a comfortable and safe space that contributes to a positive user experience. Adequate lighting levels (as well as uniformity) must be provided much like any other space, but one must also take into consideration the glare coming from the pools. The design should also take advantage of daylight sensors to adjust lighting levels automatically. Furthermore, the highly corrosive environment requires selection of long life luminaires which require less maintenance and will have a long service life. Also, for ease of maintenance (when required), the fixtures cannot be located directly over the pools.

It is not in the scope of this study to determine an optimal lighting layout or solution but to consider the energy impacts of a typical lighting system that would be employed in a pool environment. From that end, because of the advance of LED lighting technology, the team has determined that a lighting intensity of 7.5 W/m² can be achieved throughout the pool space and building as well. Daylight sensors have also been modelled in the pool space to adjust lighting levels based on available daylight, but this was not found to make a significant impact. That being said, for the small cost of the sensors it is still highly recommended to implement daylight sensors in the larger pool spaces. Occupancy sensors have been assumed throughout the entire building.

One big consideration when performing the lighting design—in terms of cost—is to make sure that the designer is not "sole sourcing" a particular fixture. This was stressed as being of great importance at the Big Room Costing meeting since this can increase the cost of the lighting system by up to 30%. A lighting system should be specified with alternates so that competitive pricing can be taken advantage of.

7.2 SOLAR PV GENERATION

One common aspect of any Net Zero building is the ability to generate energy on site. In Alberta, the best and most cost effective way to generate electricity is through solar photovoltaics (PV) and the best place for the solar PV modules is on the roof of the building. To get the best performance out of the solar PV system, each module would ideally be orientated due south with a 53° tilt angle (equal to the latitude). However, this poses a problem with density and capacity. Since a PV module at 53° will shade the one behind it, the spacing between modules must be large compared to a system that is mounted completely flat. Even though the flat mounted system would produce less energy per module, it is possible to fit approximately two times the number of modules. Since the penalty for going from the ideal angle to flat is only 10-20%, this makes the tradeoff necessary to achieve greater PV production. 10 years ago this would have been unheard of (to purposely lose 10-20% of each module) but falling PV prices have made the price penalty less significant.

For this reason, and for the purposes of this study, the Solar PV system was assumed to be mounted flat to the roof. To improve dirt run off and efficiency, we highly recommend sloping the roof minimally, as shown in the current concept drawings (Figure 21 below). This was a lesson learned from a past Net Zero project (The Mosaic Centre) where because the modules were mounted flat, water did not run off the panels and dirt accumulated on the modules.

The results of the Solar PV generation modelling are discussed in Section 8.2.11.

7.3 METERING AND REPORTING

A key aspect of any high performing building, and especially a net zero building, is the building management system (BMS) and its ability to meter and report data. It is critical to the performance of the building to be able to see real-time performance, and to track key variables like temperatures and energy flows.

As a minimum, we recommend tracking and metering the following variables and systems:

- Solar PV energy production
- Heat Pump operation and runtimes
- Pump/VFD operation and runtimes
- Temperatures at critical points including GHX inlet/outlet, waste heat exchanger inlet/outlet, heat pump loop, as well as major heating equipment.
- DWHR (drain water heat recovery) inlet and outlet temperatures

- Energy meter on GHX
- Outdoor air temperature including forecasted temperatures
- Air handling unit and energy recovery ventilators
- Monitoring (status & alarms) for at least 30 points from the pool equipment and systems

The system will also need to tie into the control system of the Omniplex (once the connection is made).

The costing for the building captures basically all of these points, but some further allowances might need to be made depending on the complexity of the final design.

8.0 ENERGY MODELLING

As with any net zero building design, energy modelling was a very crucial aspect of the net zero design and concept. The energy model was used to make early design decisions on envelope, lighting and mechanical systems and also served to quantify the entire building's energy use. Almost every design decision was quantified through the energy model to make sure that the team wasn't just relying on experience or "best practices". The following sections describe the modelling process. It should be noted that included within each section are assumptions and estimates for many variables and these can change based on many different factors. The attempt was made to make realistic assumptions as much as possible but also to err on the conservative side so as to not over state energy savings. That being said, the energy model is still based on many assumptions and estimates that are likely to change in the final design.

8.1 ENERGY MODEL ILLUSTRATIONS

Illustrations of the energy model can be seen below in Figure 21 to Figure 22.

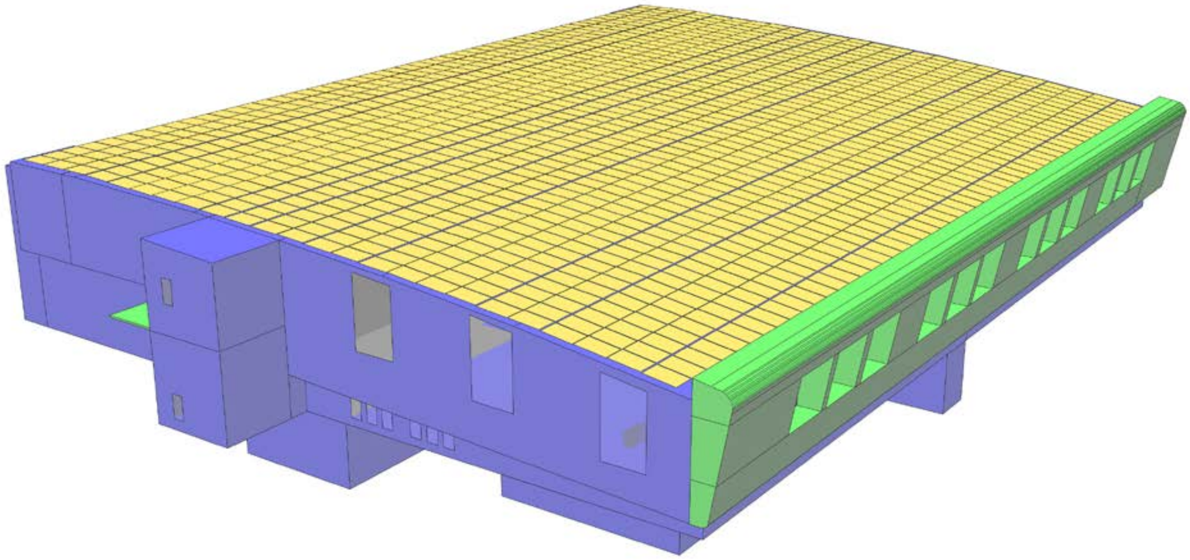


Figure 21 - Energy Model SW View

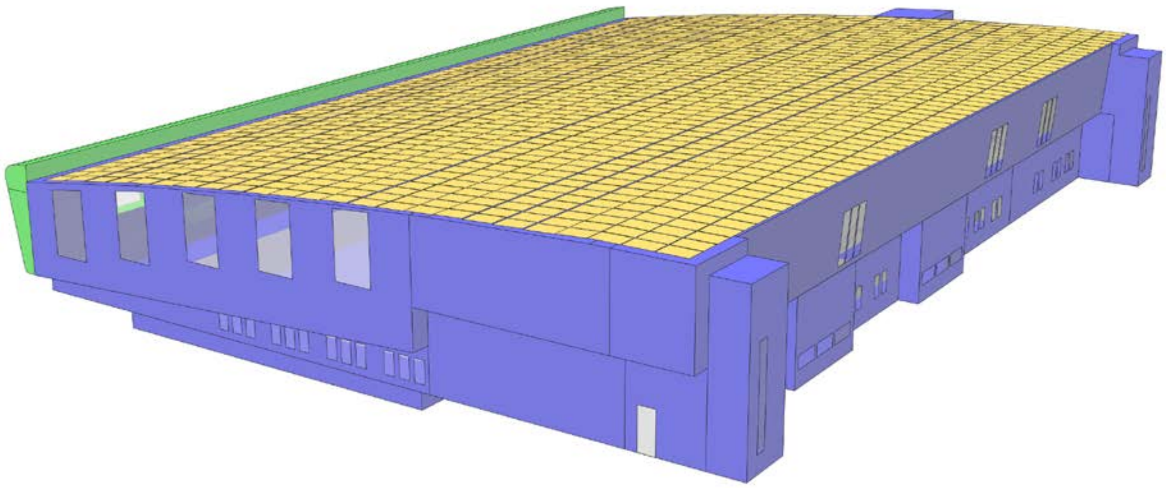


Figure 22 - Energy Model NE View

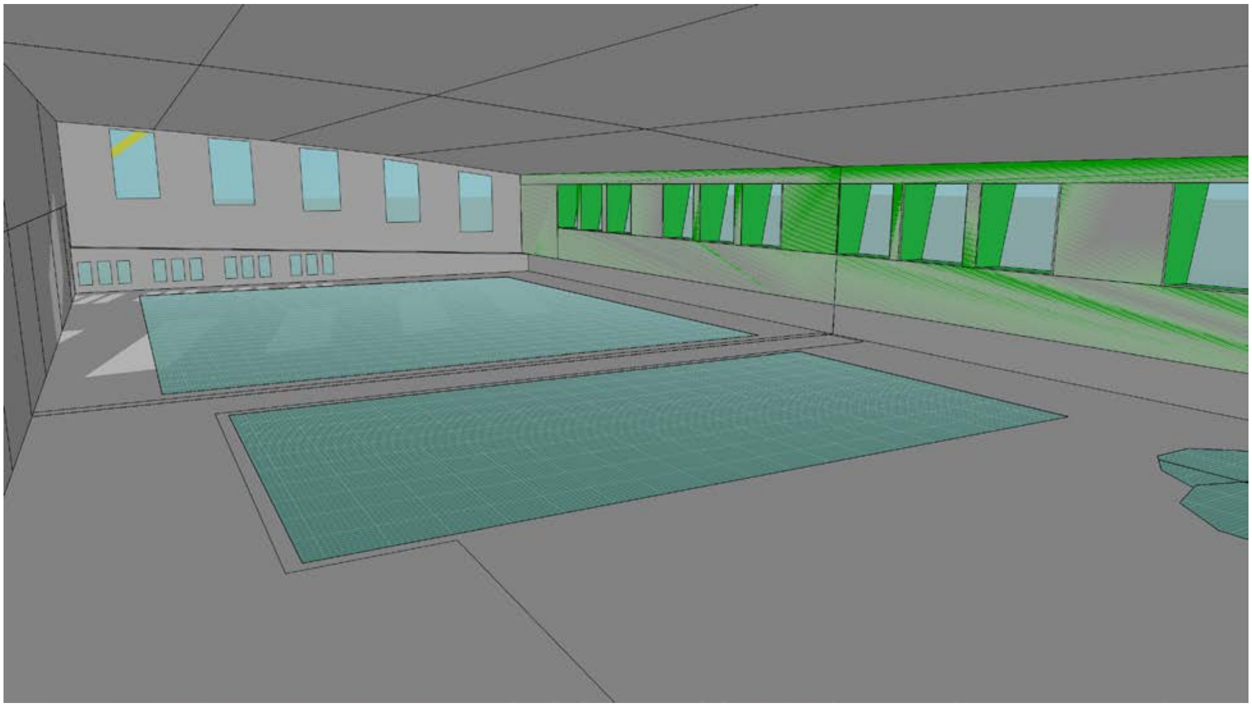


Figure 23 - Energy Model - Internal View

8.2 ENERGY MODEL DESCRIPTION

The following sections describe the approach taken for each part of the energy modelling process:

8.2.1 Weather

In order to increase modelling accuracy, a weather file was purchased from Weather Analytics which represents the most recent 15 years of weather data. This weather file is specific to the Town of Drayton Valley and should represent the most accurate data available for the region. It should be noted that future temperature increases due to climate change have not been taken into account but will certainly impact the heating demands of the building.

8.2.2 Building Geometry

The building geometry for the energy model was taken directly from the concept design drawings created by Gibbs Gage. Several iterations were modelled based on design changes but the above illustrations represent the final model.

8.2.3 Operating Schedules

The operating schedules for the building were taken from conversations with Town staff, existing Drayton Valley pool operation hours, as well as experience with other similar buildings. The operating schedules cover all aspects of the building operation including occupancy, lighting and equipment gains. Separate schedules were used for each space, including pools, offices, fitness centre, multi-purpose room etc… As with any model, where discrepancy or uncertainty exist, reasonable assumptions needed to be made. Figure 24 shows a typical schedule used in the model.

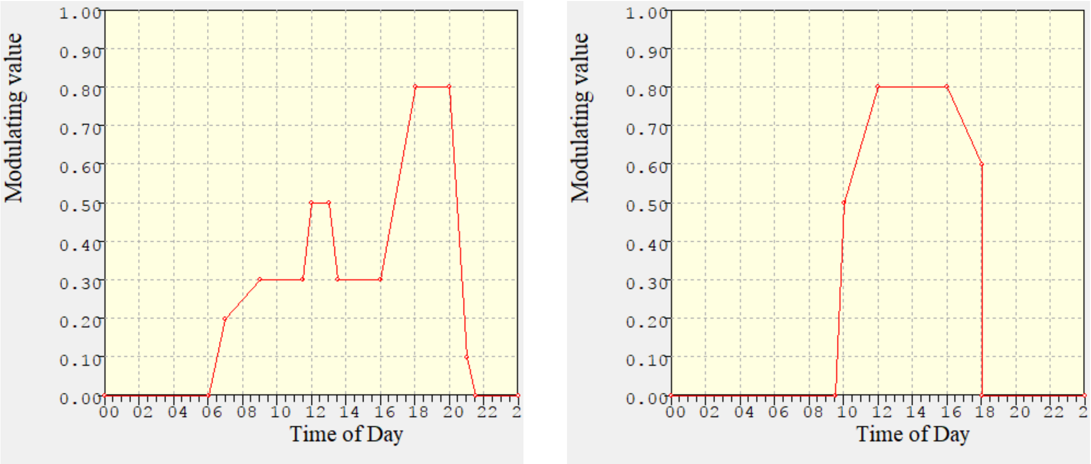


Figure 24 - Pool Weekday (left) and Weekend Operating Schedule (right)

8.2.4 Internal Loads

Similar to the operating schedules, internal loads were estimated based on experience and knowledge of similar buildings. The internal loads include gains from people, lighting and equipment.

The program design and expected capacity was used to estimate the occupancy levels in each space. While it is difficult to quantify exactly how many people would be using the pool, fitness centre and multi-purpose areas at all times, reasonable estimates were made.

Equipment gains for the fitness, office and other areas were estimated based on experience as well as industry guidelines and publications.

Lighting loads were estimated based on the anticipated LED lighting design which should achieve at least 7.5 W/m^2. Occupancy sensors were assumed throughout the entire building and daylight sensors were modelled in the pool space.

8.2.5 Infiltration

The energy model assumed a typical commercial infiltration rate based on NECB 2011 guidelines of 0.25 L/s of infiltration per square meter of external wall area.

8.2.6 Pool Sensible and Latent Heat Gains

One of the most challenging aspects of modelling a pool environment is accurately capturing the sensible and latent heat gains from such large bodies of water. Energy models do not include built-in functionality to model pools so custom calculations and workarounds were required. The following describes the process of modelling the heat gains from the swimming pools.

Sensible Heat Gain

The body of water (for each pool) was modelled as a "room" beneath the actual pool area. This room was maintained at a constant temperature set to the actual pool temperature (provided by a dummy heating system). The surface of the water was modelled as a window (as seen in Figure 23) consisting of a single pane of glass with a transmittance and refractive index of 1 and an absorptance and reflectance of 0. This essentially models the sensible heat gain from the pool to the space above.

Latent Heat Gain

Evaporation of the pool water constitutes a latent heat gain to the space above. An accurate estimate of this gain would take into account the vapour pressure difference between the pool (saturated) and the air, as well as the area of the pool surface (corrected for waves) and the area of wetted surfaces around it. Manual calculations were performed using tables from Ashrae, as well as industry information to estimate first the evaporation rate, and then the resulting heat gain to the room. These heat gains (for each pool) were applied to the pool area. The model assumed 3 pools, a 500 m^2 lap pool, a 180 m^2 leisure pool as well as a 40 m^2 whirlpool.

8.2.7 Domestic Hot Water Consumption

Domestic hot water (DHW) consumption was estimated for two separate aspects of the building. Firstly, the DHW consumption from showers and washrooms, secondly, the hot water consumption for the Pool makeup water.

The DHW for showers and washrooms was based on an expected occupancy schedule in the locker rooms as well as an industry estimate of hot water use per visit, which was set at 20 L per person, per visit. The model deliberately did *not* take credit for low flow fixtures as their usage cannot be guaranteed over the life of the building. Furthermore the daily occupancy estimate is likely high (peak of 96 people) but again, the aim is to cover the worst case scenario. The hourly peak was estimated at 2400 L/h (modulated based on occupancy).

The hot water load for pool makeup water was estimated in conjunction with the mechanical engineer and experience with similarly sized buildings. The peak pool makeup was estimated at 1250 L/h modulated based on activity factor in the pool.

It should be noted that the DHW consumption represents the majority of the energy consumption of the building and thus also represents an opportunity for savings (especially around the showers; pool makeup cannot be easily reduced).

8.2.8 Envelope Optimization

To determine the optimal envelope for the facility, an optimization study was performed using 11 different variations of envelopes (including varying wall and roof effective R-values). Scenario 10 and 11 were performed assuming the building was located at Site 3, meaning the two side walls were adjacent to existing buildings and thus had no heat loss. For all options, the windows were assumed to be triple pane with fibreglass frames (the most efficient windows available). Table 1 below shows the partial results of the study (partial results shown for brevity and clarity); note that Total Energy represents Total Energy for heating and cooling and does not include the rest of the building energy consumption (for pumps etc…). As can be seen from the results, there is not a significant reduction in energy use when increasing the R-values of both the walls and roof. In fact, even though the savings between scenario 0 and 11 are 5.2% (approximately 9.2 MWh), when considered in the context of the whole building energy use (approximately 1291 MWh), it still represents less than 0.1% of total energy consumption. Thus the recommendation of this study is not to invest heavily into the envelope as it is quite simply too small of a portion of the total energy usage. The capital cost investment for an upgraded envelope would not yield any significant savings. That being said, the envelope should still represent a balance of cost and efficiency for a Net Zero Building and thus is recommended to be similar to Scenario 4 (R25-R30 walls and R40-R45 roof).

Table 1 - Envelope Optimization Results

Option	Site Location	Wall Construction	Roof Construction	Total Energy	Savings
		Effective R-Value	Effective R-value	MWh	%
#0	Site 1 or 2	R25	R30	176.5	
#2	Site 1 or 2	R25	R50	172.2	2.5%
#4	Site 1 or 2	R30	R40	172.1	2.5%
#8	Site 1 or 2	R40	R50	168.0	4.8%
#11	Site 3 (2 adjacent walls)	R30	R40	167.3	5.2%

8.2.9 Mechanical System

The mechanical system modelled is essentially as described in Section 6.0.

Pool Unit

The pool unit was modelled as a typical air handler with a custom controller for controlling the humidity in the space using outside air. When the humidity in the pool space increases, the system increases the outside air supplied to the space which decreases the humidity (because the outside air is very dry). Simulations were run comparing this type of outdoor air dehumidification to a cooling/reheating type of system which cools the return air and then reheats it. Based on our analysis, controlling humidity via outside air is in fact the most efficient method of controlling humidity. Not only are energy savings significant, but this type of system also does not require a cooling coil and thus reduces the cost and complexity of the mechanical system. The modelled system is shown in Figure 25 below. Note that the cooling coil was turned off for the analysis. Because the pool space is maintained at 29°C, the space only requires cooling 2-3 days per year, which was considered acceptable from a comfort standpoint. Thus a cooling coil is not recommended in the design, which reduces system cost and complexity.

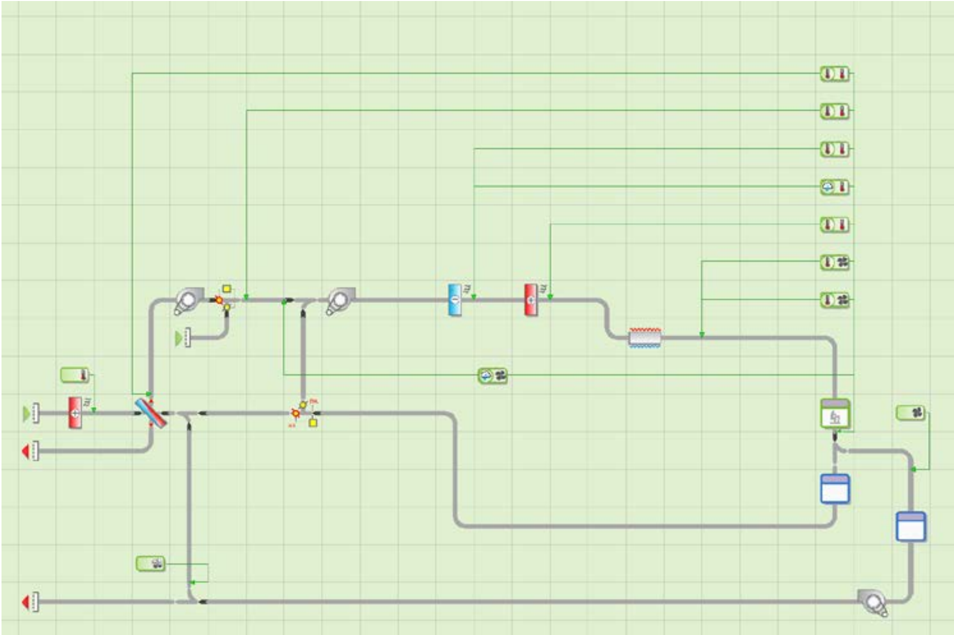


Figure 25 - Pool Unit HVAC

<u>Water-to-Air Heat Pumps</u>

The rest of the building was modelled using a distributed heat pump system which provides heating and cooling to each individual room or zone. Each floor was modelled using a separate dedicated outside air unit which includes 90% heat recovery. The only exception is the stairs and mechanical room which were modelled with electric only unit heaters (to reduce cost). The modelled hvac system can be seen in Figure 26 below.

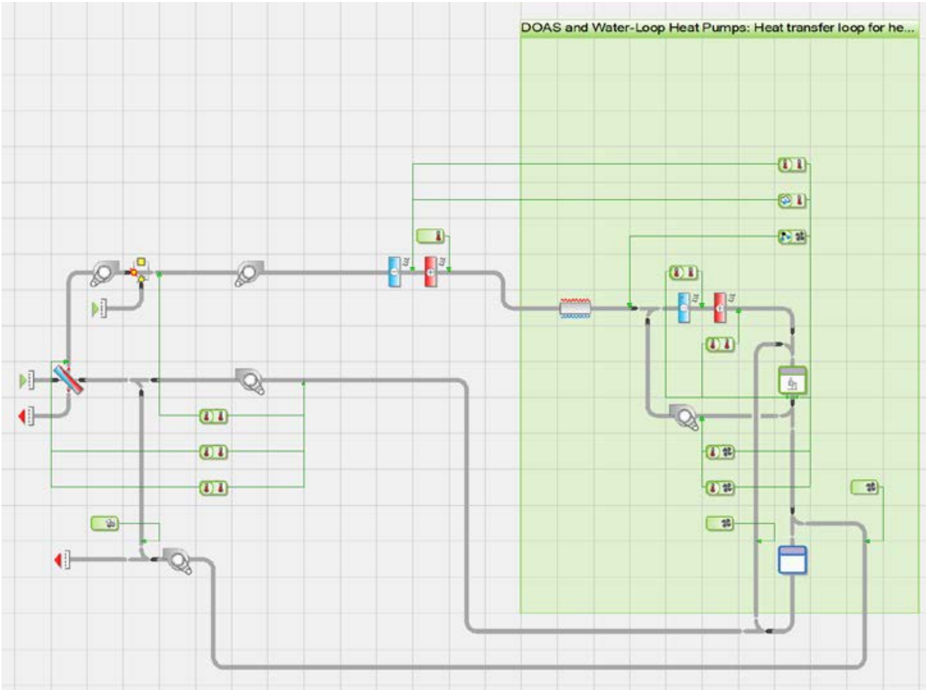


Figure 26 - W-A Heat Pump System

<u>Hot Water Heating and Heat Transfer Loop</u>

The hot water system for supplying the heating coil in the pool unit as well as domestic hot water tanks is provided by 5 Water-to-Water heat pumps which were modelled at a fixed minimum efficiency. Due to limitations in the software, the Water-to-Water heat pumps could not be modelled on the same loop as the water-to-air heat pumps (as shown in the system schematic)and so energy sharing between these two systems could not be directly accounted for. This will tend to overestimate the energy use slightly making the results slightly conservative. It should be noted that for geothermal system sizing purposes, the energy sharing was accounted for externally.

8.2.10 DRAIN WATER HEAT RECOVERY

The effects of the drain water heat recovery (DWHR) system were modelled indirectly since built-in modelling capability does not exist. To account for the DWHR system, the cold water supply temperature was increased by 5°C from the expected cold water supply from the Town. This is a conservative estimate based on known performance of DWHR units meant to account for the varying occupancy of the building. As modelled the DWHR system reduces the amount of energy required for DHW by approximately 10%.

8.2.11 SOLAR PHOTOVOLTAICS (PV)

As can be seen in Figure 21 and Figure 22, the solar PV system was modelled on the roof of the building. The system was modelled using inputs for the SunPower X-Series modules rated at 345 Watts which represent one of the most efficient solar panels on the market, rated at 21% efficiency (these were used at the Mosaic Centre). In total 1224 modules were modelled for a total system capacity of approximately 422 kW. The estimated energy production from this system was approximately 383,000 kWh, which equates to 900 kWh/kW of PV capacity. This is in line with expectations for a flat mounted PV array. It should be noted that snow accumulation was not directly accounted for, but total yearly production is still in line with expectations based on past experience.

8.2.12 ICE PLANT WASTE HEAT

The waste heat from the ice plant was modelled as a simple heat exchanger with a fixed delivery temperature connected to the heat pump loop.

8.2.13 POOL CIRCULATION PUMPS

The pool circulation pumps for all of the pools have been modelled as an additional equipment load in the mechanical room. The main filter pumps were modelled as operating continuously (to maintain filtration at all times) and other pumps were cycled on/off based on an assumed schedule (including lazy river pumps and whirlpool jet pumps).

9.0 ENERGY MODEL RESULTS

9.1 BUILDING ENERGY USE RESULTS

Table 2 and Figure 27 show the energy use results and energy breakdown for the entire building.

Table 2 - Energy Use Summary

W-W Heat Pump Space Heating	W-W Heat Pump DHW	WAHP Heating	WAHP Cooling	Electric Heat	Fans	Pumps	Lights	Main Filter Pump	Leisure Filter Pump	Whirlpool Filter Pump	Whirlpool Jet Pump	Lazy River Pumps	Misc Spray Pumps	Plug Loads	Total Energy
MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh	MWh
133.6	137.6	3.1	8.0	8.4	88.0	7.7	62.1	287.4	196.0	196.0	71.2	81.6	3.8	6.4	1291

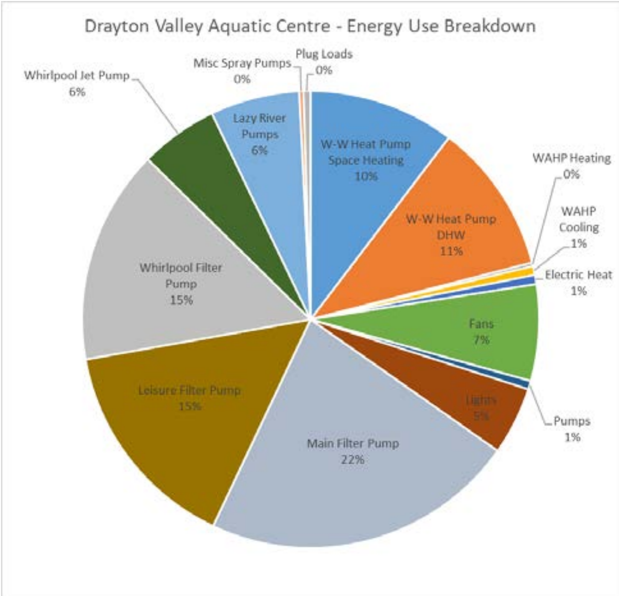


Figure 27 - Energy Use Breakdown

As can be seen from the results above, the pump energy represents approximately 65% of the total building energy consumption. This is in dramatic contrast to the energy breakdown for a traditional aquatic building (described in the next section) where the pump energy represents only 34% of the total building energy consumption (seen in Figure 28 below). This is thanks to the dramatic increase in heating efficiency of the proposed building which reduces space heating and DHW heating energy by almost 80%.

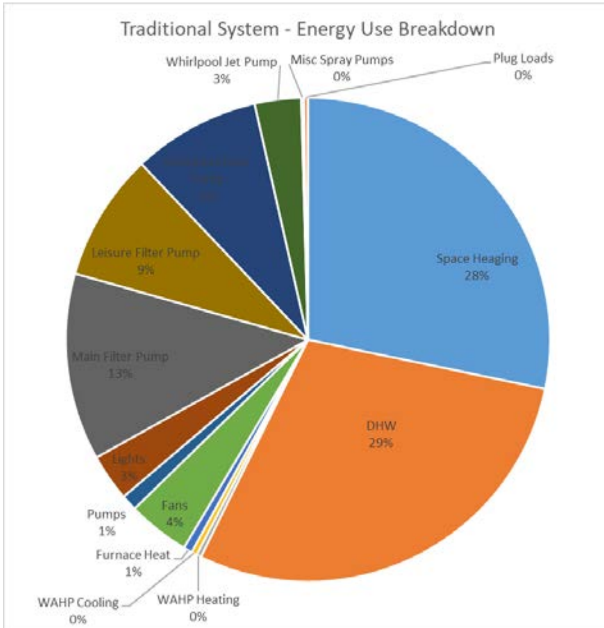


Figure 28 - Traditional System - Energy Use Breakdown

9.2 COMPARISON TO TRADITIONAL AND CODE COMPLIANT BUILDINGS

For comparison purposes, the proposed building was compared to a traditional building, heated with natural gas, as well as one built to the requirements of the new energy code (NECB 2011). The traditional building modelled was exactly the same as the proposed, but instead of the geothermal/waste heat plant, it was heated solely by a natural gas boiler.

A second comparison was also made to a reference building built to the performance requirements of the new energy code (NECB 2011). This was done to quantify improvement over an energy code compliant facility. It should be noted that the code compliant reference comparison would not constitute typical construction. NECB 2011 performance path requirements dictate that the HVAC system for the NECB reference model is dependent on the type of system used in the proposed design. In this case, where the proposed design is a ground source heat pump system, it is required that the NECB model use an air-source heat pump system (an unlikely choice for this type of building). A spreadsheet was created to model the part load curves of the air-source heat pumps at difference temperatures and COPs (coefficient of performance). The required COP of the air source heat pumps ranged from 2.78 to 3.1, depending on the heating load of the space it serves. The DHW was also modelled as an air source heat pump, as required by the NECB, with a COP of 2.1. Comparing these COPs to a traditional boiler system which has a COP of 0.9 or so, means the NECB 2011 reference building would be even more efficient than a typical aquatic facility (as shown below).

Table 3 below shows the comparison between the three buildings.

Table 3 – Energy Use Comparison

Building	Space Heating MWh	Hot Water Heating MWh	Space Cooling MWh	Fans MWh	Lights MWh	Pump Energy MWh	Plug Loads MWh	Total Energy MWh	Savings %
Traditional	663.4	667.5	12.2	95.4	62.1	835.9	760.8	2449.1	
Code Compliant	572	357	12	74	103	835.9	760.8	2331	5%
Proposed	136.7	137.6	8.0	88.0	62.1	835.9	760.8	1291	47% / 45%

As seen in Table 3, the proposed building uses 47% less energy than the traditional system (including an 80% reduction in space and water heating), and 45% less energy than the NECB 2011 reference building. The savings are attributed almost entirely to the space heating and DHW heating savings as other non-hvac factors were held constant (pump energy, plug loads etc…).

9.3 CO_2 EMISSIONS

The CO_2 emissions for the three scenarios described above were calculated using grid emissions factors found in the Alberta Government's *Carbon Offset Emissions Factors Handbook, March 2015*. It should be noted that this document is over 2 years old and that the grid emissions factor might be different now, but since better and more recent data is unavailable, this was considered the best source.

The following were the emissions factors used for calculating CO_2 emissions. Please note that the natural gas emissions factor does not include the effect of methane leakage which would increase the number significantly; but since there is no standardized procedure for including it, it was not taken into account.

Natural Gas Emissions Factor = 0.184 kg_{CO_2}/kWh

Alberta Grid Emissions Factor = 0.59 kg_{CO_2}/kWh

Table 4 below shows the estimated CO_2 emissions for the three buildings. Please note this table does *not* include the savings associated with the addition of Solar PV (shown separately below). The code compliant building shows a 52% increase in CO_2 emissions compared to the traditional building, this is due to the currently high emissions factor for Alberta's electricity grid. It should be noted that as the grid gets cleaner, this number will shrink. Furthermore, as discussed above, the natural gas emissions factor does not include the effects of methane leakage; if included, the emissions would likely be much closer if not lower. The proposed building shows a 16% reduction in emissions compared to the traditional building (again, as the grid gets cleaner, this number would increase) and a 45% emissions reduction compared to the code compliant building.

Table 4 – CO_2 Emissions Comparison

CO_2 Emissions Comparison				
	NG CO_2	Elec CO_2	Total	Savings
Building	kg_{CO2}	kg_{CO2}	kg_{CO2}	%
Traditional	244,882	659,757	904,639	
Code Compliant		1,375,053	1,375,053	-52%
Proposed		761,663	761,663	16% / 45%

The CO_2 emission savings associated with the addition of solar PV is shown in Table 5. The tables compares the proposed building (with no solar PV) to two PV scenarios. The first, where only the roof of the aquatic centre is covered with solar PV (which does not cover all of the energy demand of the building, as discussed in the next section), and second, a scenario where additional land based solar PV is added to cover all of the building's energy demands (net zero scenario).

Table 5 - CO_2 Emissions Comparison (with Solar PV)

CO_2 Emissions Comparison with Solar PV					
	Elec CO_2	PV Generation	PV Offset	Total	Savings
Building	kg_{CO2}	MWh	kg_{CO2}	kg_{CO2}	%
Proposed	761,663		-	761,663	
Proposed w/ Roof PV	761,663	383.3	226,147	535,516	30%
Proposed w/ Net Zero PV	761,663	1,291	761,690	-	100%

10.0 NET ZERO FEASIBILITY

As can be seen from the previous section, it was estimated that the proposed building will consume 1291 MWh of electricity per year. The anticipated production from a roof mounted solar PV system (as discussed in Section 8.2.11) is expected to be approximately 383 MWh. This represents only 30% of the required energy consumption and shows that it is not possible to reach Net Zero with *only* a rooftop mounted PV system.

Even though the proposed mechanical system is considered the most efficient system currently available and uses 80% less energy than a traditional system, the energy consumption of the pool pumps makes the internal loads simply too great. If pump power were removed from the equation (836 MWh) then the building would only be 15% short of Net Zero. This illustrates the challenge of reaching Net Zero in an aquatic facility.

Aquatic facilities must follow stringent government codes on filtration, turn over rates, ventilation, disinfection, water quality etc.... This drives the design of the pool circulation pumps to be essentially the same regardless of the type or location of the building; there is not much room for innovation. Other than the potential savings from an approved code variance (discussed in Section 5.2.7), and the good pump selection and design practices discussed in Section 5.2.2, there is simply no way to decrease the energy consumption of the pumps; other than decreasing pool size and/or removing pool features.

For this reason, we recommend going back to the original values of the project and "gut checking" the real needs of the project. Would a 6 lane pool be adequate for the community? Would removing certain features (whirlpool or lazy river) make sense considering the energy goals of the project? It is not our intent to say the current design is too large or wasteful, the intent is simply to make sure that the energy goals of the project are considered alongside some of the desired features (ie. 8 lanes vs 6). To be clear, even with these changes the building would not achieve Net Zero Energy from a rooftop array, but it would get a bit closer. Also, if a land based PV system is considered, it would make it significantly smaller.

10.1.1 ADDITIONAL LAND BASED PV GENERATION

Even though the project is limited in roof space, this does not mean that net zero energy could not be achieved by implementing additional solar PV generation from a land based array. Another 1000 kW of PV generation would be required on the site which would require approximately 2,900 additional solar collectors and approximately 4,750 m^2 (50,900 ft^2) of land area. The additional cost for this PV generation would be approximately $1,712,000.

These collectors could be mounted on the neighbouring land, on neighbouring roofs, or even as pole mounted parkade shading in the large parking lot (would need to cover approximately ¼ of the parking area). With a land based PV array, Net Zero Energy **is** possible to achieve.

11.0 PROJECT DELIVERY

While the world is getting more advanced in many ways, utilizing advanced technologies to improve efficiency and cost effectiveness, the same cannot be said of the construction industry (especially in North America). Figure 29 shows that while almost every industry has more than doubled in productivity, the construction industry has actually become *less* productive. While the reasons are many and too complex to discuss here, we certainly know what the result is. Contractors, engineers and architects holed up in their own silos doing the minimum work required to complete their contract, while deflecting blame and responsibility onto others wherever possible. Mistakes and omissions are dealt with change orders and lawsuits, not cooperation and problem solving. While we all suffer from this, the person that really pays for this inefficiency and dysfunction is the building owner.

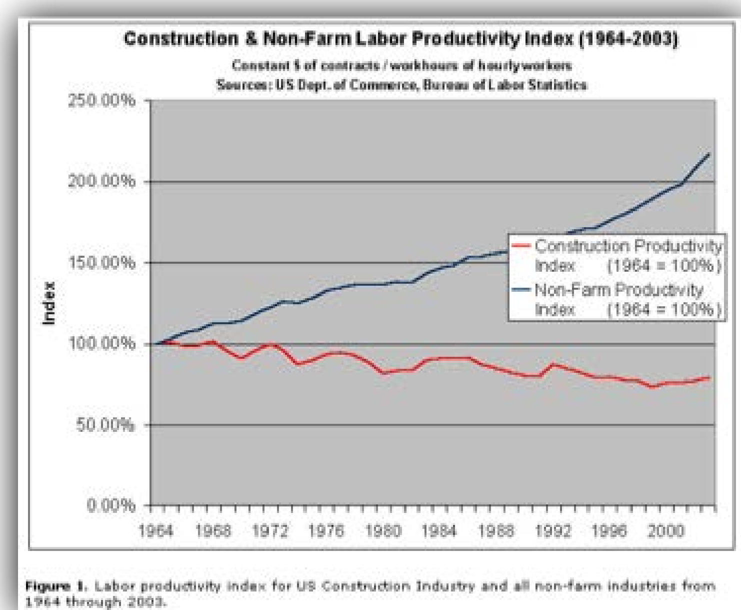


Figure 29 - Construction Productivity

Knowing this, and learning from our past experience, we know that the project delivery method will have a substantial influence on the design and construction of this future facility and will likely determine whether this project is a success, or just another ambitious attempt at a green building. Due to the complex nature of net zero and the high sustainability goals of the Town, it would be our recommendation to pursue Integrated Project Delivery (IPD) as the project delivery method for this project. IPD is a great fit for many projects, but especially projects with high levels of complexity or difficult to achieve targets. The reason for this is IPD promotes team alignment, gets the best information into the hands of the designers at the time that they are actually designing and it capitalizes on the wealth of knowledge that the trades possess regarding constructability, product selection, pricing, and operations and maintenance.

The key contractual principals of IPD set the team up for success:

- Key Participants Bound Together as Equals
- Shared Financial Risk and Reward Based on Project Outcome
- Liability Waivers between Key Participants

- Fiscal Transparency between Key Participants
- Early Involvement of Key Participants
- Intensified Design
- Jointly Developed Project Target Criteria
- Collaborative Decision Making

With a clear budget or allowable cost from the Town, along with key contractual principals including jointly developed targets and fiscal transparency among the team members, the Town can pursue project targets that might normally be out of reach. As an example, many team members thought that designing the Mosaic Centre office in Edmonton to achieve net-zero energy operations was going to be near impossible if not entirely impossible. However, in utilizing the IPD approach, the team generated amazing ideas like reducing interior lighting and balancing the photovoltaics on the roof with the envelope and geothermal system design to hit the right balance for cost and performance. Because the team had the expert knowledge in the room, jointly developed targets, and shared the financial risk, they were able to extract the best information.

Throughout the entire project, while working on this study, we have tried to mirror this process wherever possible. Values alignment, coordination workshops and big room meetings were all implemented through the delivery of the study and are all part of the IPD process. Some of the ideas that came from the most experienced pool installers were heard loud and clear and implemented throughout. In most traditional projects the people that are actually installing the systems don't ever have any input on the process or design. In our opinion, this is an absolute must for this project if success is to be achieved. While the benefits and cost savings of utilizing IPD cannot ever be quantified, going through the process just once will show even the most hardened critic that this is the only way to build.

So, although there are many aspects of IPD that make it a great project delivery method, three in particular will be highlighted: Validation Study, Co-location and project Risk Mitigation. These three featured aspects of IPD are much of why this delivery method is successful at hitting higher performance targets with regards to sustainability, schedule, and overall client value.

11.1 VALIDATION STUDY

One of the key benefits of using IPD is the validation study. The goal of a validation study is a go/no-go gate at the end providing the owner and the team with the right amount of information to make the best decision about the viability of a project with the least amount of money spent. The team wants the maximum confidence regarding the price with a minimal investment. A validation study generally costs about 1-2% of total project cost and gets cost certainty earlier with less investment spent. As an example, the Red Deer Catholic High School spent $500,000 to get to cost certainty instead of $1.8 Million to complete a full set of tender drawings (see example below). To clarify, validation does not produce tender ready information; it is the amount of information that the team, including the owner, needs so that they can say that they can or can't build what the owner wants for the allowed budget. The team, during this phase, only gets paid their costs, without profit. So, it is in everybody's best interests to make the project work. And because profit is at risk throughout, the team also has to be realistic about what it can really deliver.

Table 6 - IPD vs Traditional Project Delivery

LEAN IPDLean IPD Delivery		TRADITIONALTraditional Delivery
$35 M Project		$35 M Project

$32.6 M Actual Cost		
4 months to certainty (validated cost)		9 months to certainty (tender)
6 months to construction start		10 months to construction start
$500,000 to certainty		$1.8 M to certainty
26 months to occupancy		34 months to occupancy
Profit defined and at risk		Profit hidden and fought for
Shared risk / reward		Risk avoided / blame others
Incentive to do a great project		Incentive to protect fee, do no more than required
No RFI's		Lots of RFI's
1 Change Order		Lots of Change Orders

11.2 CO-LOCATION

In a traditional delivery method, generally speaking, designers, engineers, contractors and subcontractors work in separate spaces even though not one of them can perform their task without the aid of the other. Co-locating solves this problem. The team works together in a space they can call their own with all the breakout rooms and other materials they need. They plan together, they ask each other questions constantly and design together. Members are expected to attend all co-location days (if they have completed their work on the project, they can work on tasks unrelated to the project).

Rapid prototyping - With all parties in the room the team can make decisions very quickly. This means they can eliminate ideas right away without waiting until someone who was not in the room gets back to them. It is very important to fail quickly to ensure the right idea comes out quickly.

Co-location has several objectives and many direct and indirect benefits to the project team. First, it vastly improves collaboration and enables a higher level of integration. Subsequently, intense interdisciplinary collaboration allows the design of better systems that have less waste and fabrication inefficiencies. The workflow is more efficient and the real-time work product has less rework and revision. Second, co-location breaks down conventional company 'silos', as team members develop an understanding of each other's constraints and strengths and make decisions in the best interests of the project.

11.3 RISK MITIGATION

With construction comes risk: weather, deliveries or changes in commodity prices. Usually the risk is associated with uncertainty or unknown variables. With an IPD team, there is a much greater depth of knowledge from multiple disciplines and portions of building trades all involved in an ongoing discussion. The increased depth and diversity of knowledge at the table allows a team to:

- Assess the impacts of schedule, material selection, and weather on other aspects of the project

- Assess the potential costs of the risk and the timelines we have to find an alternate strategy

Because the team understands the ramifications of these factors they can identify strategies to mitigate them right from the beginning. Instead of having a slush fund contingency for the project, the team has robust conversations about risks continuously throughout the project. Does it Work? Yes, and has been proven with examples like the 'big hole' at the Red Deer Catholic St. Joseph's Site, where the City (prior to commencing construction) was conducting remediation on an oil well that resulted in a large excavation (200 ft x 400 ft x 21 feet deep) that significantly impacted the construction. The IPD team was able to consider a number of options such as a structural slab for the complete building, or analysing the compaction levels to determine if filling the hole was an option. They also examined the risk of the 'hole' getting bigger, and determined that a partial structural slab, closest to the well site could be an option. In the end, the team redesigned the building to go around the well site, determining this option would pose the least risk to the owner immediately and in the future. These decisions were made within a two week period (unheard of in a typical project). This speed of the decision was only possible because we had the right people at the table: those with the right expertise and those making decisions. Working together they were able to quickly resolve a significant challenge.

By identifying risks, tracking issues that need to be resolved in order to realize the opportunities, identifying the cost savings possible, and designating a team member responsible to implement them, a team can collectively determine the greatest value for the entire project. Some ideas may cost more to implement than they save, and are therefore not pursued, while some ideas can produce extensive savings that ripple through the entire project. One of the significant risks—already identified in this report—is the impact that the amount of available waste heat from the Omniplex has on the size and therefore cost of the Aquatic centre mechanical system. This is precisely the type of challenge that an IPD team would be very well suited for. This problem will require coordination and costing from many different trades (ice rink refrigeration contractor, excavation or horizontal drilling contractor, geo designer etc...) and is absolutely critical to the success of the project. Leaving such decisions and analysis to one engineer or one contractor (who might not realize, or care about the cost or practical implications of his recommendations) is fraught with risk; unfortunately, this is how the building industry currently operates.

A further benefit of an IPD team is to deliver sweeping savings. The IPD model allows us to fully and systematically pursue savings because of the integrated nature of the project. Often, system comparisons are only based on cost, but if an alternative system can save time, the full impact may include many other things such as: heating and hoarding costs, superintendent salary, trailer rentals and insurance costs - none of which add value to the project or client. When the impact of the total project are considered on a systematic scale, the system with the higher initial cost may deliver much greater overall value. The team tracks progress based on the dates assigned to ensure that they do not impact the overall project schedule. As the team develops a clear picture of the project and the improvements, they can often decrease project risk and release a portion - or all - of the dollars assigned to the potential risks back to any new opportunities that may have arisen to add value to the project or client, or savings directly back to the owner.

11.4 OWNER COMMITMENT

Integrated Project Delivery has a lot of benefits, but with those benefits comes some serious considerations. From an owner standpoint, the project requires an owner representative that is knowledgeable and able to make decisions. It is important that the person sitting at the table has authority to make a substantial amount of decisions without having to go back to a committee. That said, there are almost always key decisions that require wider consultation and input. These larger decisions can be made with wider Town input, but should not delay the process significantly. The IPD process also tends to require significant amount of time in the pre-construction phase (validation and design). The owner representative would need to be able to devote a significant portion of their time to the project in that validation and design phase. Contacting Ken Jaeger with Red Deer Catholic Schools or Wayne Ferguson with the City of Red Deer are options to get a first-hand account of the pros and cons of this delivery method from an owner perspective.

12.0 OWNING A NET ZERO BUILDING

12.1 STAFF TRAINING

While the intent of the proposed building design is to minimize operating costs and maintenance, owning a Net Zero building will require an operations staff that is attuned to the special design characteristics of the building. The building operators will need to be educated on exactly how the building operates, how the inter connected systems work, what trouble signs to look for etc.... This will take a certain amount of retraining as most operators will be used to traditional systems that use high temperature boiler systems and separate chiller systems. A low temperature, ground connected heat pump system will require the operation staff to monitor a completely different set of parameters than with a boiler system. For this reason, and because most owners/operators have never had the opportunity to operate a building with a geothermal system, the design team should include anticipated annual and daily temperature profiles for the GHX (for comparison purposes), as part of the manuals provided.

There could be resistance to change; the staff needs to be oriented with the energy goals of the facility and made aware of how important their job is to the success of these goals. Certain technologies (such as the regenerative filters) will require additional training to properly familiarize staff to their operation and benefits.

12.2 USER EDUCATION

As mentioned earlier, a Net Zero building will typically only be achieved with an owner/user/operator that is aligned with the energy goals of the project. If the building users and operators don't care or aren't aware of the goals of the project, they might revert back to wasteful practices and operations. It is critical to educate every single person that might have an impact on building operations. This includes the visitors of the building as well. For example, not showering before using the pool increases the amount of bacteria in the pool which in turn requires the addition of more chemicals, a higher filtration rate etc.... An easy way to educate the public of the impact of their actions would be to put up a sign before the pool entrance that explains these details. Or having an orientation with major user groups to discuss the story of the building and to go through such details. Whether the building actually meets its energy goals will largely depend on the users of the building, not just the building systems themselves.

13.0 RISKS

13.1 ENERGY PRICE RISKS

While the proposed approach of moving the entire building energy system to electric based is considered the best way to future proof a building (considering our need to get off fossil fuels), there are still some inherent risks in this approach. As discussed in Section 14.1.1 below, electricity prices are currently very low. However, since many different things influence the cost of electricity, there is a potential risk of a spike in electricity prices. However, there are a few factors that still make the proposed design much less risky than a traditional design, namely:

- Natural gas prices are likely to go up much faster than electricity prices. With a carbon tax and peaking production numbers natural gas is likely to increase significantly over the next few years. While a spike in natural gas prices would also impact electricity prices, the rapid implementation of renewables will slowly sever the connection between grid and fossil fuel prices.

- The largest risk to the project is rising electricity prices. However, increasing electricity prices only make the implementation of solar PV more attractive financially. So any price risk can be mediated with increased investments in solar PV. Furthermore, solar PV prices are dropping every year, and efficiencies are going up, so their implementation will only make more financial sense in the future.
- While it was shown that a traditional natural gas based system has a large portion of its energy use dedicated to heating and DHW (57%), the proposed system uses significantly less energy for heating and DHW (80% less energy, or 21% of the total). Thus, a spike in electricity prices would not impact the proposed system nearly as much as a spike in natural gas prices for the proposed system (as discussed in the next section). Furthermore, since 79% of the proposed building's energy usage is for systems common to both buildings (lights, plugs, pumps, pool equipment etc.…) a spike in electricity prices would largely impact both buildings the same (technically only 21% of the building's energy consumption is exposed to the risk).

13.2 CONSIDERATIONS

One of the main features of the proposed design is the integration of waste heat from the Omniplex ice plant. While this represents a great energy saving opportunity, it also carries with it inherent risks. The Omniplex would essentially become a heat plant for the Aquatic facility with the piping connection as the "utility" connection point. If this line became severed for any reason, the temporary operation of the aquatic facility could be jeopardized. It should be noted here that for this exact reason, a backup boiler has been included in the proposed design which would allow for normal operation of the building in such a situation. The following will focus on long term risks.

Before using the Omniplex as the main heat source, some factors need to be considered:

- Will the Omniplex always be there? Are there plans to move it?
- Will the ownership of the Omniplex change? Would the new owner allow the integration?
- Will the Omniplex undergo a major renovation that includes capturing its own waste heat? This would reduce the amount of heat available.
- What happens during a major renovation or shut down of the ice plant?

While the Omniplex is likely to be there for the foreseeable future (and the Town has some control over this obviously), the last two considerations should be addressed. Firstly, if the Omniplex underwent a major renovation that planned to use its waste heat as a heat source, the amount of waste heat available would be reduced. For this reason, it is highly recommended to investigate and quantify the amount of available waste heat before any design is started. This would quantify exactly how much heat is available and could alleviate such concerns. Furthermore, any future renovation needs to consider these factors, coordination is key.

For the last point, again, the temporary backup boiler could ensure normal operation of the building, though this would obviously compromise the Net Zero goals of the project. Furthermore, if the amount of time in shutdown is significant, the costs of such an inefficient backup source could be significant.

14.0 COSTS

14.1 OPERATING COSTS

This section will compare energy and operation costs to those of the existing facility, based on information received from the town including the 2016 operating cost budget for the existing aquatic facility. It should be noted that as mentioned earlier in this report, most of the energy and operation costs of this building will be associated with the pool equipment. This equipment is essentially mandated by codes and cannot be reduced compared to a traditional aquatic facility. While the report has suggested strategies on ways to reduce maintenance and save energy and costs—including using Regen filters, recovering heat from the backflush process etc….—the savings are still limited to those allowed for by the code. It should also be noted that the operating costs associated with labour have not been considered as part of this study.

14.1.1 ENERGY COSTS

Based on the operating budget received from the Town for the existing aquatic facility, the direct energy costs have been broken out as follows:

Utilities – Support Services - $2,156.64

Utilities – Electricity Pool - $34,295.78

Utilities – Gas Pool - $30,390.42

Total Utilities = $66,861.84

Note: Utility costs for water were not included as these will likely be similar for the new facility. Even though the use of the suggested regen filters can reduce water consumption drastically, the increased size of the facility might eliminate any potential savings.

Based on the modelled energy consumption of the building, the total yearly electricity consumption of the building is 1,291,000 kWh. Depending on the size of the installed solar PV plant, this is reduced to 908,000 kWh with a roof mounted option, or 0 kWh with a net zero land based system. The energy costs for each of these scenarios is shown in Table 7 below.

Table 7 – Energy Cost Comparison to Existing Facility

Energy Cost Comparison						
		Energy Use	Energy Cost	Total Cost	Cost per m^2	Year 1 Savings vs Existing
Scenario	Description	kWh	$/kWh	$	$/m^2	$
0	Existing Facility	-	-	$ 66,861	$ 47.55	-
1	No PV	1,291,000	0.060	$ 77,460	$ 25.82	-$ 10,598
2	Rooftop PV	908,000	0.060	$ 54,480	$ 18.16	$ 12,382
3	Net Zero PV	-	0.060	-	$ -	$ 66,862

As seen in Table 7, the base building with no solar PV production actually increases Year 1 energy costs as compared to the existing facility. This is attributed to three major factors. First is the fact that the new facility is significantly larger and includes many more amenities than the existing pool. The second, is the fact that the existing pool is heated with natural gas, and 2016 (for which utility data is available) saw the lowest prices for natural gas in 20 years (seen in Figure 30 below).

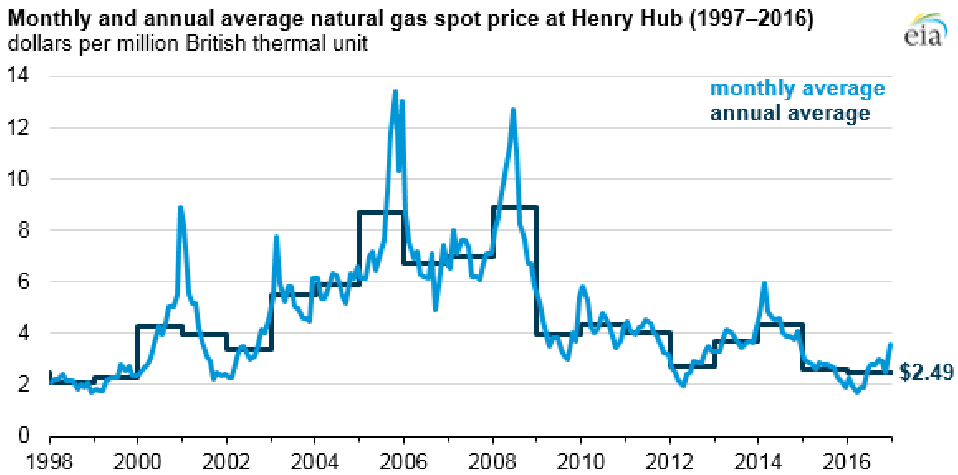


Figure 30 - Historical Natural Gas Prices – Source: US Energy Information Administration (EIA)

The third, is the disparity between electricity and natural gas costs per unit of energy. While electricity prices are also at very low historical levels, electricity is still 3.5-4 times more costly per unit of energy. Were natural gas prices to go up to those seen between 2005 and 2008, the cost of heating the pool would triple or more to approximately $90,000+ for pool heating costs alone. It should also be noted that the existing facility (or any facility heated with natural gas) would be subject to any provincial or federal carbon taxes. A carbon tax is not imposed on electricity.

When Solar PV production is added as in Scenarios 2 and 3, the energy cost savings are increased to $12,382 per year in Scenario 2, or up to $66,862 as in Scenario 3. The energy cost savings would solely depend on how much solar PV production is added. In a net zero scenario, the building would have no direct energy costs (except for fixed fee and connection costs).

14.1.2 Maintenance Costs

<u>Pool Systems</u>

Because of the complexity and uniqueness of each pool design, it is difficult to estimate and compare maintenance costs from one facility to the other. As discussed already, most pool systems are required for code compliance and cannot be eliminated simply with the intent of saving energy. The technologies and strategies recommended in this report all considered maintenance costs as a huge factor but will still include many of the same things that are included in the existing facility. Furthermore, the new facility is much larger and therefore will include more pumps, equipment, filters etc… to maintain. That being said, considering the age of the existing facility, and the newer, more efficient equipment suggested for the proposed building, a decrease in maintenance costs would be expected (once familiarity and normal operation is established).

One thing to note is that the existing facility spent $21,565 on water in 2016. A large portion of this is likely because of backflushing requirements which would be drastically reduced through the use of the recommended regenerative filters. So there is definitely opportunities for savings, but because of the nature of the facility, it will not be as a drastic as in a residential or office building.

<u>Mechanical Systems</u>

While Ashrae studies have shown that geothermal systems have some of the lowest maintenance costs of any other system, there are a few features of the proposed design that will add some additional maintenance and reduce the potential savings.

A traditional boiler/chiller system has a lifespan of 15-20 years and will cost approximately $2.15/m^2 to maintain. A typical geothermal system would be expected to cost approximately half of this ($1.08/m^2) to maintain. This includes the ground heat exchanger which does not require any maintenance and will last for several hundred years as well as the internal building heat pumps which have an average lifespan of 23-25 years (Ashrae). Assuming proper operation, these components should require very little maintenance and will last longer than a traditional system. However, the proposed system, like a more traditional system would also include the heat recovery ventilators (becoming more common) as well as the pool air handling unit, both of which would have a similar lifespan and maintenance cost in any building (traditional or otherwise). Furthermore, the ammonia to water heat exchanger and associated system might require periodic maintenance or inspection.

It should also be noted that the control system for the proposed building will be much more advanced and might require periodic tuning or at very least, monitoring.

14.2 CAPITAL COSTS

In collaboration with Chandos Construction and several sub trades, an order of magnitude construction cost was developed for the proposed design. The team held several meetings, including one day long "big room" meeting not only to establish pricing, but to ensure that the decisions the team made throughout the project made sense for the client and project, and represented best practice in the industry. While no major changes came from the big room meeting, a lot of previous decisions were confirmed, and a lot of smaller ideas and strategies were suggested which have influenced this report.

The budget cost was based on the concept design including preliminary floor plans, mechanical drawings, equipment lists and schematics created for the project. Some assumptions had to obviously be made by all of the trades as detailed drawings, geotechnical information nor a thorough building code analysis were available for the building. The following budget price is not a firm price. All costing breakdowns and assumptions can be found in Appendix D.

The budget construction cost to build the Net Zero Aquatic Facility as designed is **$24,052,000**. The following section shows a breakdown of all items included in the price. It should be noted that the extra land mounted PV systems is **not** included in this price.

14.3 CAPITAL COST BREAKDOWN

ALLOWANCES (included):

- Design Contingency - $2,400,000 (+/-10%).
- Design Fee - $1,200,000 (+/-5%).
- Signage - $50,000.
- Testing - $100,000.
- Utility Connection Fees - $90,000.
- Temporary building heat - $150,000.
- Heat recovery upgrades from existing refrigeration plant - $200,000.
- Trench lines (2 – 8" x 200m) for heat recovery from existing arena - $60,000.

GENERAL EXPENSES:

- Insurance and bonding.
- Building permit.
- Survey and site layout.
- Full time site supervision.
- Site accommodations (trailers, storage and washrooms).

- Temporary power (distribution & consumption).
- Small tools and equipment for material movement.
- Expendable tools and consumables.
- Protection of new finishes / temporary hoarding.
- Site fencing.
- Progressive cleaning and garbage removal.
- Final building clean up.

SITE WORK:

- Grade site (allowed for 15,000m2 within +/-200mm of finished elevation).
- +/-100 parking stalls.
- Paving (allowed for 5,000m2 with a combination of heavy and light duty).
- Barrier curbs (allowed for 1000m at 150mm x 400mm tall).
- Sidewalks (allowed for 250m2 at 125mm thick).
- Landscaping (allowed for 5,000m2 combination of grass / mulch with small trees and shrubs).
- Commercial curb crossing – 150mm thick.
- Parking lot drainage – tie storm drains to main line.

STRUCTURE:

- Reinforced concrete grade beam & pile caps on straight shaft friction piles (no casing).
- Reinforced concrete basement and deck slab on grade – 150mm thick.
- Structural steel columns with beams, open web steel joist and deck.
- Miscellaneous metals with stairs, railings and landings.
- Steel beams, joist and deck with reinforced concrete topping second floor common area.
- Reinforced structural concrete pool walls 310mm thick on piles.
- Reinforced concrete pool slabs on grade – 310mm thick.

FINISHES:

- T-bar ceilings to circulation, office and multi-purpose areas.
- Drywall ceiling in lobby area.
- Exposed ceilings in change, fitness, pool and mechanical areas.
- Concrete block (190mm) wall for all change, office, weight rooms and exterior walls.
- Tile floors in change, offices, lobby, circulation and pool area.
- Carpet flooring in multi-purpose area.
- 10mm rubber flooring in fitness area.
- Sealed concrete to storage and mechanical / electrical service rooms.
- Paint to all walls above tile and exposed ceilings.
- Epoxy paint to ceiling in pool area.
- Hollow metal doors, pressed steel frames for all interior doors.
- 2 stop handicap lift.

ACCESSORIES & EQUIPMENT:

- Washroom accessories (toilet partitions, soap and paper towel dispensers, grab bars).
- Change rooms (washroom accessories, benches, equipment hooks).

FAÇADE:

- Walls:

  - Masonry brick veneer c/w membrane and insulation at bottom 1.2m around perimeter.
  - Allowed for 25% of exterior façade as composite aluminum panel c/w membrane and insulation (R30).
  - Allowed for 75% of exterior façade as corrugated metal cladding c/w membrane and insulation (R30).
- Roof:
  - 2 Ply SBS membrane over a mechanically fastened Poly ISO R45 insulation.
- Glazing:
  - Aluminum curtain-wall with triple glazing at entrances.
  - Fiberglass punch windows for vision glass.

MECHANICAL:

Please refer to mechanical proposal from Priority Mechanical in Appendix D.

- Plumbing.
- Hydronics.
- Geo-exchange grid.
- Solar thermal heating system.
- HVAC.
- Mechanical insulation.
- Sprinklers.
- BMS Controls.

Pool Mechanical & Accessories: (please see Appendix D for proposal from Master Pools)

- Regenerative filtration system.
- Variable frequency drive pumps.
- Chemical controllers.
- Primary & secondary water sanitation.
- Piping and equipment.
- Grab rails and handrails at step locations.
- Portable handicap lift.
- PVC gutter grilles.
- 1m diving board.
- Water feature package (spray features and tipping bucket or similar).
- Climbing wall.
- Basketball hoops (2)

ELECTRICAL:

Please refer to attached electrical proposal from MCL Electric in Appendix D.

- LED lighting and low voltage control.
- Distribution & metering.
- Occupancy sensors & daylight harvesting.
- Power to mechanical equipment.
- Fire alarm system.
- Car plugs.
- Parking lot lighting.
- Card access on major entrances.

- Sound and PA.
- Telephone / Data cabling and outlets.
- Emergency lighting.
- Grounding as per CEC & for pool environments.
- Supply and install of a roof mounted 360kW solar PV system using all available roof space.

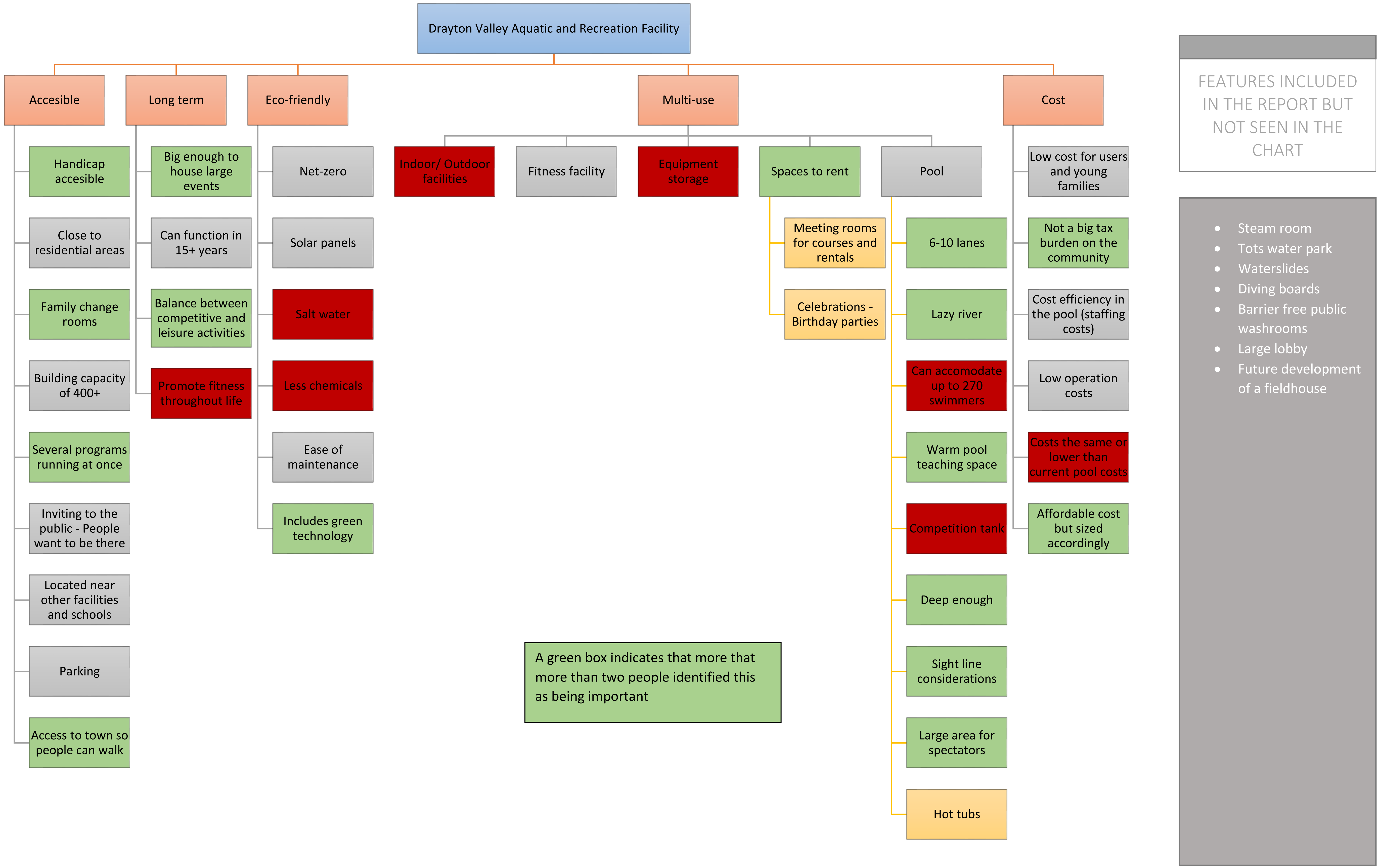
CLARIFICATIONS:

- We have not included for any Furniture, Fixtures or non-fixed Equipment (FFE).
- We have not included for any kitchen equipment.
- We have assumed the site is near to final grade.
- We have not allowed for work due to poor soil conditions.
- We have assumed a late 2018 project construction start date. Chandos recommends the owner allow for a 2% annual inflation rate thereafter.
- Costs to upgrade to a land based 1.4MW solar PV system capable of running the building during daylight hours only is an additional $2,272,000 (this does not include foundations and bases for site locations).
- Budget is based on drawings dated January 9, 2017 with the design of the facility at a total of 34,240 sf.

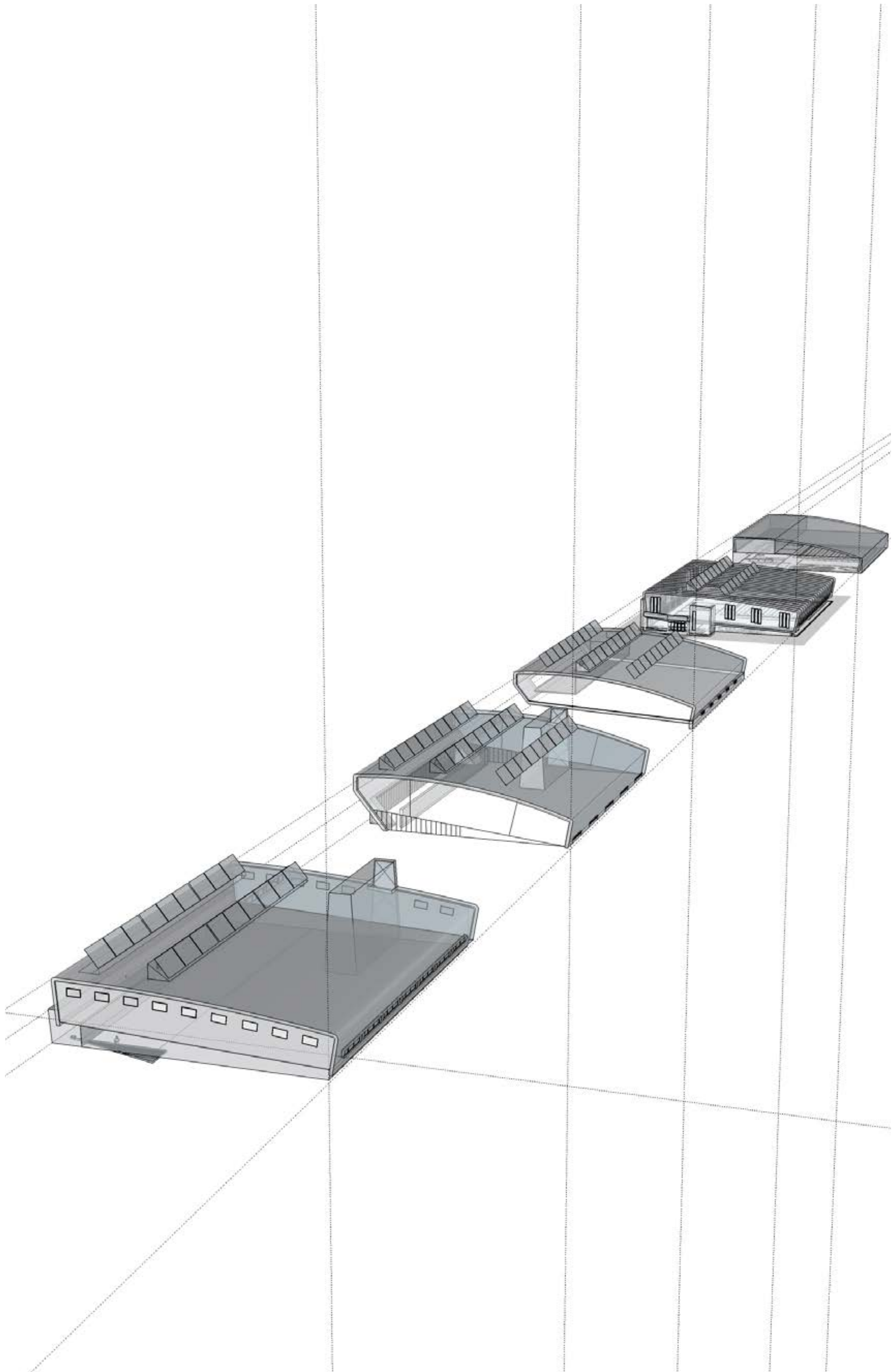
15.0 APPENDIX

Please see separate attachments for Appendices A, B, C and D.

APPENDIX A


Drayton Valley Aquatic and Recreation Facility
Accesible
Handicap accesible
Close to residential areas
Family change rooms
Building capacity of 400+
Several programs running at once
Inviting to the public - People want to be there
Located near other facilities and schools
Parking
Access to town so people can walk
Long term
Big enough to house large events
Can function in 15+ years
Balance between competitive and leisure activities
Promote fitness throughout life
Eco-friendly
Net-zero
Solar panels
Salt water
Less chemicals
Ease of maintenance
Includes green technology
Multi-use
Indoor/ Outdoor facilities
Fitness facility
Equipment storage
Spaces to rent
Meeting rooms for courses and rentals
Celebrations - Birthday parties
Pool
6-10 lanes
Lazy river
Can accomodate up to 270 swimmers
Warm pool teaching space
Competition tank
Deep enough
Sight line considerations
Large area for spectators
Hot tubs
Cost
Low cost for users and young families
Not a big tax burden on the community
Cost efficiency in the pool (staffing costs)
Low operation costs
Costs the same or lower than current pool costs
Affordable cost but sized accordingly
A green box indicates that more that more than two people identified this as being important
FEATURES INCLUDED IN THE REPORT BUT NOT SEEN IN THE CHART
Steam room
Tots water park
Waterslides
Diving boards
Barrier free public washrooms
Large lobby
Future development of a fieldhouse

APPENDIX B



CONCEPTUAL DESIGN
DRAYTON VALLEY
AQUATIC CENTRE STUDY

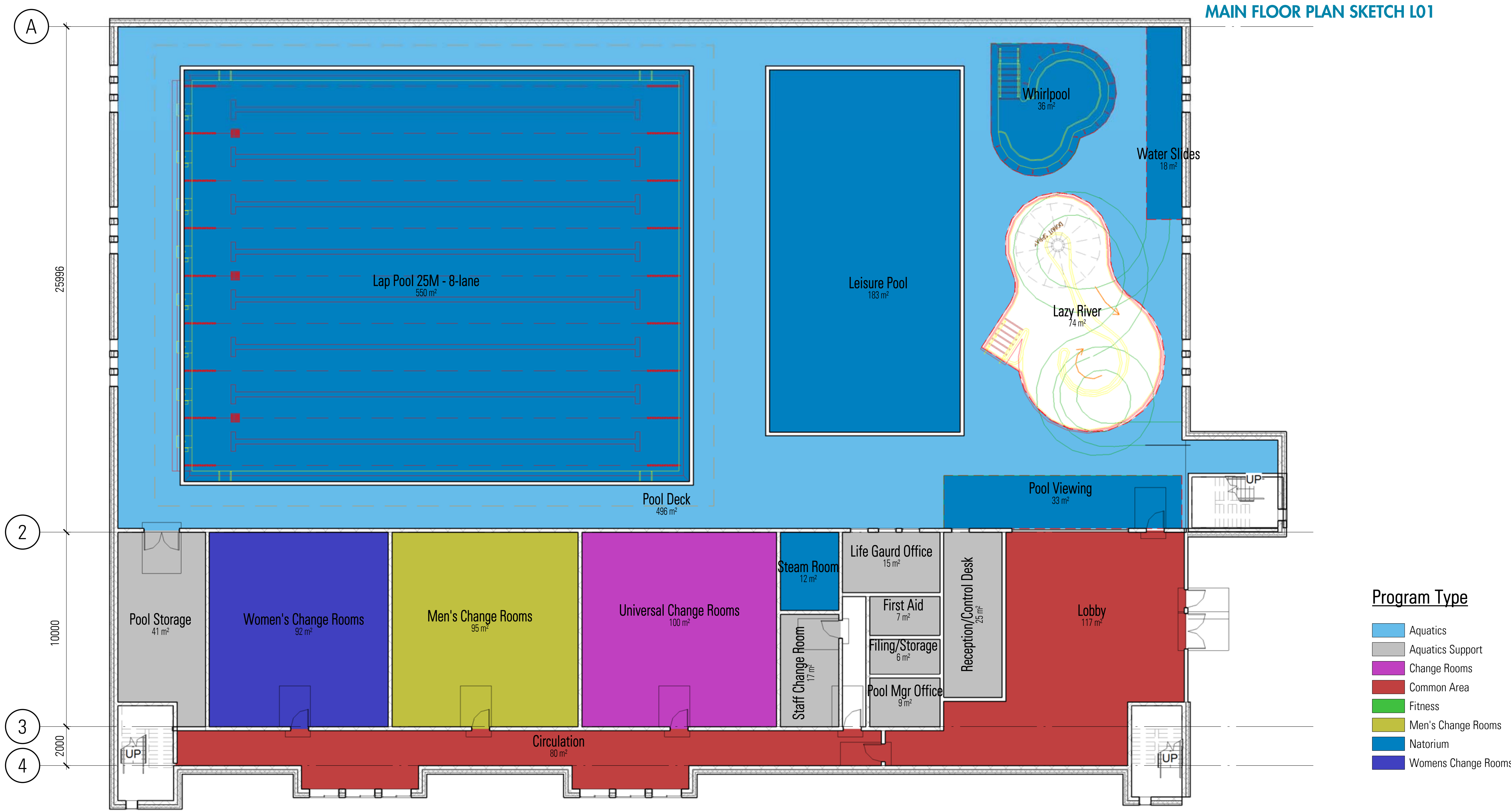
JANUARY 09, 2017 | PROJECT #: 16050

Gibbs Gage
ARCHITECTS

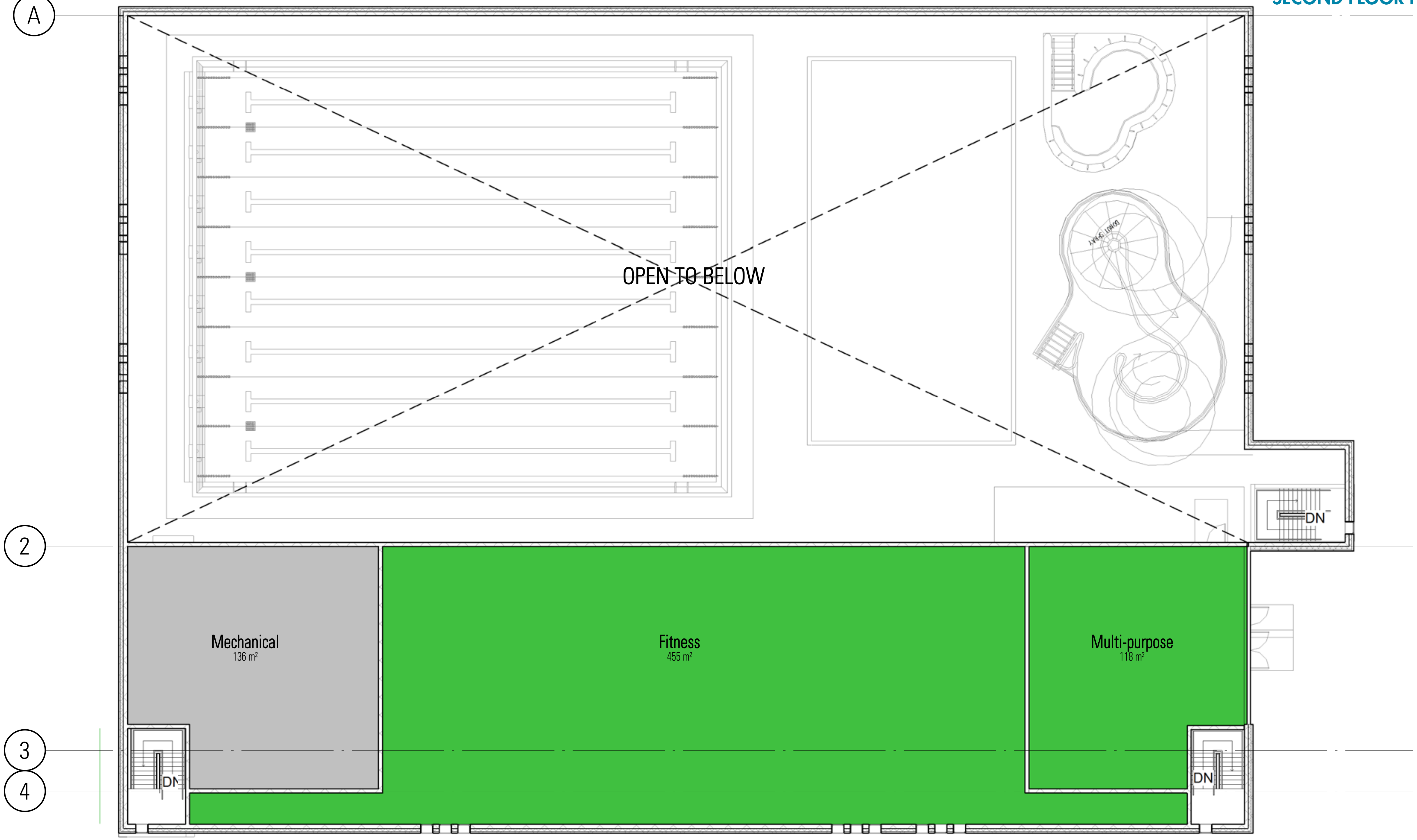
SITE LOCATIONS

SITE LOCATION 2

1 | FLOOR PLANS



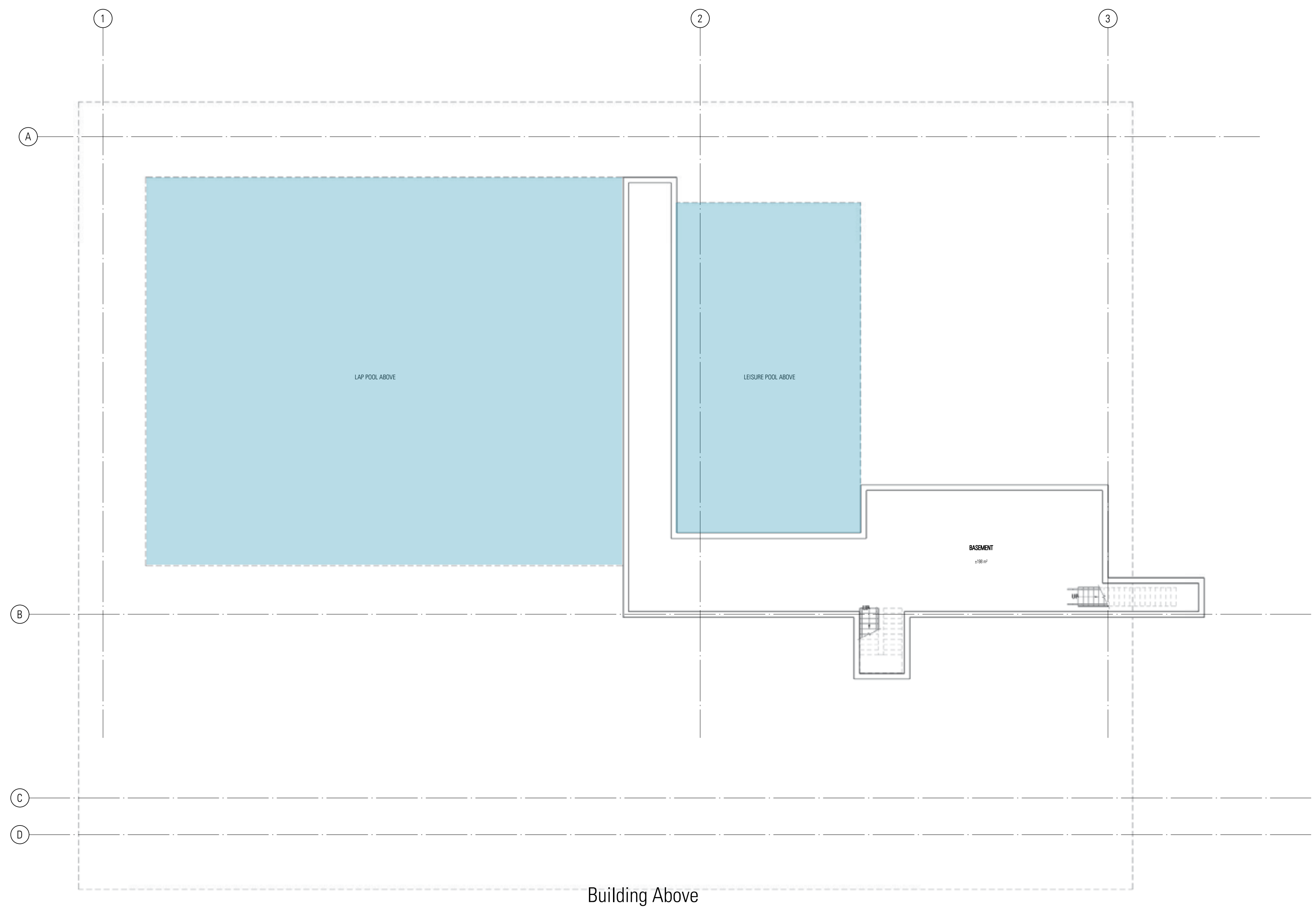
SECOND FLOOR PLAN SKETCH L02



Program Type

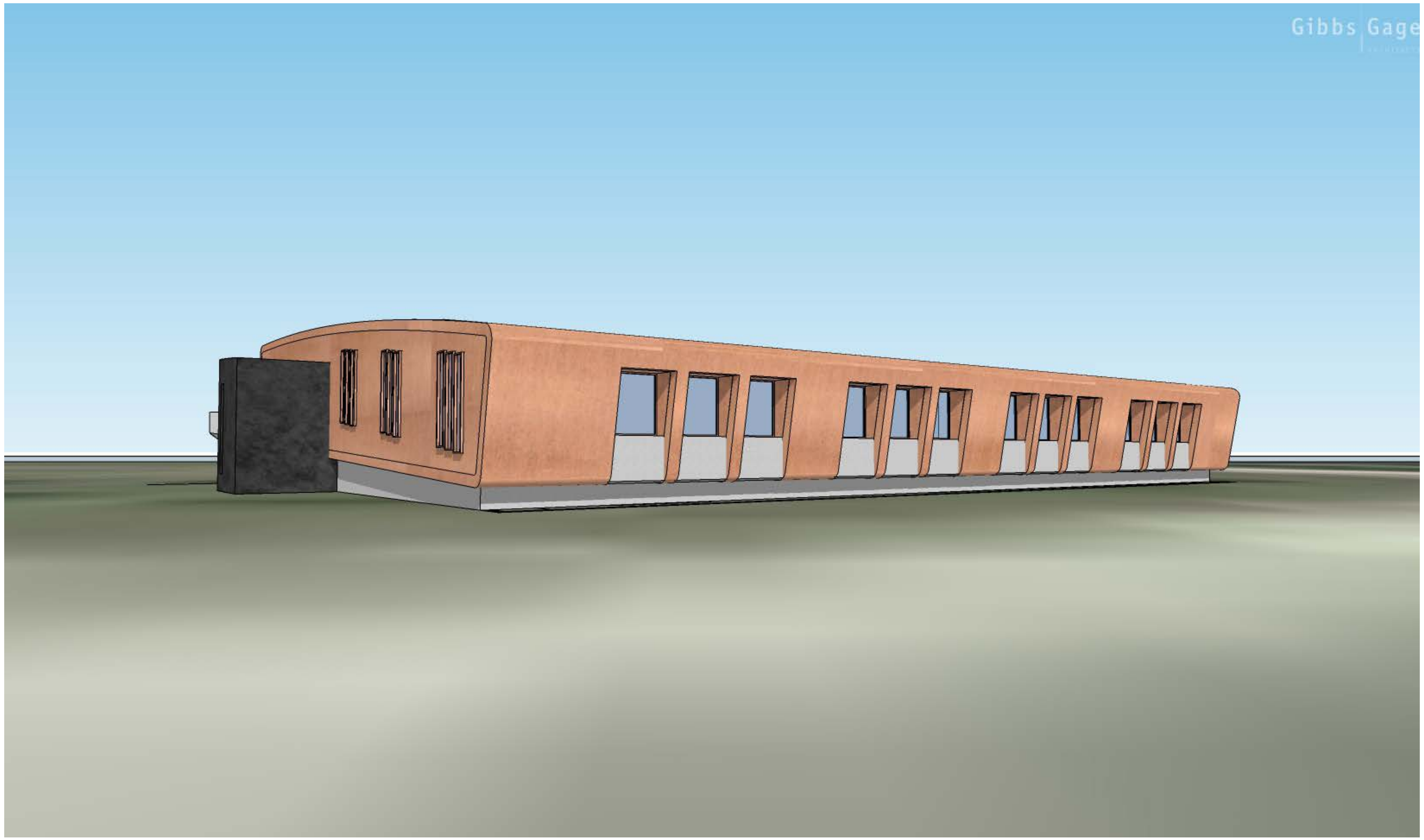
- Aquatics
- Aquatics Support
- Change Rooms
- Common Area
- Fitness
- Men's Change Rooms
- Natorium
- Womens Change Rooms

BASEMENT PLAN SKETCH L01



CONCEPTUAL MASSING

CONCEPTUAL MASSING



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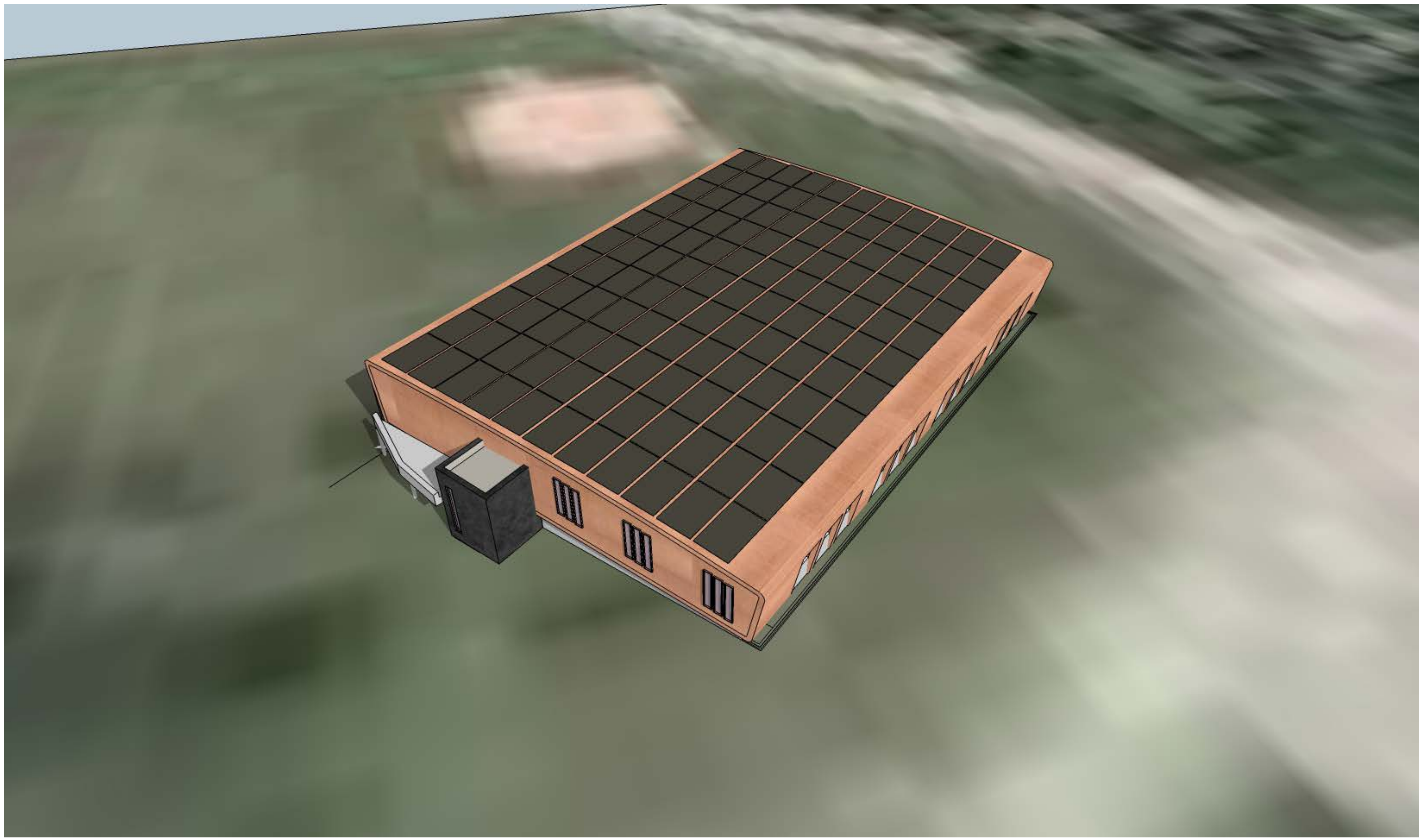
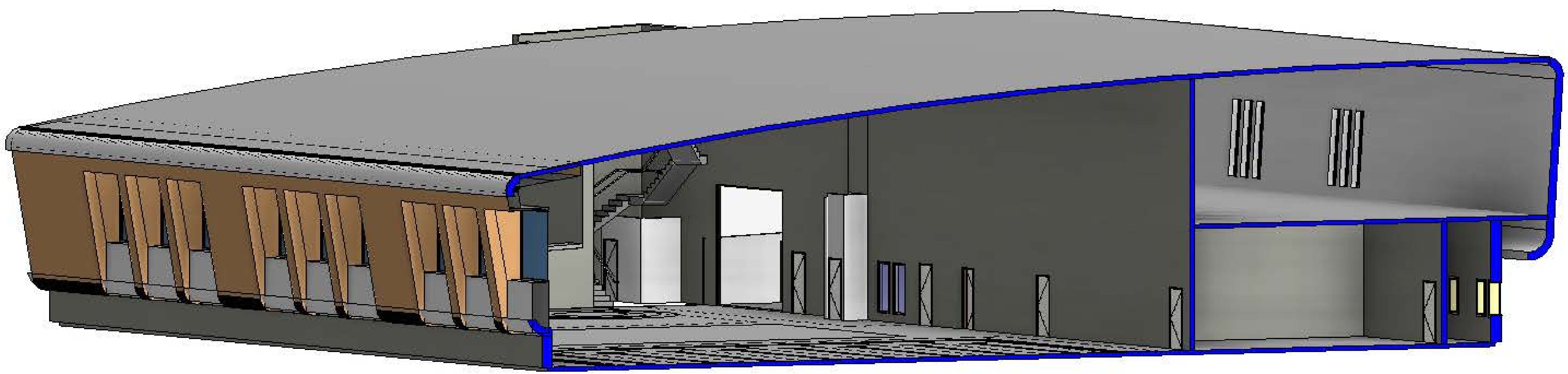
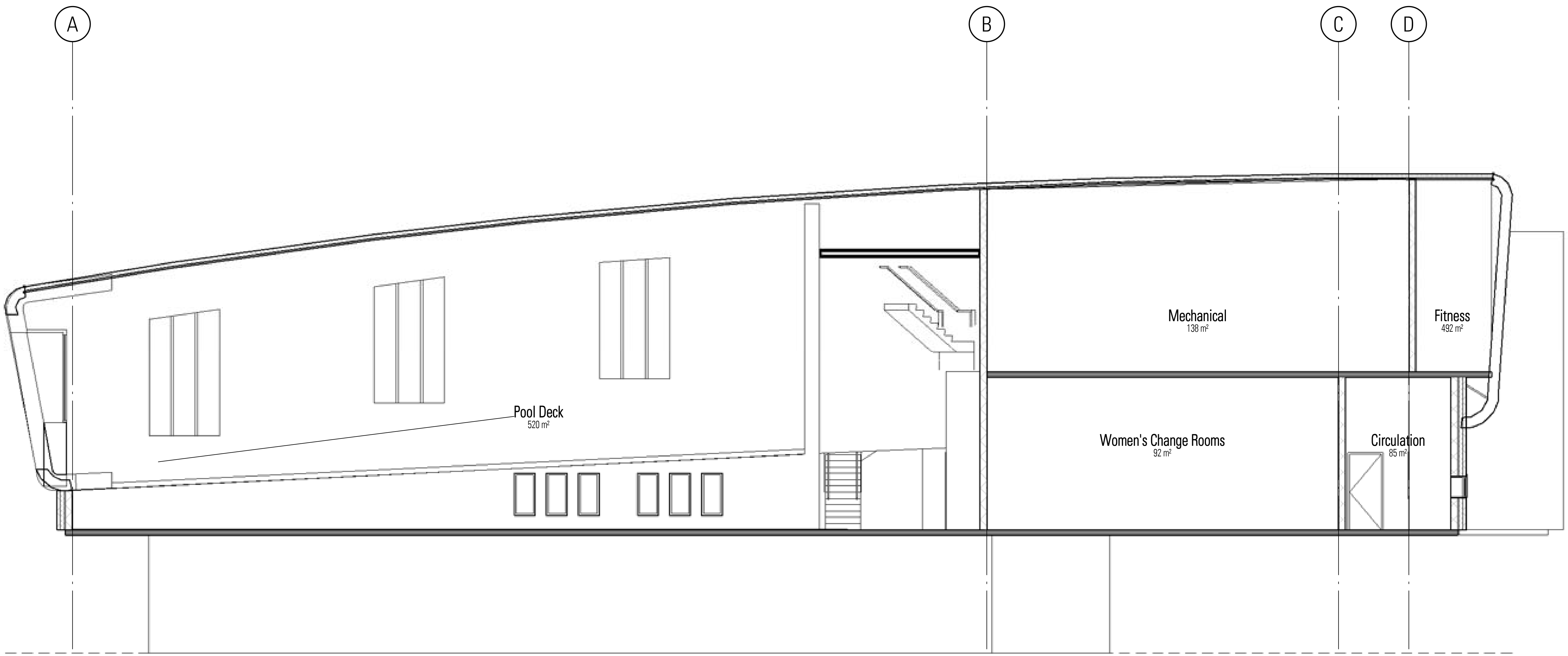


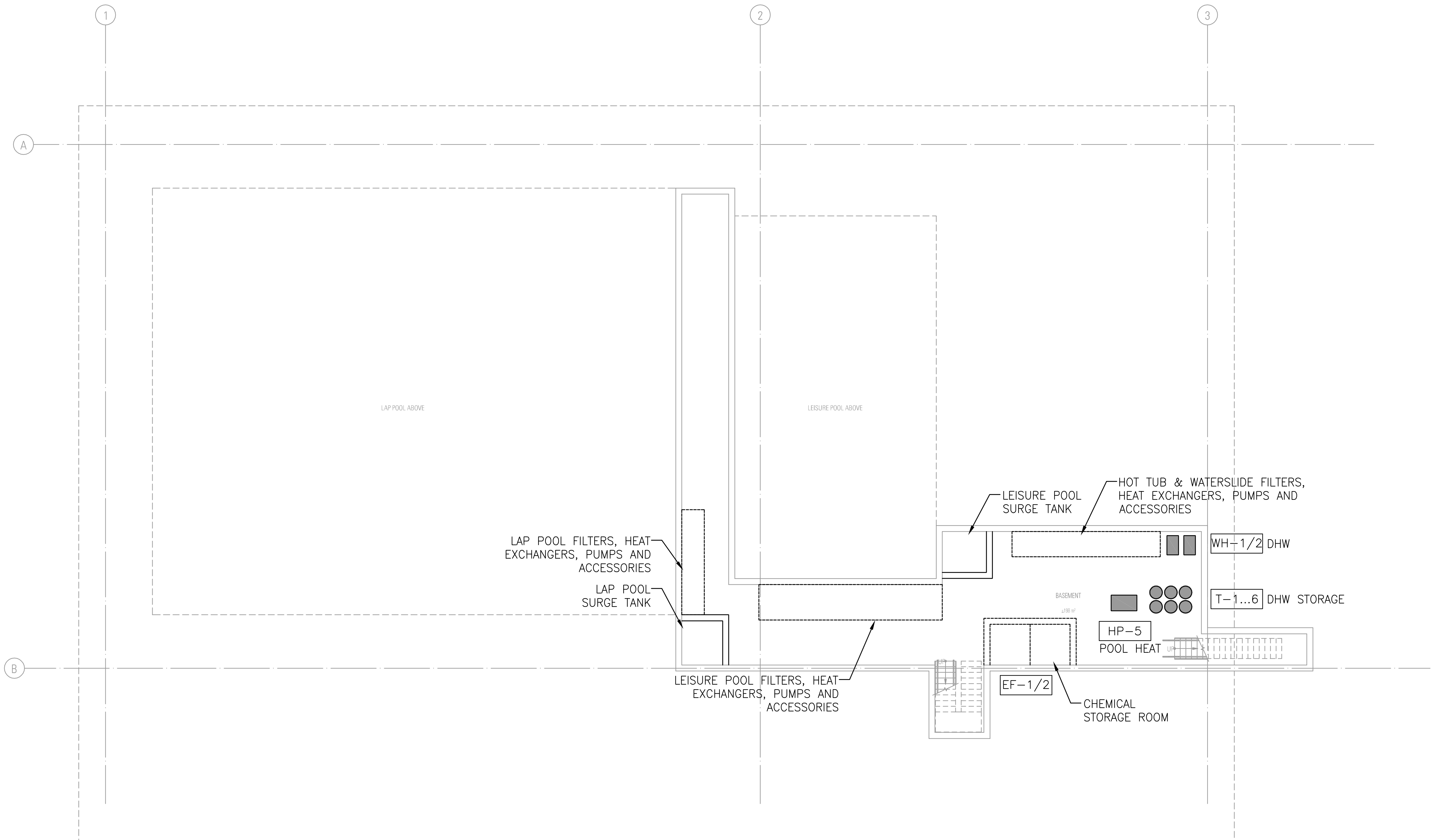
3D SECTION



SECTION SKETCH



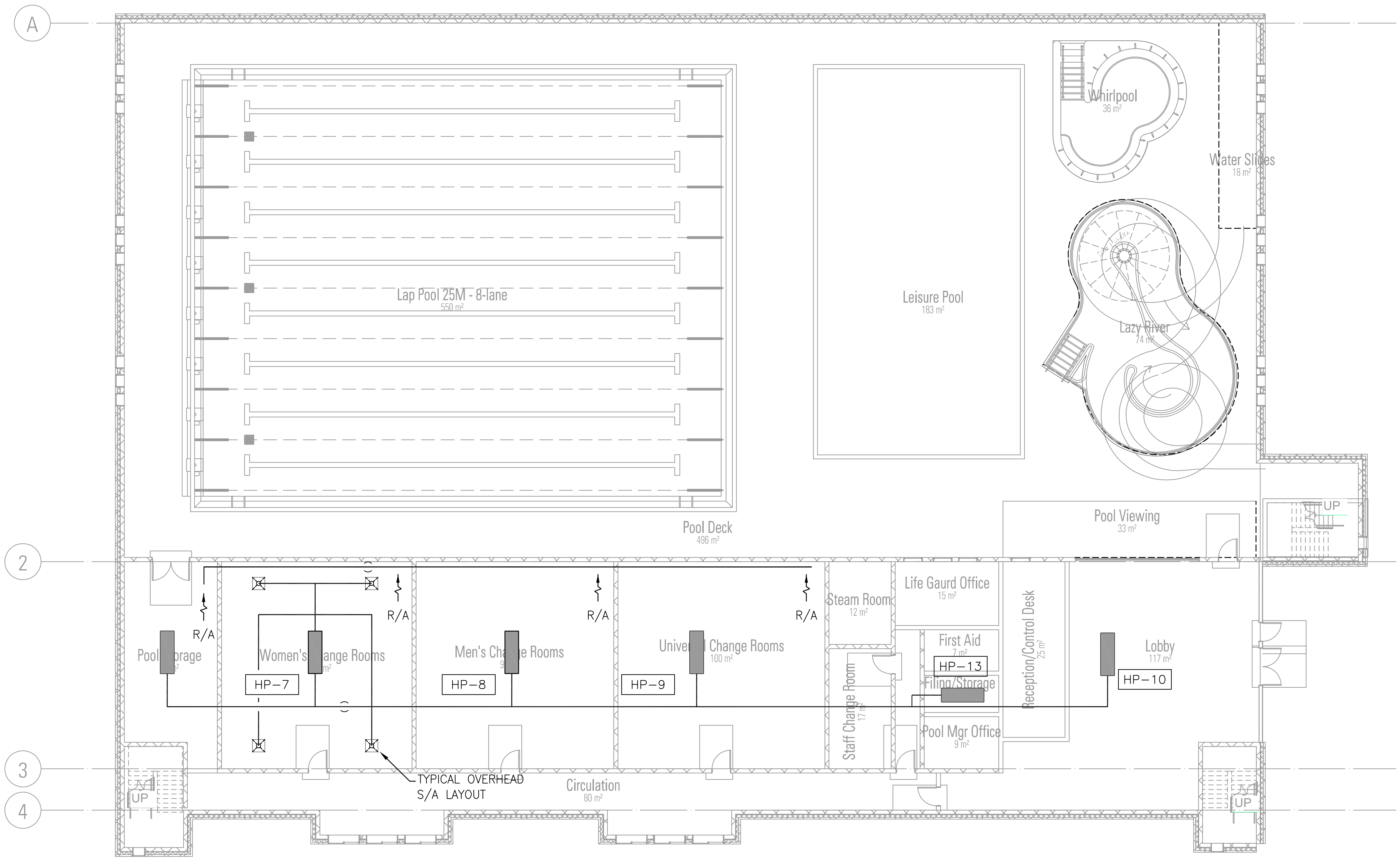
APPENDIX C



200, 1422 Kensington Rd NW
Calgary, AB. T2N 3P7
Tel: 403.984.6960
www.remedyeng.com
REMEDY Engineering

PROJECT DRAYTON VALLEY AQUATIC CENTER	DATE 2017−04−18	DRAWN SL	PROJECT NO. 16−096
DRAWING BASEMENT MECHANICAL	CHECK JH	SCALE N.T.S.	DRAWING NO. M1.0

FILE NAME:p:\2016\16−096 − drayton valley aquatic center\drawings\mechanical\dva − m1.dwg
PLOT DATE:2017−04−18 11:20:20 AM
PLOTTED BY:steve.lessoway



200, 1422 Kensington Rd NW
Calgary, AB. T2N 3P7
Tel: 403.984.6960
www.remedyeng.com
REMEDY Engineering

PROJECT: DRAYTON VALLEY AQUATIC CENTER	DATE: 2017-04-18	DRAWN: SL	PROJECT NO.: 16-096
DRAWING: MAIN FLOOR MECHANICAL	CHECK: JH	SCALE: N.T.S.	DRAWING NO.: M1.1

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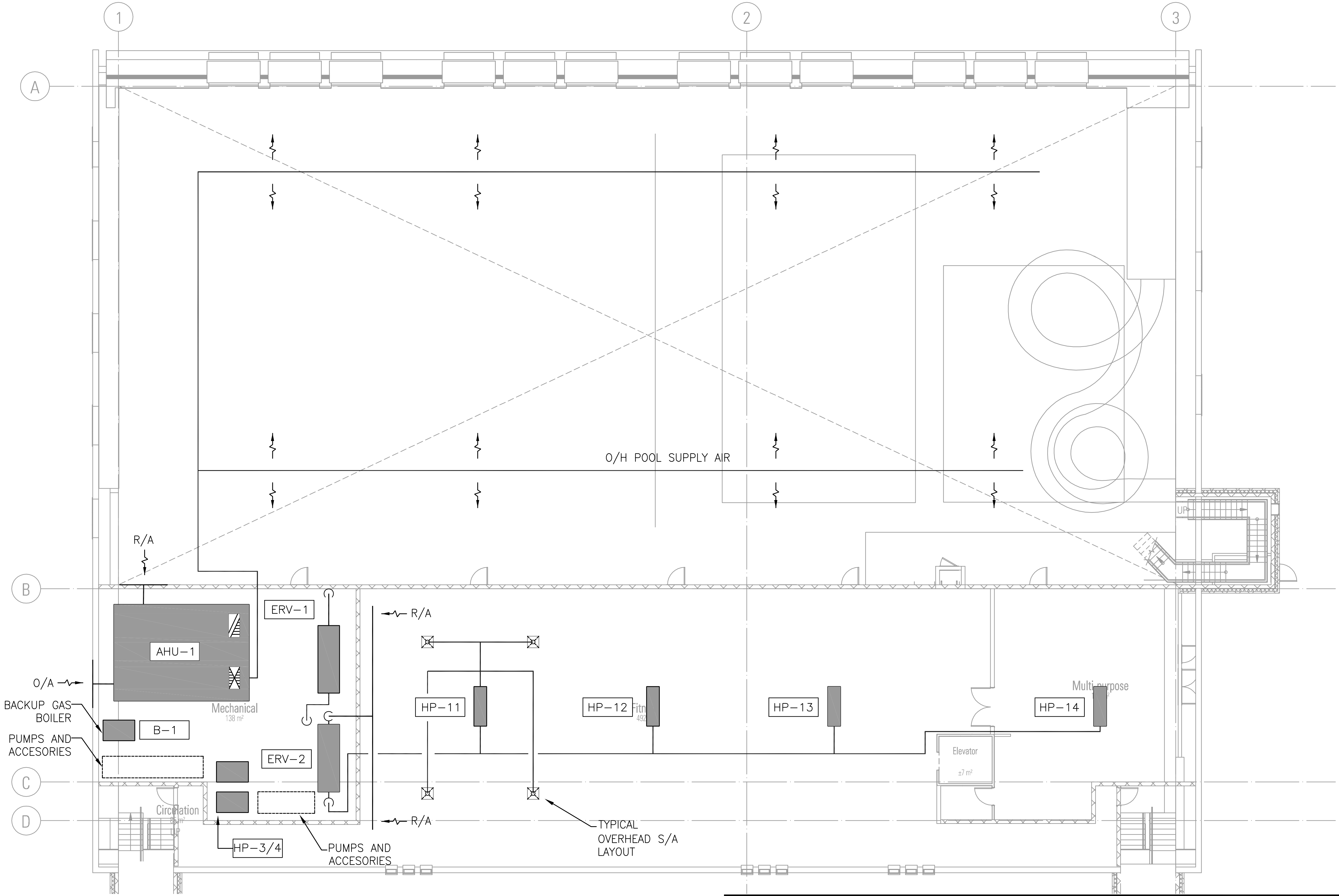
PLOTTED BY: steve.lessoway



200, 1422 Kensington Rd NW
Calgary, AB. T2N 3P7
Tel: 403.984.6960
www.remedyeng.com

REMEDY Engineering

PROJECT	DRAYTON VALLEY AQUATIC CENTER
DATE	2017-04-18
PROJECT NO.	16-096
DRAWN	SL
DRAWING	SECOND FLOOR MECHANICAL
CHECK	JH
DRAWING NO.	M1.2
SCALE	N.T.S.

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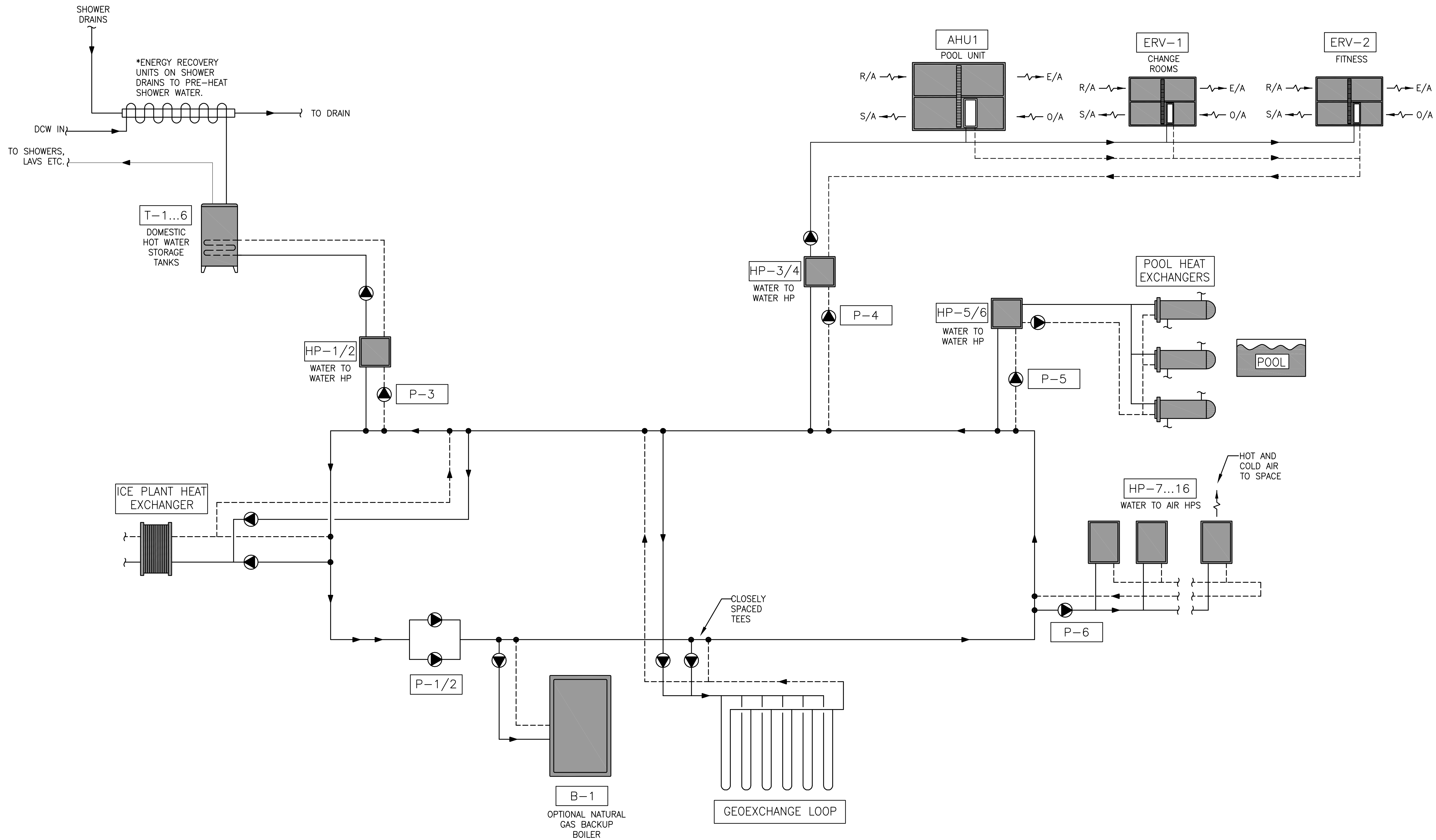

200, 1422 Kensington Rd NW
Calgary, AB. T2N 3P7
Tel: 403.984.6960
www.remedyeng.com

REMEDY Engineering

PROJECT: DRAYTON VALLEY AQUATIC CENTER	DATE: 2017−04−18	DRAWN: SL	PROJECT NO.: 16−096
DRAWING: HEATING SCHEMATIC OPTION #1	CHECK: JH	SCALE: N.T.S.	DRAWING NO.: M2.0

FILE NAME:p:\2016\16−096 − drayton valley aquatic center\drawings\mechanical\dva − m1.dwg
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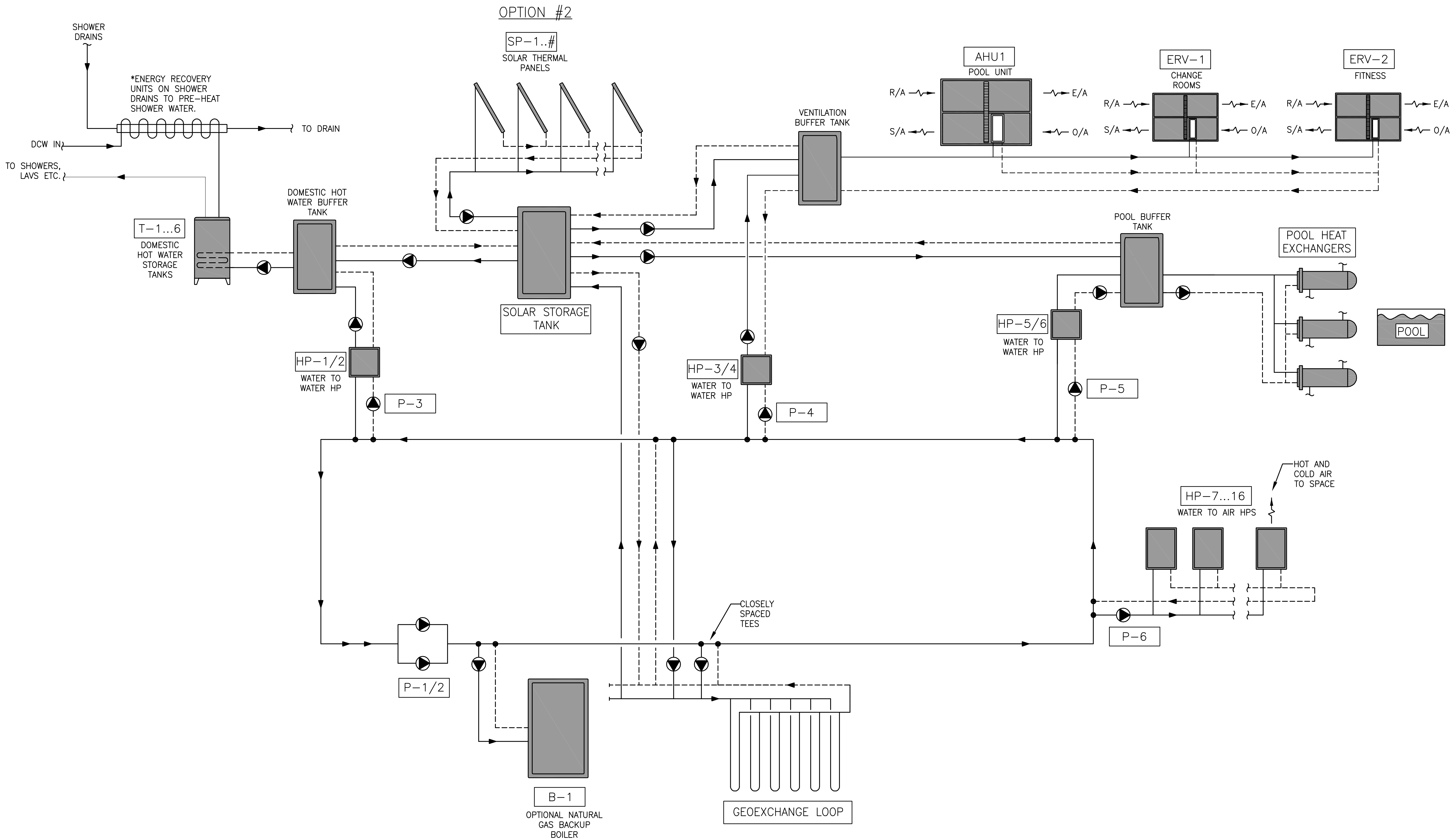
PLOTTED BY:steve.lessoway



200, 1422 Kensington Rd NW
Calgary, AB. T2N 3P7
Tel: 403.984.6960
www.remedyeng.com

REMEDY Engineering

PROJECT
DRAYTON VALLEY AQUATIC CENTER

DRAWING
HEATING SCHEMATIC OPTION #2

DATE 2017-04-18
DRAWN SL
CHECK JH
SCALE N.T.S.

PROJECT NO. 16-096
DRAWING NO. M2.1

FILE NAME:p:\2016\16-096 - drayton valley aquatic center\drawings\mechanical\dva - m1.dwg
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PLOTTED BY:steve.lessoway

APPENDIX D

CHANDOS

May 16, 2017

Revolve Engineering
9529 72 Ave.,
Edmonton, Alta
T6E 0Y4

Attention: Jacob Komar, Owner Rep, Revolve Engineering Inc.

Dear Mr. Komar:

Re: Drayton Valley Aquatic Centre, Drayton Valley, AB.

Further to our coordination meetings April 20, 2017 and May 4, 2017, Chandos is pleased to provide an Order of Magnitude budget for the construction of the Drayton Valley Aquatic Centre. We estimate the construction budget to be $24,052,000 (Twenty, Four Million, Fifty Two Thousand Dollars). Please see the attached pages for a description of the Basis for the Budget.

The budget was assembled utilizing the following methods:

- Cursory quantity take-offs of various areas and components.
- Assigning unit costs based on historical data and real time data.
- Discussions with key sub trades covering the following scopes: mechanical, electrical, structural steel, concrete, envelope, pool mechanical.

This budget is based on preliminary information, without the benefit of detailed design drawings, geotechnical information, topographical information nor a thorough building code analysis. Therefore, it cannot be considered as a firm price to perform the work. A firm price can be prepared upon development of more detailed information. Also, this budget does not include any soft costs associated with the project such as interest charges, etc., nor does it include the cost of land.

I trust this information will meet your needs. Please feel free to call me with any comments or questions.

Yours truly,
CHANDOS CONSTRUCTION LTD.

Harry Hanson
Senior Estimator
Attachment

CHANDOS

Drayton Valley Aquatic Centre
ORDER OF MAGNITUDE CLASS D BUDGET
BASIS FOR THE BUDGET

ALLOWANCES (included):
- Design Contingency - $2,400,000 (+/-10%).
- Design Fee - $1,200,000 (+/-5%).
- Signage - $50,000.
- Testing - $100,000.
- Utility Connection Fee's - $90,000.
- Temporary building heat - $150,000.
- Heat recovery upgrades from existing refrigeration plant - $200,000.
- Trench lines (2 – 8" x 200m) for heat recovery from existing arena - $60,000.

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- Insurance and bonding.
- Building permit.
- Survey and site layout.
- Full time site supervision.
- Site accommodations (trailers, storage and washrooms).
- Temporary power (distribution & consumption).
- Small tools and equipment for material movement.
- Expendable tools and consumables.
- Protection of new finishes / temporary hoarding.
- Site fencing.
- Progressive cleaning and garbage removal.
- Final building clean up.

SITE WORK:
- Grade site (allowed for 15,000m2 within +/-200mm of finished elevation).
- +/-100 parking stalls.
- Paving (allowed for 5,000m2 with a combination of heavy and light duty).
- Barrier curbs (allowed for 1000m at 150mm x 400mm tall).
- Sidewalks (allowed for 250m2 at 125mm thick).
- Landscaping (allowed for 5,000m2 combination of grass / mulch with small trees and shrubs).
- Commercial curb crossing – 150mm thick.
- Parking lot drainage – tie storm drains to main line.

STRUCTURE:
- Reinforced concrete grade beam & pile caps on straight shaft friction piles (no casing).
- Reinforced concrete basement and deck slab on grade – 150mm thick.
- Structural steel columns with beams, open web steel joist and deck.
- Miscellaneous metals with stairs, railings and landings.
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FINISHES:

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- Drywall ceiling in lobby area.
- Exposed ceilings in change, fitness, pool and mechanical areas.
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ACCESSORIES & EQUIPMENT:

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- Change rooms (washroom accessories, benches, equipment hooks).

FAÇADE:

- Walls:
  - Masonry brick veneer c/w membrane and insulation at bottom 1.2m around perimeter.
  - Allowed for 25% of exterior façade as composite aluminum panel c/w membrane and insulation (R30).
  - Allowed for 75% of exterior façade as corrugated metal cladding c/w membrane and insulation (R30).
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  - 2 Ply SBS membrane over a mechanically fastened Poly ISO R45 insulation.
- Glazing:
  - Aluminum curtain-wall with triple glazing at entrances.
  - Fiberglass punch windows for vision glass.

MECHANICAL & ELECTRICAL:

- Mechanical: (please refer to attached mechanical proposal from Priority Mechanical)
  - Plumbing.
  - Hydronics.
  - Geo-exchange grid.
  - Solar thermal heating system.
  - HVAC.
  - Mechanical insulation.
  - Sprinklers.
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- Pool Mechanical & Accessories: (please see attached proposal from Master Pools)

  - Regenerative filtration system.
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  - Chemical controllers.
  - Primary & secondary water sanitation.
  - Piping and equipment.
  - Grab rails and handrails at step locations.
  - Portable handicap lift.
  - PVC gutter grilles.
  - 1m diving board.
  - Water feature package (spray features and tipping bucket or similar).
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  - Basketball hoops (2).
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  - LED lighting and low voltage control.
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  - Fire alarm system.
  - Car plugs.
  - Parking lot lighting.
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  - Supply and install of a roof mounted 360kW solar PV system using all available roof space.

CLARIFICATIONS:

- We have not included for any Furniture, Fixtures or non-fixed Equipment (FFE).
- We have not included for any kitchen equipment.
- We have assumed the site is near to final grade.
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- We have assumed a late 2018 project construction start date. Chandos recommends the owner allow for a 2% annual inflation rate thereafter.
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- Budget is based on drawings dated January 9, 2017 with the design of the facility at a total of 34,240 sf.

MASTER POOLS ALTA LTD.
#300 – 9807-34th Ave NW Edmonton, AB T6E 5X9
Office: (780) 462-2441 Fax: (780) 462-2664
Website: www.masterpoolsalta.com

May 11/17

To: Tyler Ashford
Harry Hanson

RE: Preliminary Aquatics Scope and Budget for Drayton Valley Aquatic Facility

Tyler,
Please see below for list of inclusions and exclusions as part of the Aquatic Scope for the Drayton Valley Aquatic Facility as discussed.

Inclusions:

- Supply and Install (S&I) Pool Mechanical Equipment including pumps, VFD's for pool pumps, strainers, filters, chemical controllers, chemical feed systems (bulk CL2 feed and liquid pH feed), flow meters, UV systems, pool water level controls, main drain actuator valves as per code.
- S&I all schedule 80 pool piping/fittings, valves, pipe support, circulation fittings, VGB approved main drains, including pressure testing of all piping.
- S&I pump, valves and piping to and from waterslide.
- S&I cold side piping to Heat exchangers.
- S&I (1) common moveable pool lift.
- Supply starting blocks, handrails, grab rails, rope anchors, stanchion posts, safety rails, all associated anchors and install necessary block-outs for anchors.
- Supply of gutter grille materials, including gutter grille and straight and radius profile (to be grouted in by tile contractor).
- Supply of portable pool vacuum.
- S&I lazy river jets and jet pump to be sized based on pool dimensions.
- Commissioning of pool systems.

Exclusions:

- Waterslide
- Concrete work of any kind.
- Domestic cold-water supply and sanity drainage (including sanitary strip drains on pool deck).
- Heat exchangers and pool temperature control.
- Co-gen or heat recovery systems possibly be used to heat pool water (MPA will connect to the cold side of any HX's being used to head pool water).
- Electrical work of any kind (except low voltage control work for pool equipment). Grounding of pool equipment or deck equipment. Starters and VFD's are part of electrical scope.
- Emergency stops, if required.
- BMS tie in for pool equipment that may be required.
- Tile work.

- Garbage removal (MPA will conduct clean up of our own materials and dispose of bins provided by others)
- Hoarding (MPA requires minimum of 5'C for pipe installation in dry conditions)

Base Price: $2,100,000*
*** The base price is based on known costs from similar projects already under construction and recently completed. Please note this budget price is based on spring 2017 CAD dollar. A sizable percentage of value of materials is purchased in the USA in USD so fluctuations in the CAD and inflation can have an effect on real world cost in the future.**

Add-on Features:

1m Diving Board: $35,000
Water Feature Package (spray features and a tipping bucket or similar): $30,000
Platform Lift: $65,000 ea ($15,000 budgeted for common portable lift in base price)
Climbing Wall: $80,000
Basketball Hoops (2): $10,000

Thank you for this opportunity,

Neal Dary
Master Pools Alta Ltd.

CCS CONTRACTING LTD.

18039 - 114 Avenue
Edmonton, Alberta T5S 1T8
Tel: (780) 481-1776
Fax: (780) 481-2818

2611-58 Avenue S.E.
Calgary, Alberta T2C 0B4
Tel: (403) 215-4040
Fax: (403) 215-4044

DATE: May 11, 2017
TO: Chandos Construction Ltd.
ATTN: Harry Hanson
EMAIL: hhanson@chandos.com
FROM: Dustin Bennett

RE: LEDUC SWIMMING POOL BUDGETXS

We are pleased to provide pricing for the membrane roofing & metal cladding scopes of work for the above noted project as follows:

Membrane Roofing:
- **APPROX. UNIT RATE (GST & Bonding Not Included)** ***See Appendix A for Scope Details***
  - R35 Option ....$20.00 per ft^2 +/- $3.00
  - R45 Option ....$23.00 per ft^2 +/- $3.00

Preformed Metal Cladding:
- **APPROX. UNIT RATE (GST & Bonding Not Included)** ***See Appendix B for Scope Details***
  - R20 Option ....$30.00 per ft^2 +/- $3.00
  - R30 Option ....$35.00 per ft^2 +/- $3.00

Aluminum Composite Panels:
- **APPROX. UNIT RATE (GST & Bonding Not Included)** ***See Appendix B for Scope Details***
  - R20 Option ....$60.00 per ft^2 +/- $3.00
  - R30 Option ....$65.00 per ft^2 +/- $3.00

General Qualifications / Clarifications:
- Pricing is subject to change upon release of updated drawings and / or specifications.
- CCS Contracting will not be responsible for scheduling delays due to inclement weather that is beyond manufacturers recommended installation procedures or safe work practices, all lost days to be added to the end of schedule.
- Material lay down areas must be provided at no cost
- Parking stalls must be provided on site at no cost
- This quotation and its appendixes form the basis of the prices listed above in conjunction with, but not limited to the plans and specifications. Reference to this quotation must be made in contract upon award.
- Pricing is based on a continuous installation schedule. Should this process be interrupted, or altered by forces beyond our control, the overall project schedule will be affected.
- Pricing is based on all dependent preceding work of other trades being completed prior to mobilization. CCS is not responsible for schedule impact for work of others not being ready to receive roofing or cladding.
- Design and engineering are the responsibility of the consultant to incorporate into the project plans. CCS Contracting is not responsible for additional supports, deflection tracks, flashing, clips, details, or otherwise that may be required by manufacturer's standards or warranties that are not shown on plans.
- All compliance requirements for code, laws and regulations are the responsibility of the Prime Consultant to incorporate into the plans and specifications.
- The general contractor is responsible for providing adequate protection and coordination with other trades with regards to ensuring protection of work by all contractors. All damage caused by other trades will result in repairs at additional costs.
- All changes and force account work will be at CCS standard labour, equipment, overhead and mark-up charge out rates. Standard rates are available upon award.
- CCS Contracting Ltd. Will sign and/or accept only contracts that follow the form of the 'Alberta Standard Construction Subcontract, ACA Form A – 2013
- Quote valid for 30 days

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APPENDIX A

MEMBRANE ROOFING SCOPE DESCRIPTION

Roof Assembly:

Over a clean structurally sloped metal deck by others, supply and install:

- ½" gypsum sheathing – mechanically fastened
- Self-adhering vapour barrier membrane
- R35 Poly ISO insulation applied in 2 layers – mechanically fastened
- Coverboard – mechanically fastened
- 2 ply SBS membrane – torch on
    - *Please note this is based on a mechanically fastened system due to the slope of the roof. Adhesive applied system will add cost, and may not work in high sloped conditions.*

Inclusions:

- 10 year manufacturer's membrane material warranty
- Supply and install 24 gauge prefinished metal parapet cap flashings, colour to be chosen from manufacturer's standard 8,000 series SMP colour chart.

Exclusions:

- Snow removal
- Wood blocking, steel framing, vertical insulation, plywood sheathing for parapet or curb construction
- Gas line supports and all related components
- Fall arrest anchors and all related components
- Supply of mechanical / electrical penetration flashings (Thalers etc.)
- Woodwork, mechanical, or electrical
- Any flashings that tie into glazing
- Aluminum panel copings, and aluminum flashings
- Ladders & Wall finishes and all related components
- Protection of work from other trades and GC forces. GC to provide plywood runways, if required.
- Spray foam insulation, deck flute filler insulation and all related components
- Gutters, down-pipes and all related components
- Membrane or flashings that tie into glazing units

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APPENDIX B

SIDING SCOPE DESCRIPTION

Preformed Metal Cladding Wall Assembly:

Over a clean, true and plumb substrate by others, supply and install:

- Self-adhering vapour barrier membrane
- 18 gauge galvanized, non-adjustable Z-bars
- R20 (5" Thick) Roxul Cavityrock insulation – set between Z-bars
- 24 gauge standard corrugated metal cladding, colour to be selected from manufacturer's standard stock SMP colour chart

Aluminum Composite Panel Wall Assembly:

Over a clean, true and plumb substrate by others, supply and install:

- Self-adhering vapour barrier membrane
- 18 gauge galvanized, non-adjustable Z-bars
- R20 (5" Thick) Roxul Cavityrock insulation – set between Z-bars
- Aluminum Composite Panel System
  - 4mm PE Core
  - Colour to be selected from manufacturer's standard colour chart

Inclusions:

- Related, colour matching flashings & trims

Exclusions:

- Wood blocking, steel framing, stud infill insulation, plywood or gypsum sheathing for wall construction
- Structural angles or supports
- Foundation waterproofing, insulation, or concrete topped boards
- Spray foam insulation and all related components
- All design & engineering
- All membrane and flashings that tie into glazings
- Louvers

CCS Contracting Standard Details, material limitations and installation methods apply.

May 12, 2017

Chandos Construction
9604-20 Ave NW
Edmonton, Alberta T6N 1G1

Attention: Tyler Ashford

Re: Drayton Valley Aquatic Feasibility Study – Electrical Budget

MCL Power's electrical budget pricing for the above referenced project is as follows:

Total Budget Price **$1,256,000.00**

Included in the above budget pricing:

- Budget was based on the design information provided by Revolve Engineering
- Distribution & metering
- LED Lighting and low voltage control
- Occupancy sensors & daylight harvesting
- Emergency lighting as required by code.
- Fire Alarm
- Power for mechanical equipment
- Card access on major entrances
- Sound and PA
- Telephone/Data cabling and outlets
- Grounding as per CEC & for pool environments

Optional Budgeting (adder)

1.) Supply and install of a roof mounted solar PV system using all available roof space. This budget will provide approximately 419kW: **$ 747,000.00**

2.) Supply and install of 1.4MW solar PV system assuming all necessary land space is available: **$ 2,272,000.00**

Not included in the above budget pricing:

- Temporary Power/lighting
- Lightning protection
- Concrete, excavation, backfill, fire stopping, GST
- Cutting, coring, patch, paint, & firestop
- Bonding, GST, design fees
- Mechanical controls & BMS

Please call if you have any questions or concerns regarding the above.

Regards,

Ben Linke, Manager of Estimating

PRIORITY MECHANICAL LTD.

P.M.

9259 - 35 AVENUE, EDMONTON, ALBERTA T6E 5Y1 TELEPHONE: 780-435-3636 FAX: 780-450-3550
E-Mail: info@prioritymechanical.com

May 4th, 2017

Chandos Construction
9604 - 20 Ave. NW
Edmonton, Alberta
T6N 1G1

Attention: ***Harry Hanson***

Re: ***Drayton Valley Aquatic Centre***

We are pleased to provide our mechanical budget estimate for the above project as per preliminary mechanical plans dated July 20th, 2016 and our project review meeting held on Wednesday April 19th, 2017. Our estimate is as follows:

General:

- Labour and materials for plumbing, HVAC, mechanical insulation, fire protection sprinklers, and BMS controls for the new Drayton Valley Aquatic Centre.

Plumbing:

- Supply and install domestic cold water, domestic hot water, and domestic hot water recirculation piping systems from new water service riser (service riser by others) to plumbing fixtures. Includes domestic hot water recirculation pump.
- Supply and install 4 toilets, 4 lavatories, 4 shower heads, and trench drains for women's change room, 3 toilets, 2 urinals, 4 lavatories, 4 shower heads, and trench drains for men's change room, 4 toilets, 4 lavatories, 4 shower heads and trench drain for universal change room. All toilets, urinals, and lavatories c/w electronic hands free high efficient fixtures.
- Supply and install 2 drinking fountains (one for main lobby, one for fitness centre), 1 toilet and 1 lavatory (for main lobby area), 1 toilet and 1 lavatory (for fitness centre), one double compartment kitchen sink for second floor multi-purpose area.
- Supply and install 6 domestic hot water storage tanks.
- Sanitary drain and vent system as required for the plumbing fixtures (sanitary drain service by others).
- Supply and install PVC trench drains to serve the pool decks.
- Roof drains and above grade storm water piping to connect to storm water service (storm service by others) as required to drain rain water for the new building structure.
- Drain water heat recovery devices on the locker room shower drains to pre-heat domestic water before entering the domestic hot water storage tanks.

Hydronics:

- Supply and install hydronic piping distribution system as per mechanical schematic, including 7 hydronic system pumps, 5 water to water heat pumps, 10 water to air heat pumps, 2 domestic hot water heat exchangers, 1 main pool heat exchanger, 1 leisure pool heat exchanger, and 1 hot tub heat exchanger. Heat Pumps based on Water Furnace selections.
- Balance of hydronic water systems.

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MECHANICAL
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HVAC - Air Systems

- Supply and install one (1) glycol heating Air Handling Unit (no mechanical cooling - outside air free cooling only) c/w duct distribution, dampers, and grilles to serve the pool area. All duct work within the pool area to be aluminium. Painting of ductwork if required by others.
- Supply and install one (1) Energy Recovery Ventilation unit to serve the change rooms c/w galvanized duct distribution, dampers, and grilles.
- Supply and install one (1) Energy Recovery Ventilation unit to serve the second floor fitness centre c/w galvanized duct distribution, dampers, and grilles.
- Supply and install five (5) exhaust fans for pool chemical room (2), electrical room, data room, and elevator machine room.
- Supply and install one (1) electric heating fan coil unit for the front vestibule.
- Supply and install three (3) electric cabinet unit heaters for entry vestibules.
- Balance of air systems.

BMS Controls:

- Supply and install Building Management system to monitor and control AHU-1, ERU-1 & 2, 15 heat pumps, 8 hydronic system pumps, and 6 domestic water storage tanks.
- All other HVAC equipment (5 exhaust fans, 1 vestibule fan coil, 3 vestibule cabinet unit heaters) will have stand-alone local control with no connection to BMS.
- Provide monitoring (status & alarms) of approximately 30 points from the pool equipment and systems.

Thermal Insulation:

- Thermal insulation on new domestic hot, domestic cold, and domestic hot water recirculation piping as required.
- Thermal insulation on plumbing vent as required by code.
- Thermal insulation on outside air ductwork.
- Thermal insulation on exhaust air ductwork within 3m of building penetration.
- Thermal insulation on all HVAC ductwork, hydronic & plumbing piping within the mechanical room c/w canvas recovery jacket.
- Thermal insulation on supply air ductwork upstream and downstream of heat pumps.
  NOTE: Supply air ductwork in the pool area will not have thermal insulation and will be painted by others.

Fire Protection:

- Supply and install a wet fire protection sprinkler system to serve the new building as per NFPA 13. All fire protection piping within the pool area to be galvanized. Painting if required by others.
- Supply and install fire extinguishers to serve the new building as per code.

Total Sum: $2,625,000.00

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Separate Prices (Not Included Above):

1. Supply and install one (1) back-up 400 KW condensing boiler, c/w natural gas piping connections to boiler (gas site service by others), boiler circulation pump, hot water heating pipping connections to tempered water loop, thermal insulation, BMS controls, combustion air and chimney for boiler. **Add-On Price: $120,000.00**

2. Supply and install of window glazing sprinkler protection between pool and lobby viewing area / second floor fitness viewing area, based on 25 panes of glass, 50 sprinkler heads, and upsized sprinkler piping as required. **Add-On Price: $58,000.00**

3. Supply and install of diesel fire pump if required (electrical / wiring by others). **Add-On Price: $95,000.00**

4. For the rural site option, to supply and install piping between the roof mounted solar thermal equipment (supplied and installed by others) and the mechanical room systems, **please add on $35,000.00.**

NOTE: All pool piping systems, filters, filter pumps, chemical pumps and systems are to be supplied by others.

NOTE: The ice plant waste heat piping up to the reclaim heat exchanger (assumed to be located in the aquatic centre) is not included in our scope of work and is not included in this budget estimate.

NOTE: The installation of buried / directionally drilled waster heat recovery piping between the arena ice plant and the contemplated aquatic centre site across the parking lot is not included in our scope and is not included in this budget estimate.

NOTE: The supply and installation of the geo-exchange system piping and manifold is not included in our scope of work and is not included in this budget estimate.

NOTE: For the rural site option, we do not foresee any significant changes required to the mechanical systems other than integration of the solar thermal heating equipment into the building mechanical systems.

NOT INCLUDED: GST, BOND, ENGINEERING FEES, POOL & POOL EQUIPMENT SCOPE, SITE SERVICES OR SERVICE RISERS, CUT, CORE, X-RAY, PATCH, PAINT, ELECTRICAL, ROOFING, STRUCTURAL, PERMIT FEES, PC SUMS OR CASH ALLOWANCES, FIRE STOPPING, FIXTURE CAULKING, BACKFILL OR COMPACTION, WEEPING TILE SYSTEM, DEWATERING, FIRE ALARM DEVICES OR WIRING, HEAT TRACING, DUCT CLEANING, GLAZING SPRINKLER PROTECTION, BOILER SYSTEM, FIRE PUMP, SUPPLY OR INSTALL OF GEO-FIELD SYSTEM / ARENA ICE PLANT HEAT RECOVERY TIE-INS OR BURIED PIPING SYSTEM TO NEW AQUATIC CENTRE / SOLAR THERMAL EQUIPMENT.

Thank you for the opportunity to provide this budget estimate. Should you have any questions or concerns, please contact Derek Matter by phone at 780-435-3636 or by email at derekm@prioritymechanical.com.

Sincerely,

Derek Matter, P. Eng.