REIMAGINING WASTEWATER MANAGEMENT THROUGH ECOLOGICAL INTEGRATION IN INVERNESS, NOVA SCOTIA

Abstract

Multi-use, ecologically integrated design of urban civic infrastructure is necessary to meet the environmental demands of the future. Climate-compromised and overloaded wastewater infrastructure is an increasing concern in communities, causing disruptions to service, and detrimental impacts of population and environmental health. Water and wastewater infrastructure are essential to human settlements; without them cities and towns are uninhabitable. Yet the vital importance of these treatment plants is often unseen and under-appreciated despite their often-central location to watercourses and the communities they serve. The sites of these plants therefore hold significant potential to become a civic asset to the community.

This paper will present a case study of the wastewater treatment plant of Inverness, Nova Scotia, Canada. Located between a world-renowned golf course and a tourist beach, the aging treatment plant is failing, producing odor and noise throughout the town. In recent years, the town has gained provincial support to build a new treatment plant, but this initiative has been narrowly conceived as an engineering solution to meet minimum standards. The incorporation of ecology into design parameters to create multi-use integrated architecture is increasingly considered a baseline for such civic infrastructure — especially in an era of climate change. This paper argues that by integrating both ecological and civic considerations in the design of wastewater treatment plants there would be far greater benefits to community well-being, landscape identity, and ecological health.

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Keywords

Wastewater infrastructure, civic infrastructure, ecological architecture, multi-use architecture

Introduction

Multi-use, ecologically integrated design is necessary for the future of technology and infrastructure to mitigate impacts on the environment and demands on infrastructure due to increasing, centralizing populations and climate change. Wastewater treatment plants (WWTP) serve a vital role in centralized communities, necessary for the health of people and nature, treating and managing waste so that it can minimally impact the local environment and inhabitants (Schneider, 2011). Climate change is affecting demands on both the quantity and quality of wastewater, due to increased demand, fluctuations in precipitation, overflow contamination of waterways, and more (Rosenzweig, 2011). This new demand on WWTPs results in increased energy consumption, when already, 3–4% of national energy consumption in the United States is from municipal wastewater treatment operations (Shen et al., 2015). Rothausen & Conway (2011) point out a lack in development of energy efficient water treatment technologies and a separation from water-based renewable energy solutions, resulting in the water treatment industry relying on the production of external renewable energy consumption (Zib et al., 2021). As a result, the water and wastewater industry must turn inwards to find solutions for energy efficiency, and therefore climate change resiliency.

Figure 1: Schematic Map of Inverness, Nova Scotia. (Source: Author.)

The Municipality of the County of Inverness, Nova Scotia, Canada, is an example of a growing community that provides municipal services for the town and rural surrounding areas. Inverness' WWTP is run down, and mechanically failing, creating a nuisance to the public and a risk to the environment (Figure 1). The Inverness Wastewater Treatment Plant, located in the center of town, amidst two of the town's most important tourist destinations, world-renowned golf course, Cabot Links, and Inverness beach, was failing, producing smell and noise from the undertreated sewage. Consulting work has since occurred to begin the process of building a new WWTP, however, it only considers what is required to fulfill basic services. Consideration of ecological integration in wastewater treatment and infrastructure provides opportunities for lower operational costs, energy generation, aesthetics, community engagement, and more, which all add to the quality of life of people and the environment.

Methodology

Through a case study and critique of Inverness' current WWTP and proposal for a new WWTP, a set of architectural design objectives will be developed. These new architectural objectives will be based on furthering the design objectives identified by the Municipality of the County of Inverness and consultant reports using ecological technology solutions and additions. While Inverness was specifically studied for the purpose of this paper, the issues the wastewater infrastructure faces are not unique and are increasingly occurring across the world.

Current System

The rural community of Inverness provides municipal water and wastewater services to approximately 1,250 residents as of 2016, with an estimated annual growth of 1.5% (R.V. Anderson Associates Limited [RVA], 2021). The systems were installed in the 1970s, but some portions of wastewater infrastructure are from as early as the 1940s. This wastewater system is a conventional system with gravity sewers, pump stations, forcemains, and the wastewater treatment plant (WWTP). The current wastewater treatment plant is a lagoon-based, extended aeration facility, which includes aeration, secondary clarification, UV disinfection, aerobic digester/storage after changes to the system in the 1990s (Figure 2). The treated wastewater is discharged into the Northumberland Strait off Inverness Beach. It currently serves residential and commercial users but has higher demands from the Cabot Links golf course, a camping trailer park, and condominiums. These seasonal load fluxes occasionally result in non-compliance with effluent discharge quality due to insufficient treatment at the WWTP. Stormwater is occasionally directed into the wastewater sewers while the rest follows topography to drain to the ocean. The overall condition of the conveyance pipelines is mixed, suffering occasional overflow at pump stations, but requires replacement to meet current and future demands, as the pipes are reaching the end of their lifetime. The WWTP suffers minor mechanical failures that require manual repair. The WWTP equipment and buildings have reached their end-of-life, and the operation poses occupational health and safety concerns with no power on site, and the overall conditions and maintenance requirements. The inefficiency of the current system and outsourced sludge management increase the operational and maintenance costs of the WWTP (MacDonald, 2020).

Identified Design Criteria and Opportunities

As a result of the problems with the Inverness WWTP, in 2019 the Municipality of the County of Inverness issued a Request for Proposals (RFP) for an Inverness Wastewater Treatment Plant System Assessment Report (SAR) and Pre-design Study. R.V. Anderson Associates Limited (RVA) (2021) answered the RFP. The RFP identified the following objectives for the SAR and Pre-Design Study (MacDonald 2020; Municipality of the County of Inverness 2021):

- Capacity for estimated development growth up to 2045
- Meet current and future treatment standards
- Complexity of operation and maintenance
- Risk of technology choice
- Ability to expand the treatment capacity
- Manage seasonal fluctuations of load
- Efficient operations and maintenance (energy, labor, chemicals)
- End of life plan for current plant and future alternatives
- Capital, operation and maintenance, and lifecycle costs
- Noise and odor control
- Biosolids management
- Durability of infrastructure for weather and climate change

Figure 2: WWTP and lagoon. (Source: Ayers, 2019.)

Within these objectives, the decision criteria used by RVA (2021) included:

— Capital cost
— Operational and maintenance complexity
— Technology risk of failure
— Ability to manage seasonal fluctuations
— Ability to expand

Furthermore, the Municipality of the County of Inverness (2021) identified the following opportunities:

— Large site offers opportunity for expansion and upgrades of WWTP
— Technology improvements for more efficient treatment and costs
— Enclosing currently outdoor processes would improve efficiency, operation and management, and life expectancy of equipment
— Automation would improve treatment efficiency

Based on the project objectives, design criteria, and opportunities, RVA (2021) proposed an upgraded plant system (Figure 3).

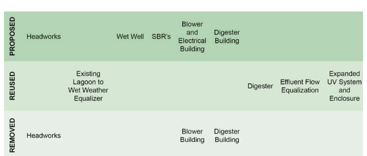

Figure 3: Current upgraded plant system proposal. (Source: Author.)

Ecological Solutions

John Todd and Beth Josephson (1996) wrote that "[e]cology is the long-term intellectual foundation for the development of new technologies to support society." Nature has spent billions of years creating systems that are adaptable and balance themselves; nature is therefore an invaluable reference for design (Todd & Josephson, 1996). Ecological treatment of water primarily uses a variety of naturally occurring mechanisms, including the sedimentation and phytoremediation of contaminants (Environment Canada, 2006). Hayward et al. (2014) discusses the ability of wetlands to efficiently treat wastewater during the treatment season in Arctic communities, specifically Coral Harbour, Nunavut. Ecological wastewater treatment is preferable to conventional mechanical systems in these regions due to high operations and maintenance costs, limited infrastructure, and labor pool (Hayward et al. 2014). The treatment efficiency of wetlands is optimized in warmer seasons, aligning with peak wastewater loads in Inverness during the summer (Environment Canada, 2006).

Using similar principles as constructed wetlands, living machines are miniature ecosystems created to work with technology. They are "self-designing, self-engineering, and self-supporting," (Todd, 1994). Treatment using this technology can treat municipal wastewater, sometimes better than conventional methods, are scalable, and well suited for populated areas because they are efficient at managing odor and noise (Ramjohn, 2000). Living machines have been implemented across North America, including in climates and communities comparable to Inverness. The City of South Burlington Municipal Eco-Machine proved to reduce odor, be similar in cost, and have high performance in a cold climate (John Todd Ecological Design, n.d.). The Omega Institute for Holistic Studies shows how living machine technology, both indoor and outdoor, can treat water for irrigation use without chemicals, and perform efficiently in colder environments (John Todd Ecological Designs, n.d.; Omega, n.d.). Using planted tanks for additional water treatment and capturing resources, the Sechelt Water Resource Centre successfully increased treatment capacity, addressed issues of odor, noise, high operation and maintenance costs, decreased waste solids, and captured resources at a municipal wastewater scale (PUBLIC Architecture + Communication, 2015; Organica News, 2018). These are only a few examples of ecological wastewater management technology which well establish that it is a reliable and effective treatment method and creates beautiful environments for secondary use while striving for best-practice environmental responsibility.

Results

The RVA (2021) SAR and Pre-Design Study solutions are engineering focused and only a technological upgrade of what exists, not a methodological change. The building upgrades are minimally mentioned and are designed based purely on function. All architectural and structural guidelines are discussed with respect to code compliance and durability for the longevity and protection of the wastewater and equipment (RVA, 2021).

The System Assessment and Pre-Design Study does not address the sustainability of the WWTP infrastructure, besides its durability and longevity. The study did not mention the consideration of material's environmental impact or the addition of green technologies. The buildings hosting the wastewater treatment system are stated to be comprised of pre-cast concrete and pre-engineered metal to maximize construction quality and minimize construction time (RVA, 2021). The addition of green technology and materials provides an opportunity to reduce operational and maintenance costs, offset capital costs, and reduce landfill fees and needs at the end of life. Therefore, to influence climate change, infrastructure and technology must strive to push its environmental impact beyond minimum guidelines set out by codes while still meeting other design requirements.

The combination of green technology and aesthetic value create an opportunity to create multi-use architecture through the additional programming of recreation, tourism, and environmental stewardship. As multi-use infrastructure, potential revenue could be gained from tourists and residents using the space, helping to offset the capital and operational costs of the facility. Due to the WWTP's location, it has a social impact on residents and tourists, reaching beyond the odor and noise issues. Visually, the WWTP is in site lines from key recreational facilities, like the golf course and beach, and is within the center of the community. A prime location, such as this one, should carefully consider its appearance and implementation of green technology as it sets a precedent for the municipality and their goals of environmental responsibility.

Conclusion

Incorporating ecological solutions in design is now necessary to curb effects of population increase and climate change, it is not enough to simply follow codes. Integrated ecological design is the new design standard. In addition to the objectives outlined in the RFP, SAR, and Pre-Design Study, the following must be considered to sincerely work towards environmental responsibility and climate change mitigation:

— Optimize minimizing environmental impact with cost
— Offset and minimize capital and operational costs through green technology
— Decrease reliance on mechanical and chemical treatment using ecological treatment solutions
— Consider infrastructure aesthetics to improve connection between infrastructure and community
— Optimize land and generate revenue through multi-use civic infrastructure

These ecologically integrated design principles for infrastructure and technology provide opportunities to minimize impacts due to climate change on wastewater infrastructure, improving treatment efficiency and resiliency, while also providing unique space for publicly engaging multi-use civic infrastructure.

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