Wastewater Infrastructure as a Public Centre for Water Awareness

by

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Dalhousie University is located in Mi'kma'ki,
the ancestral and unceded territory of the Mi'kmaq.
We are all Treaty people.

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Abstract

Globally, current water management practices are unsustainable due to increased demand and pressure stemming from climate change. The quantity and quality of resulting wastewater must be improved to minimize impacts on not just the local hydrology and environment, but also its additive effects across larger scales. Water and wastewater infrastructure is not enmeshed with its surroundings in a mutually beneficial way. As one of the primary ways people interact with water, it affects the overall relationship with water. This disconnects humans from their part in the ecosystem, and thus unsustainably demands resources and creates waste that cannot be reclaimed. Through a case study of Inverness, Nova Scotia, this thesis illustrates how integrated wastewater infrastructure can reduce potable water needs, raise awareness of water consumption, and improve overall environmental impact through resilient, adaptive infrastructure and active engagement with the public.

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Chapter 1: Introduction

The basis for all life is water. Nature relies on a complex web of interactions to ensure the survival of the system as whole. As indicated by the name, the hydrologic cycle is a constant cycle of water, transforming and flowing across anthropogenic boundaries; but it can be slowed, polluted, and contained temporarily by anthropogenic forces. Climate change as well as human population growth and actions have created unsustainable demands on water, resulting in irreparable damage to the environment, humans, and other species. The right for all species to access safe water does not currently exist in practice. Despite water being a basic need for all, it is owned, controlled, and managed by some. This increases disparities in access, especially for marginalized people and those in dry geographic areas who do not have the means to transport water.

Wastewater is produced as a consequence of water consumption and use. Wastewater has the added effect on both the hydrologic cycle and nature itself, contaminating its disposal site, making it unusable for secondary consumption unless treated. Even then, wastewater may not be treated or diluted enough to sustain life, thus decreasing the overall amount of usable water, and disrupting the interdependence amongst living things. The over-consumption and inefficient use of water only amplifies the resultant wastewater issues. Centralized populations require collective wastewater management to maintain sanitation due to the volume of wastewater produced exceeding the area needed to manage it without compromising the environment. Wastewater treatment plants (WWTPs) are designed to treat high volumes of wastewater to a level that will minimize impacts on its surroundings. Urbanization and overall population growth increase the need for WWTPs and efficient management of wastewater. This results in WWTPs having to be located central to those populations.

WWTPs tend to be private facilities that are unassuming in appearance, however, completely inaccessible to the public. While it is important for WWTPs to be secure for the safety of both the public and the facility itself, WWTPs serve the public. The accumulation of individual actions and community management choices impacts how much and what kind of waste the WWTP treats, and ultimately disposes into the environment. Thus, individual and community decisions are key to the operation and impact of WWTPs on water and nature; the responsibility is not solely on WWTP technology. To place responsibility back on the public, people must be confronted with the impact of their actions on the surrounding and greater environment. This includes not only animals and plants, but also other humans. Due to the nature of WWTP services, they must be centrally located and often in close proximity to bodies of water, which makes the space they inhabit extremely valuable. The prime location of critical water infrastructure creates an opportunity to draw in users with public programming in conjunction with wastewater education and awareness. This creates a hub of water rejuvenation and a representation of how water can be treated with collective responsibility.

The strategies in this thesis, discussed through a case study of Inverness, Nova Scotia, illustrates the potential of wastewater infrastructure to further develop collective environmental responsibility across all scales, from small rural communities to urban capitals. This thesis will illustrate how publicly integrated wastewater infrastructure can raise awareness of water consumption and improve overall environmental impact through resilient, adaptive infrastructure and active engagement with the public.

Chapter 2: Theory

The Wastewater Treatment Plant

No matter who, where, or when throughout time, every human must eat, and therefore create waste. While unglamorous, waste must be disposed of. Waste management throughout history consisted of direct land application, which is still practiced in some areas today. However, as people formed communities, the densification also resulted in a densification of waste production. When communities reach a certain population, there is too much waste in a small area to be managed individually, so it must be collected and disposed of elsewhere to maintain sanitation. Many ancient civilizations developed drainage systems in cities, managing both waste and stormwater. Treatment of this wastewater was minimal if present, often consisting of cesspits (Fardin et al. 2013, 720). Untreated wastewater was then applied to land as fertilizer or discharged into a body of water.

Modern wastewater management became crucial in the 19th century as urbanization and industrialization skyrocketed waste production in cities. The waste management strategy at the time consisted of moving it elsewhere, which resulted in an oversaturation of waste in fields and in water bodies, further contaminating land and water now too polluted for use and consumption. Treatment of wastewater became necessary to break down and neutralize waste to a level considered manageable or safe when applied to land or discharged into water and prevent further contamination downstream. Some strategies of treatment introduced in the early 19th century included septic tanks, biological filters, and activated sludge, all of which are still in use today (Schneider 2011).

Treatment plants are designed to hide water and wastewater infrastructure in plain sight, allowing it to blend in. This method of design allows the technology to be aesthetically unobtrusive and thus also provide security by not attracting attention. However, these sites are inherently centrally located to provide their services, using valuable space that is inaccessible for any additional public service or activity, while providing a service for the public. The dichotomy of a public service that is inaccessible to the public shows an opportunity for exploring the relationship between water and wastewater infrastructure, the public it serves, and the environment it treats. The infrastructure goals of blending in to be unobtrusive and secure in practice work against themselves. Certain parts of water and wastewater treatment create concerns for surrounding inhabitants – typically noise, odour, and safety (reasonably or not). While these concerns may be mitigated by hiding them in a decorated box, this does not change the processes within the building, but merely makes people unaware of them.

The R. C. Harris Filtration Plant in Toronto, Canada is an example of water infrastructure that is inhabited by the public, unlike other water and wastewater infrastructure. The plant is Toronto’s largest water treatment plant, producing approximately 30% of the city’s drinking water (Doors Open Ontario n.d.). The plant is a designated historical building and a prime example of Art Deco architecture, built in the 1930s (Doors Open Ontario n.d.). The building is often used in the film industry for its appearance, dubbed “The Palace of Purification” (City of Toronto n.d.). The R. C. Harris Treatment Plant provides an argument for form in tandem with function. The plant is open to the public, contrary to most water treatment plants. The plant’s architectural considerations,

R. C. Harris Water Treatment Plant (City of Toronto n.d.)

namely the aesthetics and public programming, have made it a destination, recognized internationally because of its use in media (City of Toronto n.d.). Infrastructure that provides services for the public, especially when government funded, should be usable by the public. Municipal infrastructure is often highly defined by budget, and while this is important, by adding additional program (such as tours and parks), the building gains value for its cost. The infrastructure proposed in this thesis will layer programs to create a publicly engaging site that can optimize its value, aided by aesthetics. Both form and function must work together to find a balance that meets all needs.

The Environment

Everything on Earth was "designed" to coexist with each other in a balance that allows the planet to continue to operate. Designers must be aware of the consequences of their design in disrupting this equilibrium and have a broad understanding of the factors that influence the design. Designing within a social context means to design with an awareness of the social and environmental impacts (Papanek 1971). Through design, systematic change can be made to improve conditions for all. Nature's system was designed to resolve imbalances; it is only through human interception that an imbalance has been created. Victor Papanek (1971) uses the term "bionics" to describe using solutions from nature to solve human needs. Papanek states that a designer’s role is to understand a broad range of topics so that solutions can be found which take into consideration the larger system in which the design exists. Papanek also believes that due to the human-caused deterioration of the planet, the path forward must be interdisciplinary and that solutions can be found through bionics. As the largest scale and most complex system, Earth’s natural solutions offer insight into how we may solve anthropogenic problems (Papanek 1971).

Cosgrove (1984) discusses how landscapes have their own history which is woven with the human history around them. Cosgrove states that relationship between people and the land has followed the trends of society, especially towards capitalism and away from artistic, symbolic meaning over time. The harvesting of resources across colonies put a monetary value on land based on what could be taken from it and sold for profit, often at a detriment to the landscape, but the aesthetic beauty of some landscapes allowed them to remain unexploited and continue to exist in a harmonious ecosystem (Cosgrove 1984). When engaging with a site, it is important to ensure whatever is taken is given back, keeping the balance required to ensure a healthy landscape. Deteriorated landscapes do not benefit anything or anyone, they can no longer provide resources or habitat, and they lose their aesthetic value. Designing in a way that retains or enhances a landscape’s aesthetic provides a visual value which may be more recognizable to users without the complete understanding of the landscape and its larger balanced ecosystem (Cosgrove 1984). The aesthetics of a landscape thus serve as a gateway to allow users to understand and appreciate the perhaps hidden, inherent value of a landscape and its functions (Cosgrove 1984). The landscape surrounding water and wastewater treatment plants is often merely a by-product of what is not needed by the plant itself. However, the surrounding landscape is what users will first engage with when entering a treatment site. If the user can be hooked by that first view of the overall landscape, then they can be drawn further in to learn the value of the water treated within the site.

Indigenous Ways of Knowing

“Integrative Science” teaches Indigenous and Western science through Two-Eyed Seeing, Etuaptmumk. A healthy future for communities is paramount, but community is not just people, it is also the environment (Bartlett et al. 2015). Indigenous ways of knowing are based on observations of nature, the same as Western, and has a long history (Bartlett et al. 2015). Integrative Science is not two ways of knowing becoming one, possibly causing erasure, and it is not taking pieces of each (Bartlett et al. 2015). Water is at the centre of this project, and it is everyone’s right to have access to clean, safe drinking water. The knowledge held, and work done to protect the water and landscape by Indigenous Elders, activists, and community members should be acknowledged as it has been critical to protecting water for communities and the overall envvironment. This relationship is reflected by the collective rights to goods all beings need to live: ie. water, and the collective responsibility to take care it.

Braiding Sweetgrass by Robin Wall Kimmerer (2014) shares knowledge through storytelling, using the act of braiding sweetgrass to share stories while working together; the three braided strands represent Indigenous ways of knowing, scientific knowledge, and the joining of the two (Kimmerer 2014). The "intertwining of science, spirit, and story", represented in the braiding of the sweetgrass strands, has the opportunity to find solutions that will heal people and the environment; reciprocal relationships are sustainable and balanced (Kimmerer 2014). Kimmerer describes the way the world is interconnected, creating food from the elements, a chain of relationships that make the world work, as a system of stories. The key to sustainable relationships is sharing stories, or knowledge, in a way that does not assume that any one is better than the other (Kimmerer 2014). Kimmerer points out the separation of knowledge and responsibility; humans have the unique ability of complex communication, so it should be used to benefit all. This thesis looks at the principle of learning and understanding will lead to an obligation of understanding, achieved through engaging the public directly with water treatment and management, making the knowledge accessible and tangible for all.

The Public

In Vitruvius' *The Ten Books on Architecture*, water was regarded as the most important element. Vitruvius suggests that water and air were made by the creators placed on the earth and free because they are essential for life. As Vitruvius' treatise makes clear, everyone has a right to that which is essential for life, and thus water should be respected. Somewhere in the last 2000 years, this philosophy of water being a universal right and upheld as a powerful force became lost. Instead, water has become a commodity for profit. Water conservation was considered when constructing waterways so that reservoir overflow would have space to move without being wasted and additional reservoirs were created along the water's route so that if part of the system failed, the water would not be wasted and the problem could be identified and repaired (Vitruvius 1960). The water supply was efficiently divided between baths, private water supplies, public basins and fountains wheree the baths would in-turn give income back to the state and the private sources would pay taxes for their own source; the revenue from these two consumers would then help fund the construction and operation of the water system (Vitruvius 1960). These efforts helped to protect the water, recognizing its value to everyone, and making sure that everyone would have equitable access.

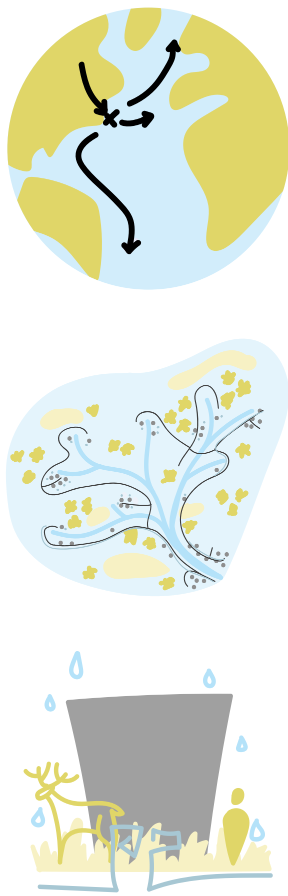
McHarg (1971) suggests that energy is what is moved and exchanged throughout the ecological model, not being destroyed, but rather changed and transferred. Water is key to the operation of everything on Earth. The water cycle acts similarly to the energy model he proposed, transferring it from one organism to another, changing its state from gas to liquid to solid and back to gas again. He emphasizes “human cooperation and biological partnership” to push both people and nature to their greatest potential.

It is impossible to separate water from the larger hydrologic cycle; thus, it is crucial to understand the scales of interaction between water, infrastructure, and those who inhabit the common space.

The hydrological cycle transforms and moves water over time and space, as it is able to travel great distances and exists forever. Many smaller pieces form the hydrologic cycle, with water bodies connecting to one another, and users connecting to a larger system. It is impossible to separate water from its existence as a piece of the whole collective.

Water bodies connect to one another and act as large gathering areas known as watersheds. The ecosystems at this scale have a heavy impact on one another, but also to the larger cycles and each organism that makes use of these ecosystems.

From bacteria to humans, all organisms possess the basic need for safe water to be healthy and survive. Water molecules collect together to form droplets, which then flow, collecting other matter along the way. When the water finds a spot to pause, it then gets absorbed and proceeds to evaporate.

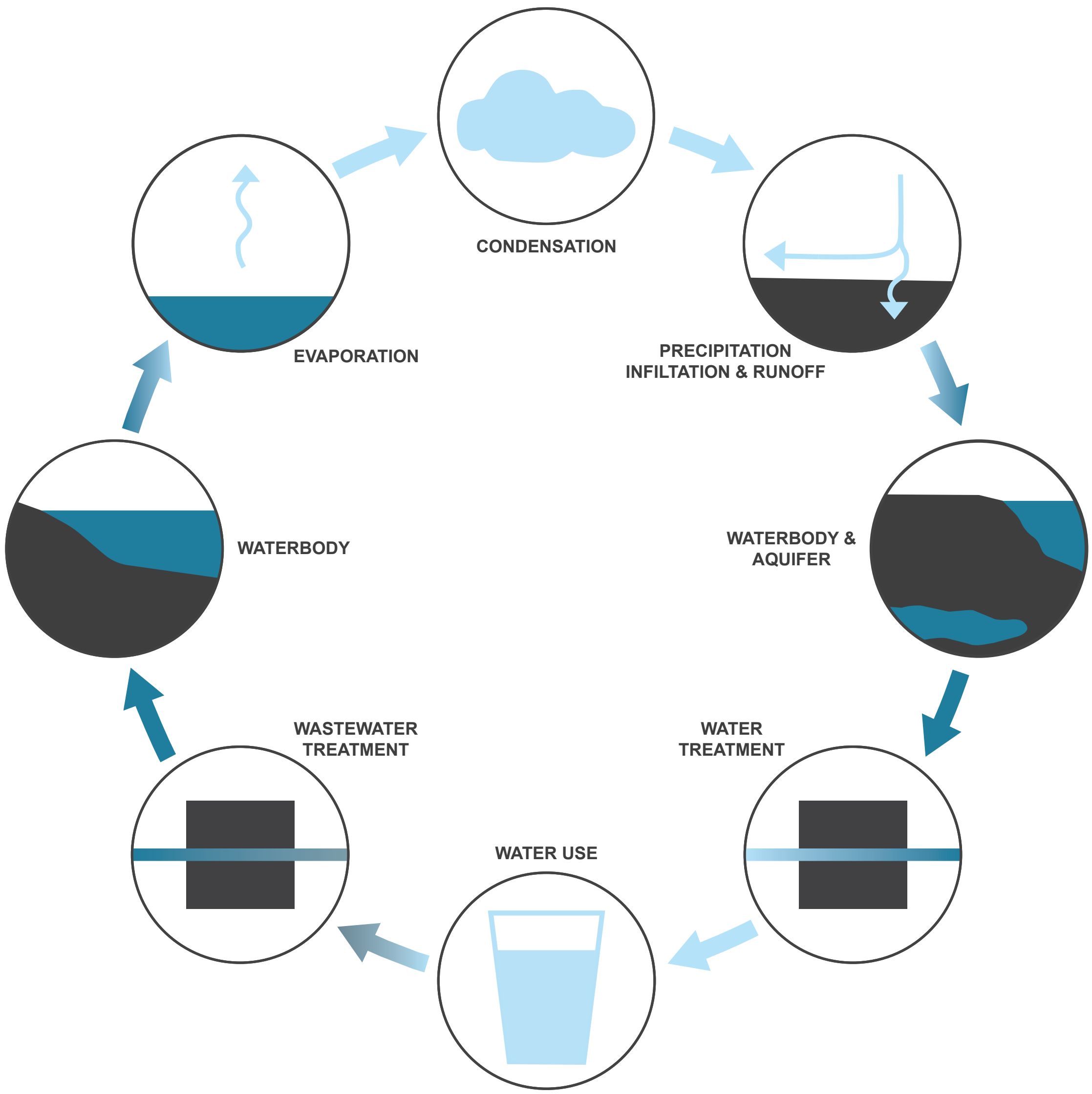


Scales of interaction with water - global, watershed, and individual.

The Integration

Water is required by everyone and everything for there to be life. In places with easy access to water, it comes at the turn of a tap, or in a plastic bottle that a company claims to own. In reality, water is part of a global cycle that extends far beyond our own hands, even beyond borders of so-called ownership, as it is much greater than any individual or community. Everyone deserves access to safe water, but this means everyone must also work to protect water and take an active part in its management.

Collective responsibility is collective accountability. Wastewater treatment is a closed-door process, for public safety, plant safety, and propriety reasons. However, this puts the management, treatment, and accountability of water and wastewater onto a very small group of people, despite the service being for the collective. Public awareness and involvement in water and wastewater management is currently minimal, but by improving understanding of the processes and awareness of issues, small changes in activity by each individual accumulate to have an impactful result on water and wastewater. The public involvement and understanding also increases safety through collective awareness of water quality, potential contaminants, treatment technology, functioning, and more.



Hydrologic cycle and anthropogenic interactions.

Chapter 3: Context

History of Inverness

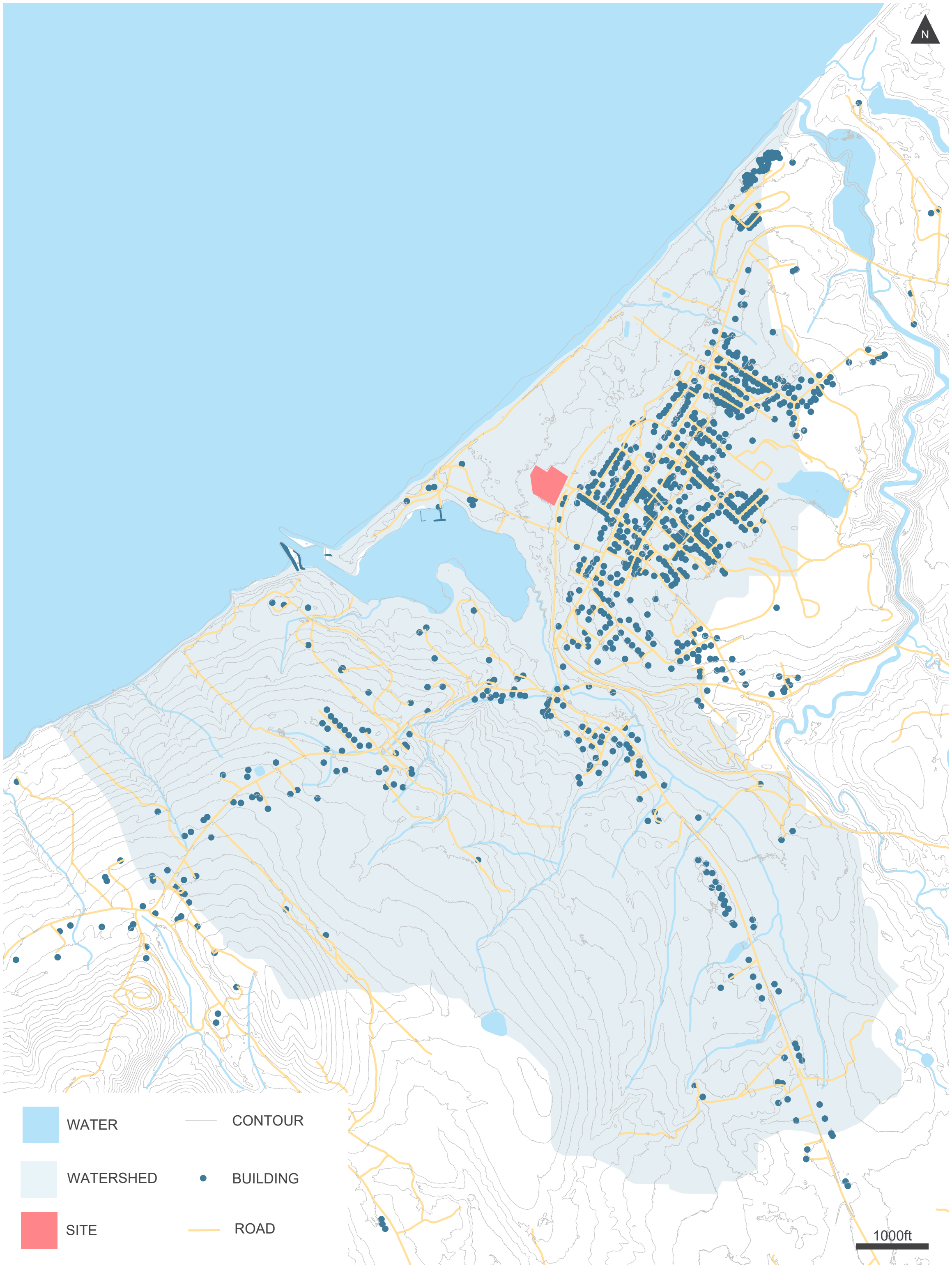
Inverness is a community in the Municipality of the County of Inverness, in Nova Scotia, Canada. The County of Inverness makes up the west coast of Cape Breton Island. Inverness is in Mi'kma'ki, the traditional and unceded territory of the Mi'kmaq people, and is part of the Peace and Friendship Treaties (Government of Nova Scotia n.d.a.; Treaty Education Nova Scotia and Government of Nova Scotia 2023). Inverness is located on Cape Breton Island, Unama'ki in Mi'kmaq, meaning "the land of the fog" (Mi'kmaw Place Names n.d.). Scottish, Irish, and French settlers arrived in Cape Breton in the late 1700s onwards, maintaining many cultural traditions practiced today (Inverness Miners Museum n.d.c). Gàidhlig, or Scottish Gaelic, is still spoken across Cape Breton and featured on many signs and at tourist destinations, including historical museums and ceilidhs, traditional music and dance social events. (Inverness Miners Museum n.d.c) Inverness was settled by the Scottish, named after Inverness in Scotland, and given the Gàidhlig name Sithean, meaning "the land of the fairies" (Inverness Miners Museum n.d.a). The settlers

Historic painting of Inverness (MacDonald n.d.).

arrived in the early 1800s and farmed the land, until the mid-1800s when coal was found and mined until the mid-1900s (Inverness Miners Museum n.d.b; Inverness Miners Museum n.d.c).

Inverness Today

The community of Inverness has approximately 1600 residents, and is supported by healthcare infrastructure, schools, municipal water and waste services, transit, commercial businesses, recreational trails, beaches, museums, and a Links golf course. The town experiences large waves of tourists from May to September, lessening during the winter months. Inverness faces threats to its ecosystem due to climate change, including storm surges and events, reduced sea ice, sea level rise, increased annual temperatures, water scarcity, and seawater intrusion (CBCL 2013). These effects primarily threaten habitats due to changing weather, erosion destroying the habitats, and threats to human health and safety (CBCL 2013). While the expected sea level rise was categorized as minor to moderate by CBCL (2013), the combination of climate change effects threatens infrastructure, including the Cabot Trail and other roads through Inverness, wharves, the water supply, wastewater infrastructure, and Inverness Beach. Cape Breton is reliant on the landscape for its economy, whether through resources or tourism such as Inverness Beach, all of which are greatly threatened by climate change. CBCL (2013) identified some considerations for emergency preparedness, including back-up power for critical infrastructure, sewage treatment outfall inspection for monitoring damage and erosion, infrastructure to handle snow loading, monitoring of closed landfill sites to ensure integrity, stormwater management, protection

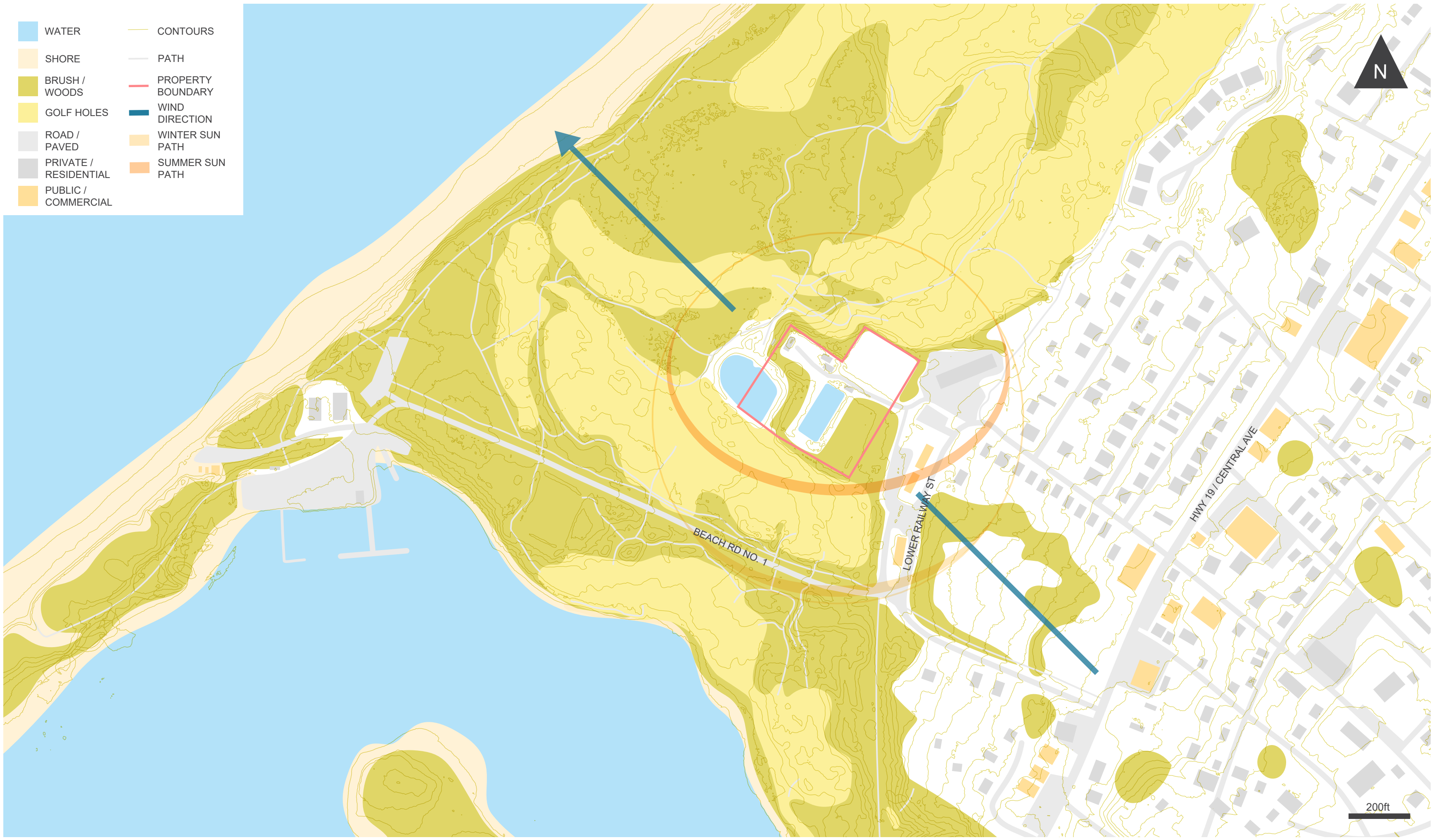


Map of Inverness, with design site highlighted in red (data from Government of Nova Scotia n.d.b.).

against flooding, education of the public on climate change impacts, maintenance of access to coastal land for tourism, development of a plan for climate change, and production of mapping, data, and by-laws to mitigate risks.

The Site

The existing wastewater treatment plant is located at 58 Lower Railway Street off Central Avenue/Highway 19. There is a residential strip between Highway 19 and Lower Railway Street, with a boardwalk going to the beach entrance parallel to Beach Road 1 and ending at Lower Railway Street. On this road, adjacent to the site, is a community market, a café (The Annex), and the Inverness Miners Museum. These three buildings create a local cultural hub that has connections to recreation areas. The Ceilidh Trail entrance is adjacent to the museum entrance and the boardwalk leading to the beach. On three sides of the site is the golf course; these three sides also face the ocean and harbour. The current road to the wastewater treatment plant is the residential Lower Railway Street. In the development plan produced in 2013, this Lower Railway Street was identified as a potential development location for further recreation and community uses due to the already present community infrastructure, central location, connection to the boardwalk and Ceilidh Trail, and the surrounding golf holes providing 270° views around the site to water, with the remaining 90° being towards the Lower Railway Street residences and partially the Annex, museum, and market. It is important not to obstruct the views from these existing buildings and ensure paths do not get disrupted but rather enhanced. Also identified in the Development Plan (2013) were issues with connection to the beach, as there is only one primary entrance on Beach Road 1 that connects the boardwalk to



Site context map, illustrating surrounding environment, infrastructure, sun and wind (data from Government of Nova Scotia, n.d.b.).

the remaining paths across the dunes blocked by the golf course which takes up the rest of the waterfront.

Inverness Wastewater Treatment Plant

The community of Inverness, while small, is representative of communities from rural to urban scales. Inverness provides the basic communal services required by any community to support dense areas of living, especially at large, urban city scales. Water infrastructure is a requirement for communities to accommodate a density of people that is greater than the water sources of that same area can provide. Wastewater infrastructure is also vital to communities as everyone produces bodily waste, along with additional waste through daily activity, which requires space that is not available in dense settings. Water and wastewater account for 58% of greenhouse gas emissions from municipal buildings, facilities, and equipment in the County of Inverness, partially due to inefficient technology and aging/at capacity infrastructure (CBCL 2013).

Existing Wastewater Treatment Plant and Current Proposal

Following consultation on the Inverness WWTP, R.V. Anderson Associates Limited (2021) chose a conceptual design based on capital cost, operational complexity, maintenance requirements, technology risk, ability to handle fluctuating loads, and the possibility of expansion in the future.

The Conceptual Plan for the Community of Inverness, developed by Conrad Taves Design Consulting and Dalhousie University School of Planning Cities & Environment Unit (2013), suggested development projects and aesthetic guidelines to help Inverness reinforce its identity and support its tourism and community growth. Relevant general goals established with community consultancy included energy development, inclusion of history and culture, and highlight the natural environment, and specifically, the Conceptual Plan (2013) identified the Boardwalk and Lower Railway Commons as a potential development area for growth, community programming, and connection to the waterfront.

Chapter 4: Methodology

This thesis does not design the system and technology of the WWTP, but looks at how the system may be architecturally understood and integrated with socio-cultural programming.

Based on the WWTP technology system, the general layout of the plant must be similar to the process to allow for efficient flow of sewage from treatment step to treatment step. From this, additional programming may be laid out in reference to the core treatment program. Basic programming includes chemical storage, loading bay, entrance, parking, lab, washrooms, and general service spaces. If the treatment plant is occupied frequently and there is frequent traffic to the site for waste hauling, chemical delivery, etc., additional programming such as offices, reception, meeting rooms, and a kitchenette are helpful.

This design takes the program of the WWTP one step further, adding public spaces to the interior and exterior of the plant to integrate with the public. As discussed in Chapter 3, Inverness has identified Lower Railway Street as a potential development area. As there is already a museum, cafe, market, trail, and boardwalk beside the site, adding additional social, education, and recreation program to the WWTP capitalizes on its location and gives the treatment program a dual function. A classroom expands upon the lab, allowing educational opportunities for local groups. A lobby, circulation separate from operators' space, and signage throughout the plant allows for tours and safe experiences with the various treatment processes throughout the plant. Tourism is a key factor in Inverness' economics, so creating spaces for tourists can offer economic benefits, draw in people and extend circulation to adjacent businesses.

The three treatment systems added to the process proposed by RVA (2021) do not change the system proposed, but add to it. These additions provide further treatment, redundancy for safety, and water reuse opportunities. Firstly, planted aerobic reactors have been added for their treatment capabilities but also because this method is aesthetically pleasing and intriguing to the public. This system can also be used to test phytoremediation treatment methods. Secondly, on-site sludge management is expanded to include hydrothermal carbonization to create by-products such as biochar and heat; the former can be sold as fertilizer or a filter, and the latter used for heat recapture and energy to operate the plant and store. Lastly, water storage has been added and expanded upon to hold treated effluent for water re-use. This takes the form of an expanded pond and stream, used by the golf course, and a small water tower.

The current proposal for the upgraded WWTP fails to address socio-environmental aspects of the treatment plant. For the purposes of this project, the WWTP system proposed by RVA (2021) will be used in this design. While this thesis proposes additional objectives for the WWTP design, the methodology for design is focused on socio-environmental impacts of the WWTP overall and how parts of the treatment process may be highlighted; this thesis does not address the choice of treatment methods.

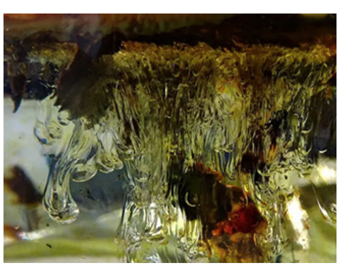
Methodologically, design must consider the site in relation to the people, animals, plants, and water; then, how these relationships tie into the larger community, ecosystem, and watershed; and lastly, how this site relates to the global system. The design response of this thesis focuses on the interactions of organisms, water, and the wastewater treatment plant, across the scales of the individual, site, and community.

Sechelt Water Resource Centre (PUBLIC Architecture + Communication 2015).

Precedents

Ecologist John Todd designed “living machines” with the idea that “waste is a resource out of place and that nature handles every form of waste by turning it into a resource, our systems imitate the purifying and recycling abilities of natural aquatic ecosystems” (Todd and Todd 1993). Todd’s work focused on natural methods of treating waste, as these processes have been developed over thousands of years, but human consumption is out-pacing the natural processes and methods of adapting.

PUBLIC’s Sechelt wastewater treatment plant in British Columbia uses planted tanks as a step in the treatment process, offering tours through the greenhouse-like section of the plant, but the rest is closed off or visible through glass, maintaining safety but allowing the public to engage in the plant’s operation (PUBLIC Architecture + Communication 2015).



Bubbles 22 by Rachel Armstrong, hydrophilic and hydrophobic material interaction (Gioia 2017).

Rachel Armstrong, a professor at the Department of Architecture, Planning and Landscape at Newcastle University, develops “living architecture”, defining living as “the modes of inhabitation within a space as much as it is a technology that connects the structures and choreography to the much broader environment and ecology in which the architecture is situated” (Gioia 2017; Living Architecture Systems Group 2023). Armstrong pointed at humans’ disconnect from the natural processes of the world. Other living beings also create waste, but their waste becomes a resource for something else, while human waste does not. To be sustainable, we need to reestablish this cycle

Whitney Purification Facility and Park, Connecticut, USA (Steven Holl Architects 2005).

and relationship. Lessons can be taken from the natural functioning of the planet and used to explore potential ways to mimic these interactions with technology. The simple equilibrium of the planet itself can be a goal for future development, requiring even higher best practices to actively give back to the environment instead of doing as little harm as possible.

Steven Holl's Water Purification Plant in Connecticut layers recreational walking trails and planted habitat onto a water treatment site to beautify the site but illustrates the processes instead of directly engaging with them (Steven Holl Architects 2005). Holl produces beautiful moments that highlight aspects of the program and site but only allows engagement with the beautified or translated parts of the plant, still keeping visitors at a sanitized distance from understanding the processes within. Inhabitation of space requires a draw into the site and what occurs there, from human scale programs such as walking trails, pollinator gardens, and the treatment processes of water. Every aspect of the site should be integrated and inhabited.

The Integration

Three goals were identified, based on the above precedents and research to form a basis for design decisions:

- Identify programs that expand upon existing wastewater treatment plant programs.
- Create spaces that bridge boundaries of the conventionally private wastewater infrastructure and surrounding socio-cultural infrastructure.
- Create moments of wastewater monitoring for the public to improve hydrologic awareness and understanding.

These goals also acknowledge that land use in centralized and/or water zones is valuable space for the public, but wastewater infrastructure is also valuable because it is required for the health and safety of a community. Inhabiting the wastewater infrastructure and site will induce interaction between the public and system. This increases multi-use possibilities and improves understanding of the system to increase water consumption responsibility.

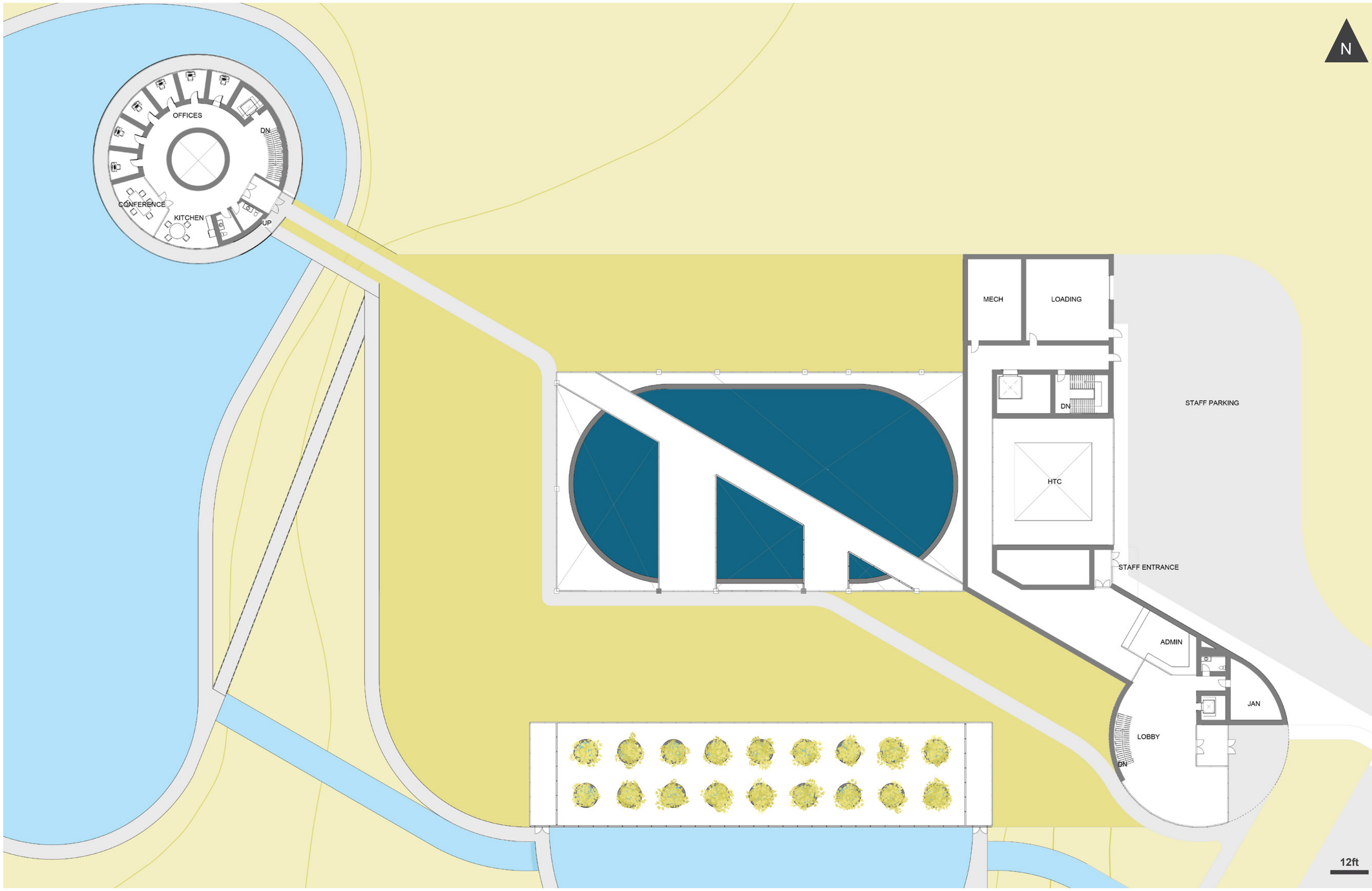
Proposed wastewater treatment plant process from R.V. Anderson Associates (2021) with biochar and phytoremediation additions.

Chapter 5: Design Response

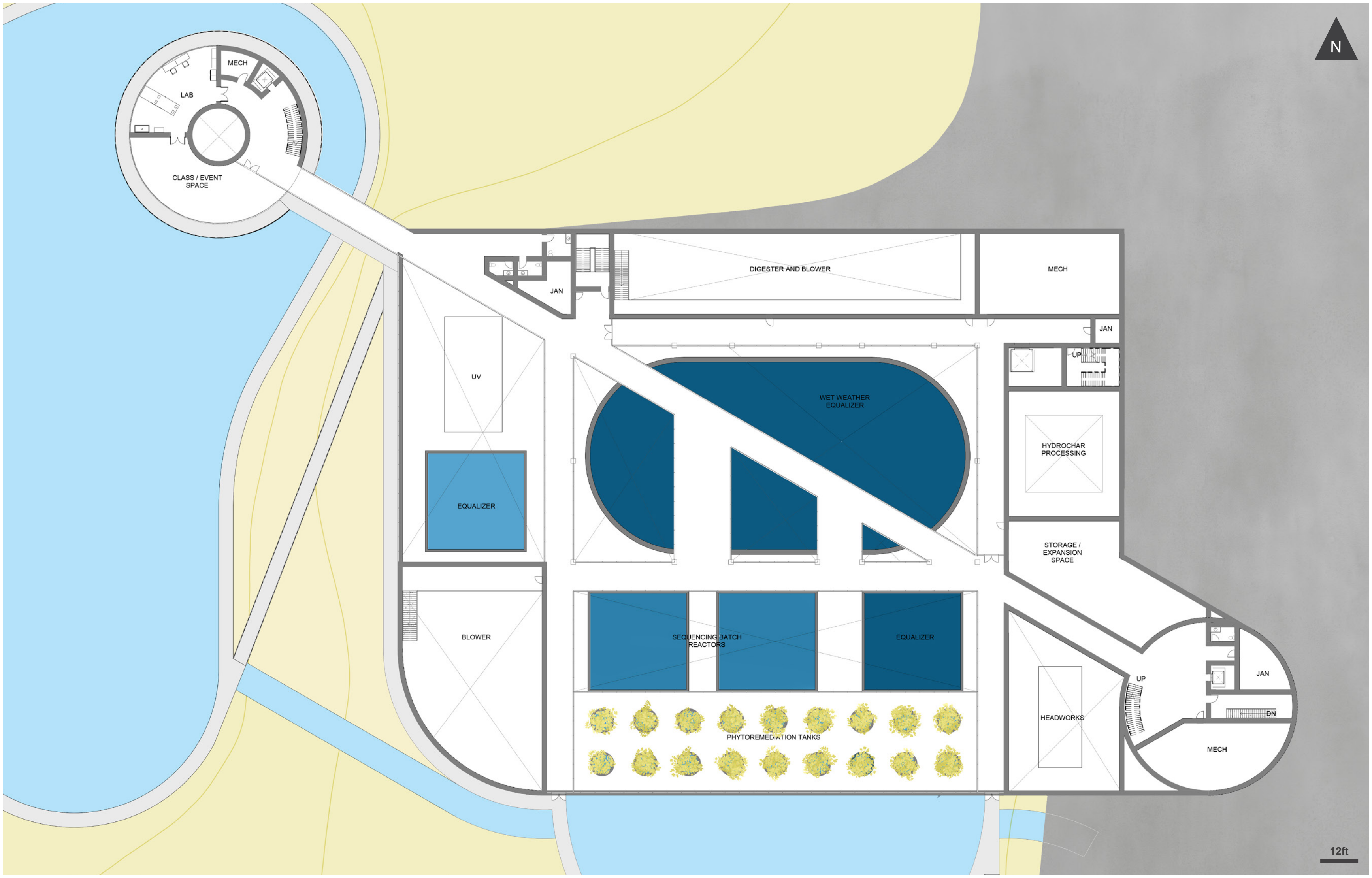
The design for the new wastewater treatment plant first required understanding the technology system and the flow from one step to the next to form the base organization of the plant. Water and human circulation reflect one another through the building, illustrating the water's transformation as it is treated. While the details of the wastewater treatment process are not developed in this thesis, approximate sizing for equipment was completed, referencing the conceptual plan developed by RVA (2021), then allowing additional space for increased capacities and potential expansion.

Additional treatment and/or storage options were then added in their corresponding locations along the treatment process. These additions consist of effluent storage for greywater reuse (irrigation), planted aerobic reactors and a constructed wetland for phytoremediation of wastewater. These additions, as well as the wet weather overflow storage, serve as public engagement and monitoring of wastewater processes in a safe and educative method, beginning to invite public inhabitation of the treatment plant.

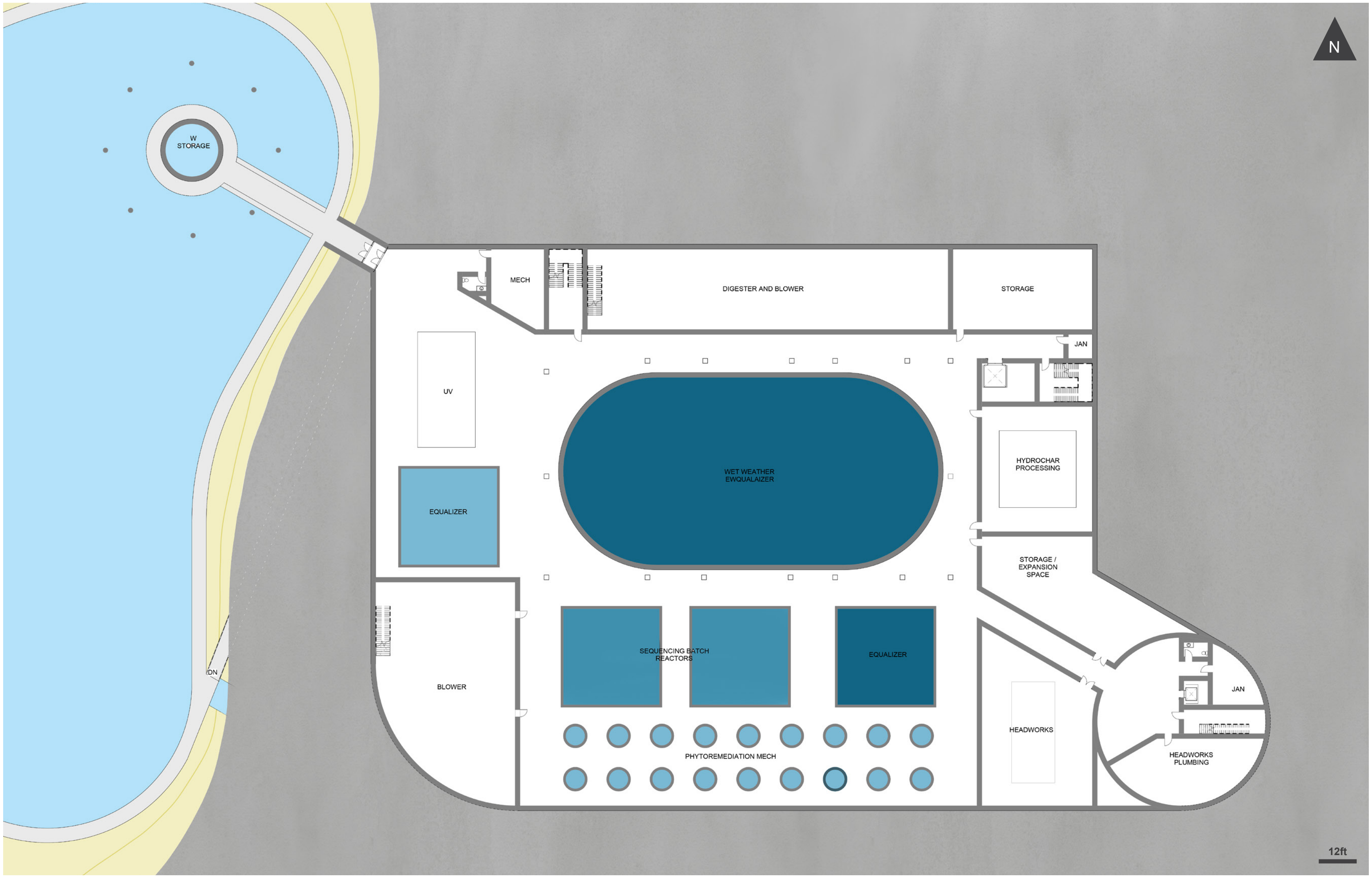
Programs were then added for the public and employees to use beyond observation and operation of the treatment process, including classrooms, labs, offices, lounge, kitchenette, trails on and around the building, gardens, and connections to the commercial area of the current cafe, museum, and market.



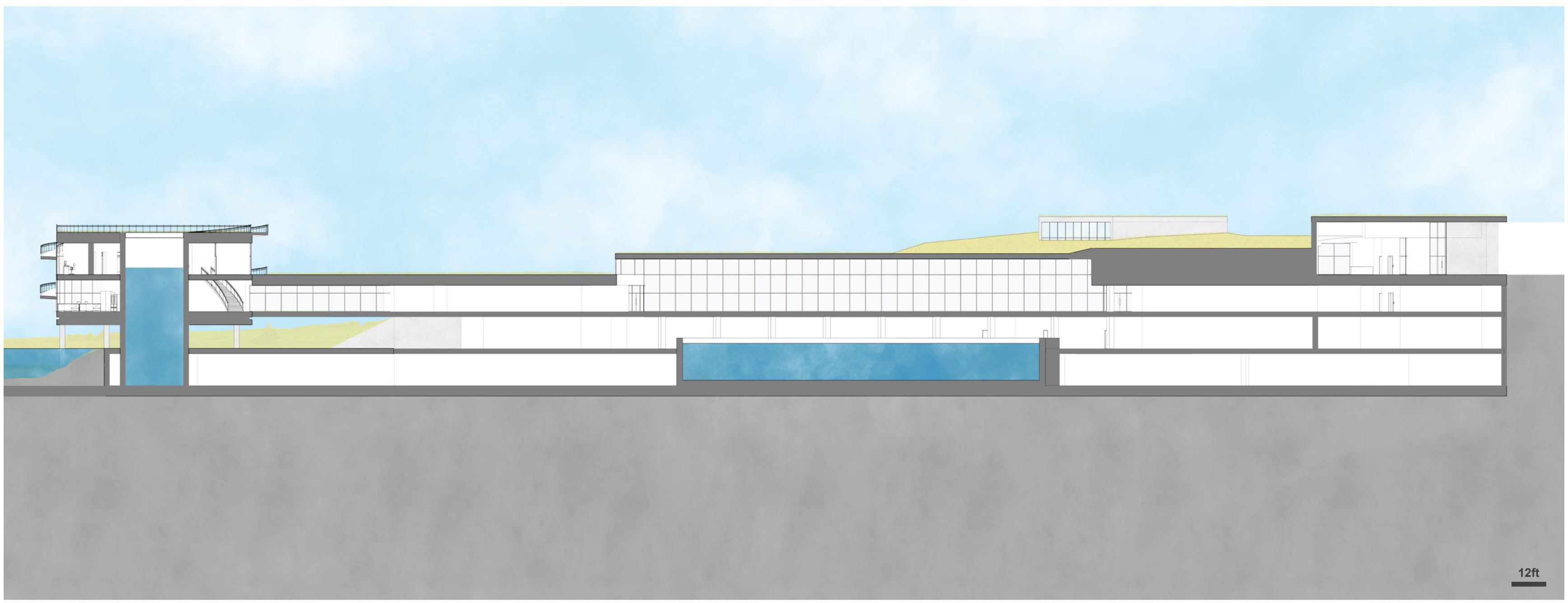
Level 1 Floor Plan: Entrance from Lower Railway Street, commercial complex, and parking.



Level 2 floor plan: publlic paths and garden.



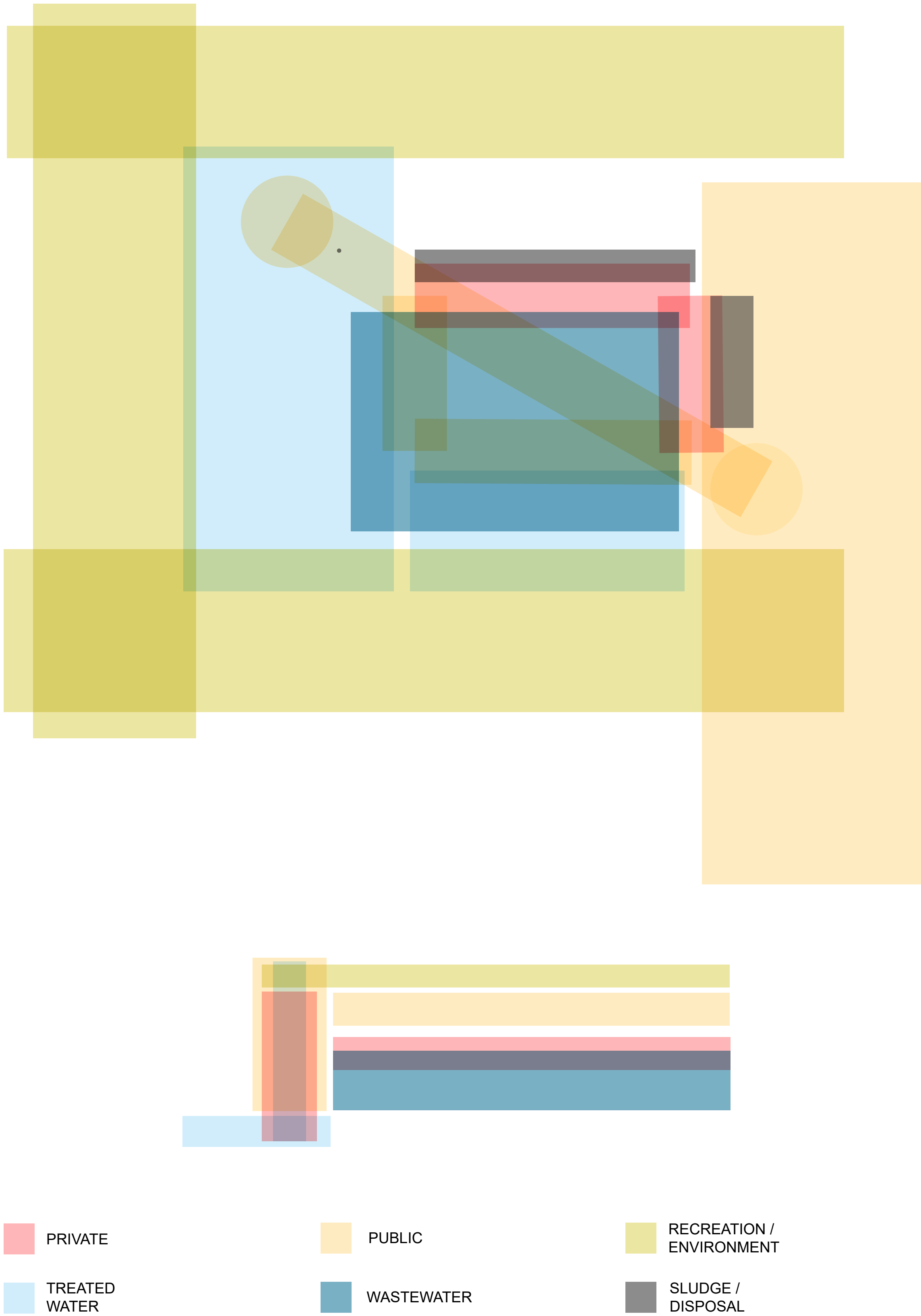
Level 3 floor plan: operations and maintenance.



Building section: west-east axis.

Health and safety are of the utmost importance for workers and the public. It is important to have moments of interacting with the treatment process for the public; however, separation between the operation side of the plant and areas the public could walk into is vital. This separation was achieved by differentiating an enclosed public catwalk on Level 2 from Level 3, where most equipment is open for ease of maintenance. The glass enclosure of the halls on Level 2 allows the public to view the operations of Level 3 below, without interfering with any equipment and workers. The classrooms, offices, loading bay, storage facilities, and administration are also separated from the equipment by walls and doors for circulation. The separation of spaces between protects the workers and public from inherent nuisances in the treatment plant such as odour and noise in order to make the space inhabitable.

Worker and public programmed spaces were orirented on the site according to their proximity to their respective entrances, the garden, and views to the ocean. The public circulation through the building mimics the wastewater treatment process. This allows the public to passively understand the process through observation on their journey through the building.

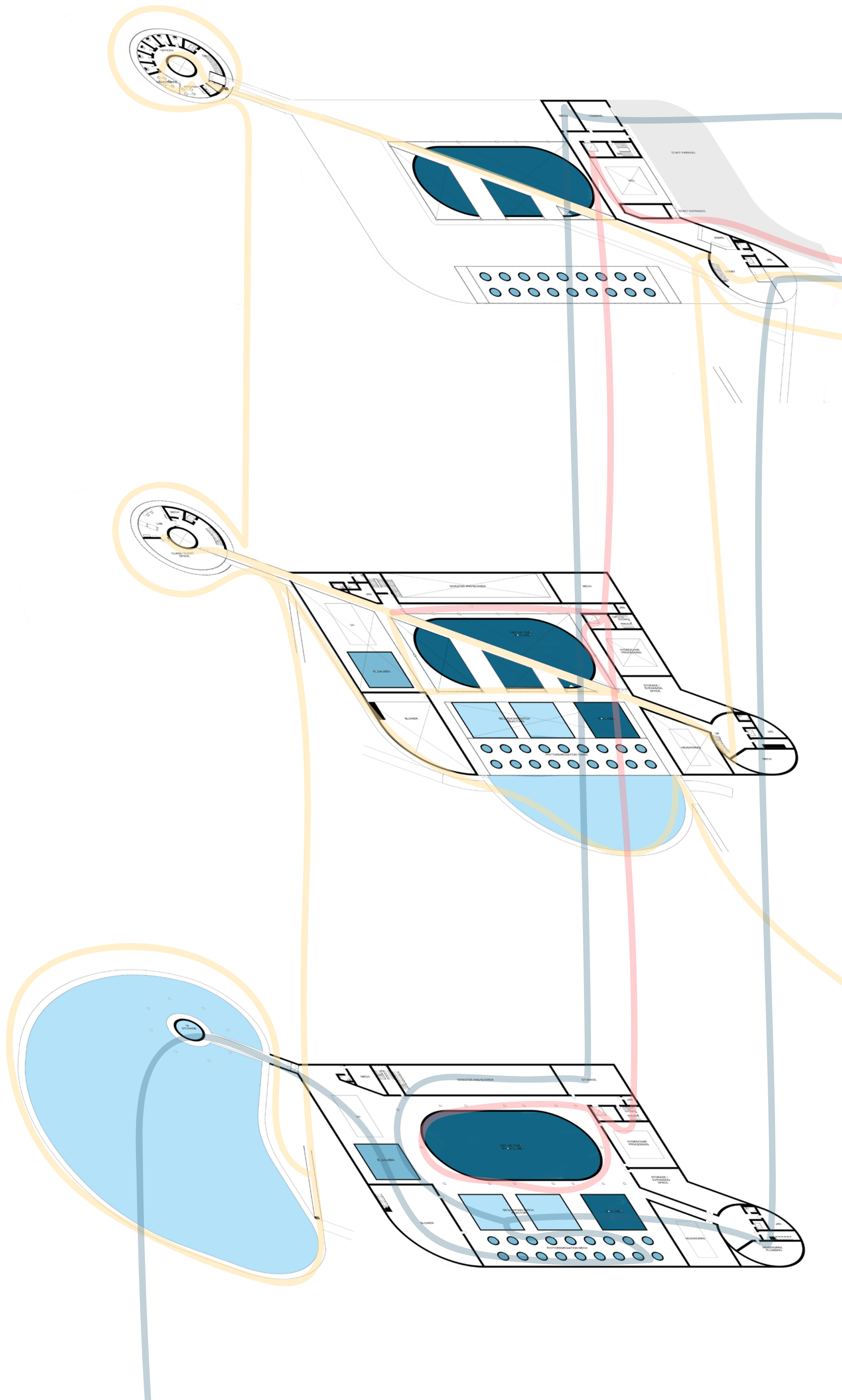


Programmatic diagrams in plan (top) and section (bottom).

Level 1

Level 2

Level 3



Circulation diagram of public (yellow), operation and maintenance workers (pink), and water (blue).

View of the new wastewater treatment plant from Cabot Linnks golf course to the west of the site.

Chapter 6: Conclusion

Through creating space for inhabitation in and around the Inverness Wastewater Treatment Plant, opportunities for connection to the larger part each individual has in water management and the larger hydrologic cycle become apparent. Public understanding of the wastewater treatment process is improved through observation, drawing the public in through gardens, classrooms and paths, leading to moments of water management quality markers that do not require an understanding of the technology within the plant. The paths and gardens of the treatment plant serve as extensions of existing public recreation and commercial space, encouraging further and prolonged inhabitation. This integration of public use and service infrastructure is critical to maximizing land-use in high demand places. More importantly, it is crucial to bringing water management to the forefront of people's lives by encouraging interaction with the treatment process itself and illustrating the effect and connection of these practices on its surroundings.

Due to water's existence all across the planet and requirement for life, this project could be further studied in any number of ways. Wastewater treatment technology is not currently designed for its appearance; however, it's possible that by considering its aesthetics or relationship to the public in a new way, different ways of incorporating it into infrastructure could be considered. Throughout the thesis, ecological relationships were mentioned, but minimally involved. Expansion on specific species in a site's context and how they may inhabit the site alongside human inhabitants, and possibly layer added programs and positive effects would be beneficial. This concept could add biophilic elements to aesthetics and technology. Each wastewater treatment plant site is unique, and as such would have different opportunities for public engagement. Inverness' site has many existing public programs that this thesis worked to expand on overall but not in depth, however each one of these opportunities (i.e., commercial development, trails expansion) could be a small project on its own.

Globally, the climate crisis is affecting everyone, but disproportionately affects those who have the least carbon use and funds. It is therefore crucial that people and infrastructure with a large influence, such as governments who operate water and wastewater infrastructure, do the utmost to minimize their environmental impact. An optimized, efficient, safe, environmentally conscious water management practice by the government would provide an example for others. The ripple effect of best water management practices could be scaled across industries or down to the individual, and gain the collective improvement provided by individual change. As evidenced by the hydrologic cycle, water management practices affect one another, but also all life connected to them. Thus, any small or large improvement in water management has a ripple effect in improving the quality of water management and life beyond it.

References

Bartlett, C., M. Marshall, A. Marshall and M. Iwama. 2015. “Integrative Science and Two-Eyed Seeing: Enriching the Discussion Framework for Healthy Communities.” In *Ecosystems, Society and Health: Pathways through Diversity, Convergence and Integration*, edited by Lars Hallström, Nicholas Guehlstorf, and Margot Parkes, 280-326. Montreal: McGill-Queen’s University Press.

CBCL Limited. 2013. “Municipal Climate Change Action Plan for Port Hawkesbury, Victoria County and Inverness County Final Report”. The Municipality of the County of Inverness. https://invernesscounty.ca/wp-content/uploads/2021/03/5-Municipal-Climate-Change-Action-Plan.pdf.

City of Toronto. n.d. “Fast Facts about the City’s Water Treatment Plants”. Accessed October 18, 2023. https://www.toronto.ca/services-payments/water-environment/tap-water-in-toronto/fast-facts-about-the-citys-water-treatment-plants/

Conrad Taves Design Consulting and Cities & Environment Unit. 2013. “Conceptual Plan for the Community of Inverness”. https://invernesscapebreton.com/wp-content/uploads/2017/09/Inverness-Concept-Plan-Final-2013-05-28.pdf

Cosgrove, Denis. 1984. *Social Formation and Symbolic Landscape*. Madison, WI: University of Wisconsin Press.

Doors Open Ontario. n.d. “R. C. Harris Treatment Plant”. Accessed October 18, 2023. https://www.doorsopenontario.on.ca/toronto/r-c-harris-water-treatment-plant.

Fardin, H. F., A. Holle, E. Gautier, and J. Haury. 2013. “Wastewater Management Techniques from Ancient Civilizations to Modern Ages: Examples from South Asia.” *Water Science & Technology. Water Supply* 13, no. 3: 719–26. https://doi.org/10.2166/ws.2013.066.

Gioia, Ted. 2017. “Rachel Armstrong’s vision for “living” buildings that grow, metabolise and defend us like an immune system”. It’s Nice That. August 4, 2017. https://www.itsnicethat.com/articles/rachel-armstrong-university-of-the-underground-architecture-040817.

Government of Nova Scotia. n.d.a. “Map of First Nations in Nova Scotia”. Accessed November 2, 2023. Office of L’nu Affairs. https://novascotia.ca/abor/aboriginal-people/community-info/.

Government of Nova Scotia. n.d.b. “Data Locator”. Accessed January 12, 2024. https://nsgi.novascotia.ca/gdd/.

Inverness Miners Museum. n.d.a. “Firsts”. Accessed October 26, 2023. https://www.invernessminersmuseum.com/firsts-for-inverness.

Inverness Miners Museum. n.d.b. “The Mines”. Accessed October 26, 2023. https://www.invernessminersmuseum.com/the-mines.

Inverness Miners Museum. n.d.c. “The Town”. Accessed October 26, 2023. https://www.invernessminersmuseum.com/the-town.

Kimmerer, Robin Wall. 2014. *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teaching of Plants*. Minneapolis, MN: Milkweed Editions.

Kumar, Pankaj, Ram Avtar, Rajarshi Dasgupta, Brian Alan Johnson, Abhijit Mukherjee, Md. Nasif Ahsan, Duc Cong Hiep Nguyen, Hong Quan Nguyen, Rajib Shaw, and Binaya Kumar Mishra. 2020. “Socio-Hydrology: A Key Approach for Adaptation to Water Scarcity and Achieving Human Well-Being in Large Riverine Islands.” *Progress in Disaster Science 8*: 100134–. https://doi.org/10.1016/j.pdisas.2020.100134.

Living Architecture Systems Group. 2023. “Rachel Armstrong”. Partners. https://livingarchitecturesystems.com/people/rachel-armstrong/.

MacDonald, Terry. n.d. “Inverness Biography”. Inverness, Cape Breton. Accessed October 26, 2023. https://invernesscapebreton.com/inverness-biography/.

McHarg, Ian. 1971. *Design with Nature*. New York: Wiley.

Mi’kmaw Place Names. n.d. Accessed November 2, 2023. https://placenames.mapdev.ca/.

Papanek, Victor. 1971. *Design for the Real World: Human Ecology and Social Change.* New York: Pantheon House.

PUBLIC Architecture + Communication. 2015. “Sechelt Water Resource Centre.” *ArchDaily*. https://www.archdaily.com/896286/sechelt-water-resource-centre-public.

R.V. Anderson Associates Limited. 2021. “Community of Inverness WWTP System Assessment Report and Pre-Design Study: Preliminary Design Report – Final.” The Municipality of the County of Inverness.

Schneider, Daniel. 2011. *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Ecosystem*. Cambridge, MA: MIT Press.

Steven Holl Architects. 2005. “Whitney Water Purification Facility and Park”. https://www.stevenholl.com/project/whitney-water-facility/.

Todd, Nancy Jack, and John Todd. 1993. *From Eco-Cities to Living Machines: Principles of Ecological Design*. Berkley, CA: North Atlantic Books.

Treaty Education Nova Scotia and Government of Nova Scotia. 2023. “We Are All Treaty People”. North American Indigenous Games. https://naig2023.com/wp-content/uploads/2023/05/TENS-NAIG-Brochure-8.5x5.5-REV-MAY15-WEB.pdf

Vitruvius Pollio. 1960. *Vitruvius: the Ten Books on Architecture*. Translated by M.H. Morgan. New York, N.Y.: Dover Publications.