



Good Practice Report:

Supporting Sustainable and Regenerative Tourism Through Improved Wastewater Management: The Barösund Marina Case

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1. Sustainable and Regenerative Tourism Framework

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1.1. Introduction

The Ingå archipelago region, with its rich biodiversity and cultural heritage, presents both opportunities and challenges for sustainable tourism. The Scola restaurant and Bårosund guest harbor have actively integrating Visit Finland's Sustainable Travel Finland (STF) principles into their operations. These principles emphasize environmental stewardship, community engagement, and economic sustainability. Sustainable tourism is built upon three interconnected pillars: ecological, socio-cultural, and economic responsibility. Ecological criteria emphasize minimizing the environmental footprint of tourism by promoting renewable energy, reducing waste and emissions, conserving natural habitats, and encouraging sustainable transportation. Socio-cultural criteria focus on preserving local heritage and enhancing community well-being by supporting traditions, ensuring fair participation of residents in tourism development, and fostering mutual respect between visitors and hosts. Economic criteria highlight the importance of generating tangible benefits for local communities through job creation, support for local businesses, fair working conditions, and equitable distribution of tourism revenue. Together, these criteria form a comprehensive framework for tourism that respects nature, empowers people, and strengthens local economies.

1.2. Implementing Sustainable Tourism Principles in Barösund

Adoption of Sustainable Tourism Principles

Scola and Bårosund have embraced Visit Finland's sustainability criteria by implementing eco-friendly practices, fostering local collaboration, and contributing to regional economic resilience. Their efforts reflect a holistic approach to sustainability, where tourism supports—not strains—the local environment and community.

Participation in the ROOPE Marina Program

The Bårosund guest harbor is a certified member of the ROOPE Marina Program, coordinated by the Keep the Archipelago Tidy Association. This program promotes high environmental and safety standards for Finnish marinas. Through training, certification, and increased visibility, the harbor demonstrates its commitment to responsible tourism and aligns closely with the STF framework.

Water Conservation and Wastewater Management

As part of the NURSECOAST-II project, in collaboration with the municipality of Ingå and local water cooperative, the entrepreneur has improved water-saving infrastructure and introduced a new wastewater treatment system at both the restaurant and harbor. These

upgrades were designed with sensitivity to local ecosystems, including spawning areas for pikeperch and nesting zones for archipelago birds. This initiative not only reduces pollution but also enhances ecological resilience and supports long-term tourism viability.

1.3. Local Food, Culture and Community Benefits

A standout feature of Scola is its restaurant model, which prioritizes seasonal, locally sourced ingredients such as fish, grains, berries, and vegetables. This approach minimizes environmental impact, supports biodiversity, and strengthens the region's culinary identity. Adjacent to the restaurant, a retail space showcases products from local artisans, farmers, and producers. This integration of food and culture fosters ethical consumption, community empowerment, and storytelling rooted in place.

2. From Sustainability Ambitions to Practical Implementation

2.1. Translating Sustainability Goals into Infrastructure Development

Enhanced wastewater treatment is a cornerstone of environmental responsibility under Visit Finland's Sustainable Travel Finland (STF) program. By reducing pollutant loads and safeguarding aquatic ecosystems, the new system directly supports one of the core pillars of the STF framework. Protecting water quality preserves natural beauty and maintains the ecological carrying capacity of tourism destinations, ensuring visitor numbers do not compromise ecosystem health. It also enables operators to meet certification standards, boosting credibility among environmentally conscious travelers.

The upgraded treatment plant is engineered for seasonal fluctuations, accommodating peak loads of approximately 200 population equivalents (PE) during high season and lower volumes off-season. This design minimizes ecological impact and ensures compliance with water quality objectives. To protect biodiversity, the discharge point is in a designated pikeperch spawning zone, and construction activities such as dredging were scheduled outside the spawning season (May–June). Prior to implementation, site-specific assessments e.g. verification of pressurized groundwater, were conducted to prevent unintended environmental risks.

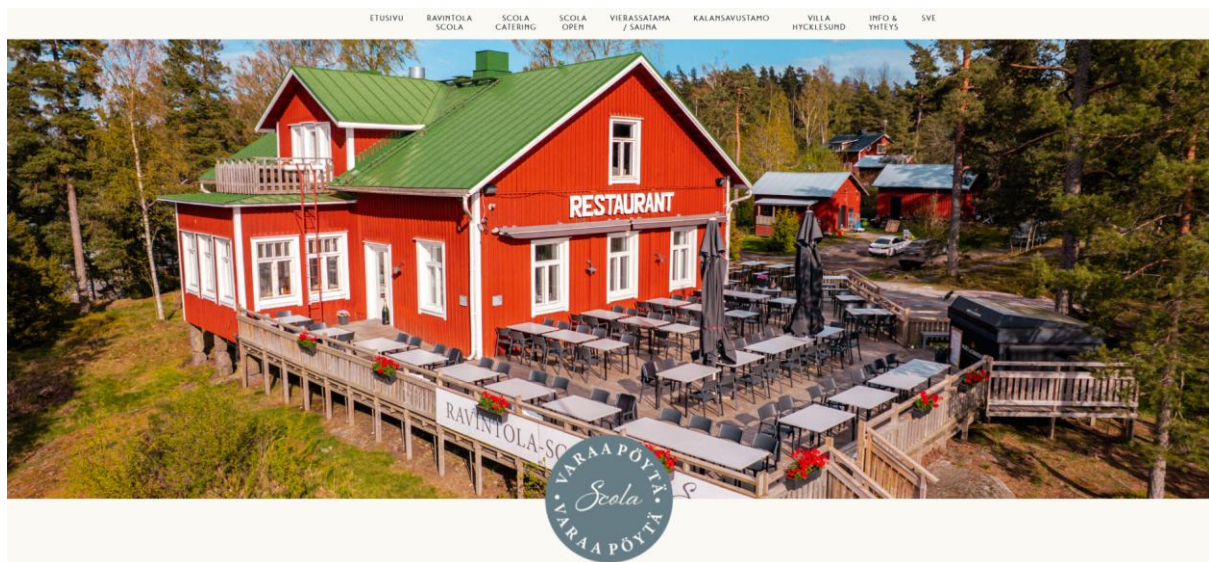
The system required an environmental permit, which involved strong community engagement. In line with Finnish environmental legislation, landowners within a 500-meter radius, local commercial fishermen, and joint property holders were informed, particularly regarding the outfall pipe crossing shared water areas. Public consultations addressed concerns related to water quality, fishing impacts, boating safety, and visual landscape, reinforcing transparency and stakeholder trust.

Health and safety measures include documented emergency procedures for operational disturbances (e.g., power outages, system failures) and strict protocols for chemical use and

storage to minimize environmental and health risks. The investment is justified by the current lack of treatment capacity, which necessitates costly daily wastewater transport during summer. Alternative solutions, such as constructing a transfer sewer to the BB facility, were deemed economically unfeasible due to distance and low volumes.

Cost-efficiency and technical robustness were prioritized using prefabricated modular units, tailored to seasonal loads and requiring minimal maintenance. As a municipally led initiative, the project had financial security.

Reducing pollution, protecting unique aquatic ecosystems, and ensuring adherence to regional sustainability standards reinforce the area's reputation as a responsible tourism destination. It empowers local operators to achieve STF certification, builds trust among environmentally conscious travelers, and safeguards the natural assets that define the region's appeal and long-term tourism viability.



Picture 1. Scola, the former village school of Källnäsudd, has been lovingly restored into a year-round archipelago restaurant. The historic building welcomes boaters, summer residents, and visitors attending celebrations and meetings, while serving high-quality food made from locally sourced and responsibly produced ingredients.



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3. Technical Implementation of the Barösund Wastewater Treatment Plant Renewal

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3.1. 3.1 Background and Identification of the Need for Renewal

The Barösund Marina wastewater treatment plant serves a unique coastal tourism and service area in Inkoo, Southern Finland. The catchment includes public sanitary facilities, a marina hotel, rental sauna facilities, showers, restaurants, cafés, a fish-smoking facility, and two residential properties. Wastewater generation is highly seasonal, with the majority of the annual load occurring during the summer tourism season between June and August. During this period, the marina may receive up to 200 visitors per day, resulting in substantial hydraulic and pollutant loads. Outside the summer season, wastewater flows are significantly lower and more variable, creating challenging operational conditions for wastewater treatment. The combination of high seasonal peaks and very low winter flows required a treatment solution capable of maintaining stable performance throughout the year.

Barösund Water Cooperative's wastewater is treated in a small-scale wastewater treatment plant commissioned in 2005. The facility consists of a WehoPuts 30 biological-chemical batch treatment plant equipped with a 30 m³ equalization tank. The system includes an underground collection and process tank together with the associated treatment equipment, while phosphorus removal is achieved through chemical precipitation. Eleven

properties are connected to the cooperative's water supply network, four of which are permanently occupied, serving approximately 20 year-round residents.

Although the treatment plant had been designed for a capacity of approximately 30 population equivalents (PE), wastewater monitoring carried out during the summer season of 2023 showed that the actual load reached approximately 127 PE during peak operation. The study also revealed substantial seasonal variation in wastewater generation, with relatively low loads during winter and significantly higher loads during the summer tourism season. Such fluctuations create operational challenges for biological treatment processes, which must perform effectively under both low-flow and high-load conditions. The results demonstrated that the existing facility was no longer adequately sized for current wastewater loads and that replacement with a larger treatment system designed for the actual operating conditions was necessary.

The renewal of the wastewater treatment system at Barösund Marina followed a structured process that combined regulatory requirements, technical planning, environmental considerations, and procurement procedures. According to Finnish best practice guidelines for on-site wastewater system projects, the first step is to determine the existing situation, assess legal requirements, and identify available wastewater management alternatives. This includes reviewing whether connection to a municipal sewer network is possible and consulting the local environmental and building authorities regarding permit requirements and future infrastructure plans. When no suitable sewer connection is available, the property owner must proceed with the planning of an independent wastewater treatment solution.



Picture 2. The Barösund ferry crosses the 285-meter-wide strait in just a few minutes. The ferry connects the mainland to the island of Orslandet, providing access to Elisaari and the rest of Inkoo's beautiful archipelago.

3.2. Baseline Studies

The need to renew the wastewater treatment system emerged as operational problems increased at the existing treatment plant. During the summer season, the treatment plant regularly operated beyond its design capacity, resulting in the need to transport excess wastewater and sludge to the municipal wastewater treatment plant in Ingå/Inkoo on a weekly basis. Occasional overflows, odour nuisances, and concerns regarding environmental impacts and the protection of nearby groundwater resources were also reported. As visitor numbers and service activities at the marina continued to increase, the municipality initiated several studies to identify sustainable long-term solutions for wastewater management.

The first major study was the report “Municipality of Inkoo, Barösund Marina Water Services Study” (Inkoon kunta, Bärösundin venesataman vesihuoltoselvitys), prepared by Ramboll Finland Oy in 2020. The study reviewed the existing water supply and wastewater management system, analysed water consumption patterns and seasonal load variations, and evaluated several alternative solutions for improving wastewater treatment capacity. The alternatives included continuation of the existing arrangement, separation and separate treatment of greywater, construction of soil filtration or biofiltration systems, water-saving measures, and expansion of treatment capacity through a larger wastewater treatment plant. The study concluded that the highly seasonal nature of wastewater generation posed a significant challenge and that additional treatment capacity would ultimately be required to support future development of the marina area.

The second key background document was the “Municipality of Inkoo, Water Services Development Plan” (Inkoon kunta, Vesihuollon kehittämissuunnitelma), 18.12.2020, updated in 23.2.2023 by the Municipality of Inkoo. The development plan reviewed long-term water supply and wastewater management needs throughout the municipality and included a specific assessment of the Barösund Water Cooperative. The plan recognised that wastewater loads in the marina area exceeded the capacity of the existing treatment plant during peak season and referred to the 2020 water services study as the basis for future improvements. The development plan identified construction of a new wastewater treatment plant through external funding as the preferred long-term solution and highlighted the challenges caused by highly uneven seasonal loading.

These background studies demonstrated that the existing treatment system had become undersized for actual operating conditions and that continued operation through temporary measures alone would not provide a sustainable solution. They therefore formed the basis for subsequent technical investigations, environmental permitting, wastewater monitoring, and the eventual planning of a new treatment plant.

3.3. Preliminary Market Consultation

Prior to formal procurement, a preliminary market consultation was conducted to identify available treatment technologies and assess supplier capabilities. This phase helped ensure

that realistic performance requirements could be specified in the procurement documents and that the market was capable of delivering a treatment plant suitable for highly variable seasonal operating conditions.

The consultation aimed to identify the wastewater treatment solutions best suited to the project requirements and to compare the characteristics and performance of alternative small-scale treatment systems available on the market. Particular attention was given to the challenges of the Barösund area, including significant seasonal fluctuations in wastewater volumes, very low loads outside the boating season, and site-specific constraints such as rocky terrain.

The market dialogue was held at the Inkoo Municipal Hall (Rantatie 2, Inkoo) between 14 and 16 March 2023. Three technology suppliers participated in the discussions and presented treatment solutions suitable for the site: the WEHOPUTS biochemical treatment system, the Vestelli Bikube continuously operating bioreactor, and the Busse GmbH small-scale sewage treatment system based on membrane bioreactor (MBR) technology. Following the assessment, the Busse GmbH MBR solution was excluded from further consideration due to its significantly higher investment cost compared with the other alternatives.

The market dialogue allowed the project team to gain a better understanding of lifecycle costs, maintenance requirements, remote monitoring solutions, biological treatment performance during low winter loads, and available support services. In addition, suppliers were invited to present their technical solutions and discuss their suitability for the planned implementation schedule. The information gathered was incorporated into the final procurement strategy, evaluation criteria, and technical specifications.

3.4. Baseline Water Quality Monitoring and Environmental Permit Assessment

Before deciding on the scope of the investment, wastewater sampling and loading studies were carried out during the summer season of 2023. The purpose of the monitoring programme was to understand the actual hydraulic and pollution loads entering the treatment plant and to determine whether the facility remained within the regulatory threshold that allows operation without an environmental permit.

Table 1. Design Loading Criteria for the New Barösund Marina Wastewater Treatment Plant.

Parameter	Unit	Off-season	Peak season
Flows			
Qaverage	m ³ /d	2.0	12
Qmax	m ³ /d	–	15
qmax	m ³ /h	–	2.5
BOD₇-ATU			
Average load	kg/d	0.74	8.9
Maximum load	kg/d	1.5	11

Average concentration	mg/L	370	740
Total Phosphorus			
Average load	kg/d	0.018	0.24
Maximum load	kg/d	0.040	0.27
Average concentration	mg/L	9.0	18
Total Nitrogen			
Average load	kg/d	0.14	1.7
Maximum load	kg/d	0.28	2.1
Average concentration	mg/L	70	140
Suspended Solids (TSS)			
Average load	kg/d	0.20	2.3
Maximum load	kg/d	0.38	3.0
Average concentration	mg/L	100	200
Population Equivalent (PE)	average	11	127

The monitoring results demonstrated (Table 1) that the calculated loading during peak season reached approximately 127 population equivalents, exceeding the 100 population equivalent threshold generally associated with simplified permitting requirements. The analyses also showed (Table 2.) that the wastewater was relatively strong, particularly because of the contribution from restaurant and café kitchens. These findings provided the technical basis for initiating an environmental permitting process and demonstrated the necessity of upgrading the treatment system.

Table 2. Quality characteristics of influent wastewater entering the Barösund Marina wastewater treatment plant during the summer season of 2023.

Date	Suspended Solids (mg/L)	BOD ₇ -ATU (mg/L)	CODCr (mg/L)	Total Nitrogen (mg/L)	Ammonium Nitrogen (mg/L)	Fats and Oils (mg/L)
10 Jul 2023	170	760	1300	130	110	23
11 Jul 2023	210	770	1300	140	120	16
19 Jul 2023	190	690	1200	140	110	13
Average	190	740	1267	137	113	17.3

Date	Total Phosphorus (mg/L)	Soluble Phosphorus (mg/L)	pH	Alkalinity (mmol/L)	Conductivity (mS/m)
10 Jul 2023	17	16	7.0	14	220
11 Jul 2023	19	16	7.0	14	230
19 Jul 2023	19	14	7.1	13	220

Average	18.3	15.3	7.0	13.7	223
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3.5. Procurement Planning and Technical Specification Development

Once the need for renewal had been established, qualified wastewater specialists were engaged to evaluate treatment alternatives and prepare the necessary technical studies. Finnish best practice guidance emphasises that wastewater treatment projects should be designed by competent professionals capable of assessing site-specific conditions, treatment requirements, and regulatory obligations.

To support the procurement and implementation of the project, the Municipality of Inkoo commissioned Ramboll Finland Oy to prepare a procurement programme entitled “Inkoon kunta. Barösundin venesataman uusi jätevedenpuhdistamo”, dated 25 June 2025. The procurement covered the design and delivery of the new wastewater treatment plant to the site, as well as supervision of the treatment plant installation works. A key requirement was that the selected treatment process must comply with the treatment performance standards specified in the environmental permit.

The procurement programme defined the treatment objectives, design criteria, seasonal wastewater loads, discharge arrangements, sludge management requirements, and automation specifications for the new treatment plant. It also included technical drawings, process descriptions, procurement documentation, and detailed technical requirements for the treatment plant and its operation.

3.6. Environmental Permit Application and Regulatory Approvals

Based on the design studies, wastewater monitoring results, and environmental impact assessments, a comprehensive environmental permit application was prepared and submitted to the competent permitting authority. The application process required detailed technical, environmental, and operational information demonstrating that the proposed facility would comply with applicable legislation and environmental protection objectives. This included descriptions of the treatment process, design capacity, expected wastewater loads, pollutant removal efficiencies, discharge arrangements, and compliance with best available techniques (BAT).

The permit application also included assessments of the receiving water body, baseline environmental conditions, potential impacts on water quality, aquatic ecosystems, fisheries, recreational use, nearby residents, and protected environmental values. Applicants were required to evaluate both normal operating conditions and exceptional situations, such as equipment failures, bypass events, overflows, chemical spills, and power outages, together with proposed mitigation and contingency measures.

A key requirement of the permitting process was the demonstration that the treatment plant would be designed, operated, and maintained to achieve high treatment reliability

throughout varying hydraulic and pollutant loading conditions. The application therefore included treatment performance targets, process control principles, sludge management arrangements, chemical storage and handling procedures, monitoring programmes, and plans for operational supervision. Special attention was given to nutrient removal performance, minimization of environmental risks, and protection of surface waters.

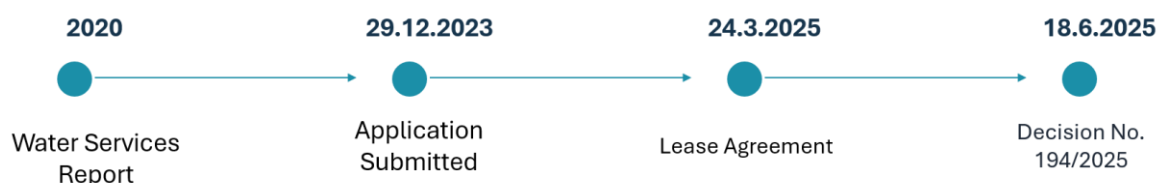


Figure 1. Permit Process Timeline

In addition, the applicant was required to prepare environmental monitoring and reporting programmes covering operational monitoring, effluent quality monitoring, receiving water monitoring, record keeping, and reporting to regulatory authorities. The permit process also involved consultation with environmental authorities, municipal authorities, fisheries authorities, landowners, and other stakeholders, ensuring that all relevant environmental and societal concerns were addressed before permit approval.

The environmental permit was granted in June 2025 and established the legally binding treatment performance requirements, monitoring obligations, reporting procedures, risk management measures, and environmental protection conditions that the future treatment plant must comply with throughout its operation. The permit also required regular environmental monitoring, maintenance of contingency plans, and continuous demonstration of compliance with permit limits.

Table 3. The environmental permit application proposed the following treatment performance requirements for the new wastewater treatment plant:

Parameter	Effluent Concentration	Removal Efficiency
Organic matter (BOD₇-ATU)	≤ 15 mg/L	≥ 95%
CODCr	≤ 125 mg/L	≥ 90%
Total phosphorus (P)	≤ 0.5 mg/L	≥ 95%
Suspended solids	≤ 15 mg/L	≥ 90%

- With regard to nitrogen, the objective is to achieve the highest practicable level of ammonium nitrogen removal.
- Emission limit values shall be assessed as annual average concentrations, taking into account any bypass discharges and exceptional operating situations.
- The treatment requirements must be achieved under both peak seasonal conditions with high influent flow rates and pollutant loads, and winter conditions characterized by low influent flows and reduced loading. The treatment plant shall therefore be designed and operated to maintain stable and reliable treatment performance across the full range of anticipated hydraulic and organic loading conditions.

In parallel with the environmental permitting process, the municipality secured all necessary construction-related approvals, land-use agreements, easements, and infrastructure permits. The project was closely coordinated with landowners, regulatory authorities, utility operators, and other stakeholders to ensure regulatory compliance, constructability, environmental protection, and long-term operational sustainability of the wastewater treatment system.

Best practice for environmental permit applicants is to initiate environmental baseline studies and stakeholder engagement at an early stage, maintain transparent communication with authorities, develop robust monitoring and risk management plans, demonstrate the application of best available techniques, and provide sufficient technical evidence to show that the project will not cause unacceptable environmental impacts or prevent the achievement of applicable water protection objectives.

3.7. Competitive Tendering Process

After obtaining the required permits, a competitive procurement process was initiated through an open tendering procedure. The tender documents defined the technical, environmental, operational, and maintenance requirements for the new wastewater treatment plant and associated infrastructure. The procurement covered the detailed design of the treatment facility, equipment supply, installation, commissioning, performance testing, and long-term operation and maintenance services.

Potential suppliers were required to demonstrate that their proposed technology could reliably achieve the permit conditions under both summer peak loads and winter low-load conditions. In addition, bidders were requested to provide references from at least one comparable wastewater treatment plant using the proposed treatment technology, including documented treatment performance results and client contact information.

The procurement package included requirements for preparation of complete design documentation, delivery and installation of all process equipment, start-up and commissioning of the plant, operator training, preparation of operating manuals, warranty testing, and provision of maintenance services. Particular emphasis was placed on demonstrating process performance through laboratory analyses and documented acceptance testing after biological treatment and chemical dosing had achieved normal operating conditions.

To ensure long-term operational reliability, bidders were also required to submit proposals for operation and maintenance services covering an initial two-year period, with an option for extension. Maintenance obligations included regular site visits, monitoring of process performance, response to alarms, and support for plant operators. Tenderers were furthermore required to provide technical descriptions, process schematics, warranty commitments, and detailed maintenance arrangements as part of their offer.

Separate procurement was carried out for the civil engineering works associated with the treatment plant and sewer pipelines. This contract included earthworks, rock excavation, pipeline installation, and underwater construction works required for connecting the new facility to the wastewater collection network.

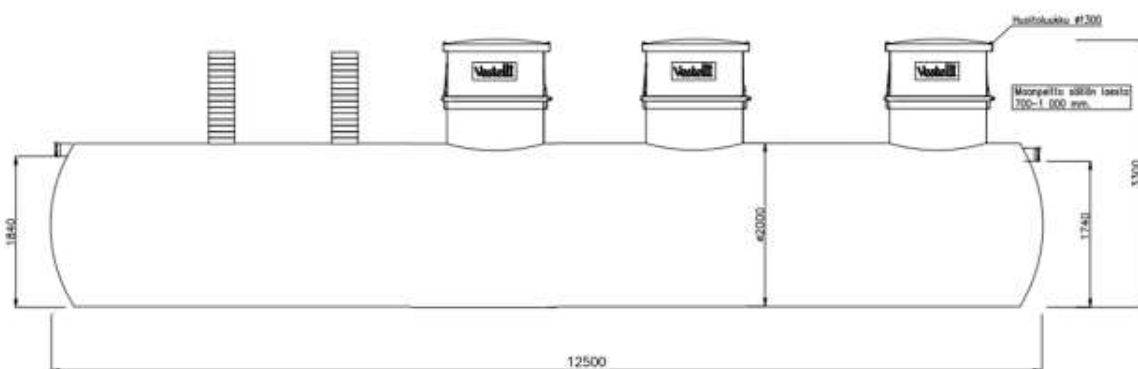
The contract award was based on the lowest compliant price among tenders meeting all technical, financial, and professional qualification requirements defined in the procurement documents.

3.8. Supplier Interviews and Technical Evaluation

Following the submission of tenders, supplier interviews and technical evaluations were carried out. This stage allowed the project team to verify technical assumptions, clarify maintenance responsibilities, examine reference projects, assess operational reliability, and evaluate supplier competence.

Particular attention was given to the ability of candidate technologies to cope with large seasonal fluctuations in wastewater flow, to provide stable phosphorus removal, and to enable remote supervision with minimal on-site staffing.

For the wastewater treatment technology, only one compliant tender was received from Vestelli Oy. Consequently, detailed technical discussions were held with the supplier to evaluate process design, operational performance, maintenance arrangements, remote monitoring capabilities, and lifecycle requirements. The evaluation confirmed that the proposed biological-chemical treatment process was specifically designed to handle highly variable seasonal wastewater flows (approximately 2-15 m³/day), while maintaining high phosphorus removal efficiency and allowing continuous remote supervision through an integrated monitoring system. The supplier also demonstrated a comprehensive maintenance concept, including routine service visits, alarm-based response procedures, operator training, and local spare-part availability.



Length: 12,500 mm, Diameter: 2,000 mm, Height: 3,300 mm, Weight: 3,600 kg

Note: The illustration does not include the ventilation pipes equipped with activated carbon filters, nor the electrical and chemical dosing connections.

Figure 2. Vestelli Wastewater Treatment Plant (Biokube Jupiter)

For the civil engineering and earthworks contract, three tenders were received. Both submissions were reviewed with respect to technical compliance, relevant experience, execution capability, quality assurance procedures, and overall value for money. Following the comparative assessment, Maanrakennus Marela Oy was selected as the preferred contractor. The company demonstrated the required competence to deliver the excavation, pipeline installation, blasting, marine works, demolition, and site restoration activities specified for the Barösund project, while providing the most advantageous overall solution in terms of technical capability and commercial evaluation.

The interview and evaluation process reduced technical and implementation risks prior to contract award and ensured that both the treatment technology supplier and the civil works contractor possessed the experience, resources, and operational approach necessary for the successful delivery of the project.

3.9. Contract Negotiation and Formal Agreements

After selecting the preferred supplier, formal agreements were established between the municipality, the treatment plant supplier, consultants, and contractors. The contractual framework defined project responsibilities, schedules, quality requirements, guarantee obligations, maintenance services, reporting requirements, testing programmes, and acceptance procedures.

The final agreement specified the design, delivery, installation, commissioning, testing, operational guidance and training services for the wastewater treatment plant. To ensure effective coordination during construction, the treatment plant supplier was appointed as a subordinate contractor under the main civil works contractor through a dedicated subcontracting agreement. Detailed contract documents established a clear hierarchy of contractual and technical requirements, including the procurement programme, environmental permit conditions, technical drawings, supplier guarantees, and negotiated clarifications.

Particular attention was given to operational performance and long-term reliability. The supplier committed to achieving the required treatment efficiencies for BOD, COD, phosphorus and suspended solids, supported by a two-year warranty period, structured testing procedures, and performance verification through accredited laboratory analyses. The contract also included detailed maintenance obligations, monitoring requirements, operator training, remote supervision, reporting procedures, and documented maintenance records to ensure compliance with environmental permit requirements throughout the warranty period and operational phase.

Clear contractual arrangements ensured that all parties understood their obligations and that regulatory compliance requirements would be fulfilled throughout the project lifecycle.

3.10. Construction Supervision and Project Management

Good practice requires active supervision throughout implementation. The project therefore included continuous construction supervision, site inspections, contractor coordination, quality assurance procedures, and systematic documentation. Key supervisory roles were carried out by Lasse Åkerlund and Matti Talja from Vestelli Oy, with oversight provided by site supervisor Jorma Skyttä. Regular monitoring visits, inspections, commissioning checks, process follow-up, and training events were conducted throughout the installation and start-up period.

The treatment plant supplier, Vestelli Oy, operated as a subcontractor under the main civil engineering contractor Maanrakennus Marela Oy, requiring close coordination between equipment delivery, excavation works, pipeline installation, electrical installations by Vaajakosken Sähkösepät Oy, automation integration, and commissioning activities. During construction, site conditions, including shallow bedrock encountered during excavation, required several layout and elevation adjustments. These modifications were reviewed jointly with the site supervisor and incorporated into updated plans and project documentation.

Construction records were maintained throughout the project in the form of a detailed installation diary covering the period from September to November 2025. The records documented excavation and tank installation works, anchoring and insulation measures, electrical and automation installations, process start-up activities, operational testing, water quality monitoring, training of operating personnel, and corrective actions identified during the trial operation period. Regular site meetings and inspections ensured that construction quality, operational performance, and environmental permit requirements were continuously verified and documented.

3.11. Earthworks, Installation and Site Infrastructure

Implementation of the project commenced in September 2025 with preparatory earthworks undertaken by Maanrakennus Marela Oy. Site inspections were initiated on 19 September 2025 to verify the locations of the treatment plant structures before excavation works commenced. Preparatory excavation and site clearance activities had already been started by the contractor prior to the first installation visit. During the initial excavation phase on 22 September, extensive bedrock was encountered close to the ground surface, requiring revision of the original elevation design and optimisation of the tank layout. To minimise construction risks, excavation was completed for both the settling tank and process tank areas before final installation levels were confirmed. Together with construction supervisor Jorma Skyttä, the project team also decided to install additional drainage between the tanks

to facilitate groundwater removal from the bedrock surface and improve long-term operational reliability.

Between 23 and 30 September 2025, the main underground structures were installed. The overflow tank and settling tank were placed, anchored with anchoring fabrics and partially backfilled, while additional insulation measures were incorporated through the installation of insulation mats above the standard insulation boards. Installation of the pumping station, flow measurement chamber and sampling well followed, including connection of pressure sewers and isolation valves according to the approved plans. During construction, local bedrock conditions required several minor adjustments to the positioning of chambers and tanks. All modifications were documented and incorporated into the final construction documentation. During this period, the overflow arrangement was reassessed, and the original design was updated to improve system functionality. The revised arrangements were incorporated into the final construction plans prepared by Matti Talja.



Picture 3. Preparatory earthworks undertaken by Maanrakennus Marela Oy

A significant milestone was reached on 26 September 2025 when the process tank was lifted into position, anchored and connected to the previously installed infrastructure. During the following days, the process tank was connected to the sampling chamber, remaining interconnections between process units were completed, and extensive backfilling and insulation works were finalised. By the end of September, the primary treatment structures, pipelines and hydraulic connections had been successfully installed and covered.



Picture 4. The process tank was lifted into position, anchored and connected to the previously installed infrastructure.

The installation phase continued at the beginning of October. On 1 October 2025, the service building and its foundation slab were delivered to the site. The planned elevation of the service building was subsequently raised to ensure appropriate drainage and gravity connections to the newly installed treatment infrastructure. Electrical installation works commenced on 2 October and were undertaken by Vaajakosken Sähkösepät Oy. These works included cable conduit installations, electrical connections, automation infrastructure, pump integration and commissioning of the control systems. Electrical power was connected to the service building on 3 October, enabling functional testing and the start of commissioning activities.

The treatment plant supplier, Vestelli Oy, subsequently completed the installation of the biological-chemical wastewater treatment system, including process equipment, instrumentation, automation systems, chemical dosing facilities and process control functions. The chemical storage tank was installed on 6 October 2025, and activated sludge was transferred from The Bärö Hotel wastewater treatment plant to accelerate development of the biological treatment process during start-up. During the commissioning phase, aeration systems, process controls, instrumentation and chemical dosing functions were progressively adjusted and optimised. Outstanding automation issues relating to energy metering, telemetry and flow measurement were resolved through cooperation between Vestelli Oy and the electrical contractor.



Picture 5. Installation of the service building.

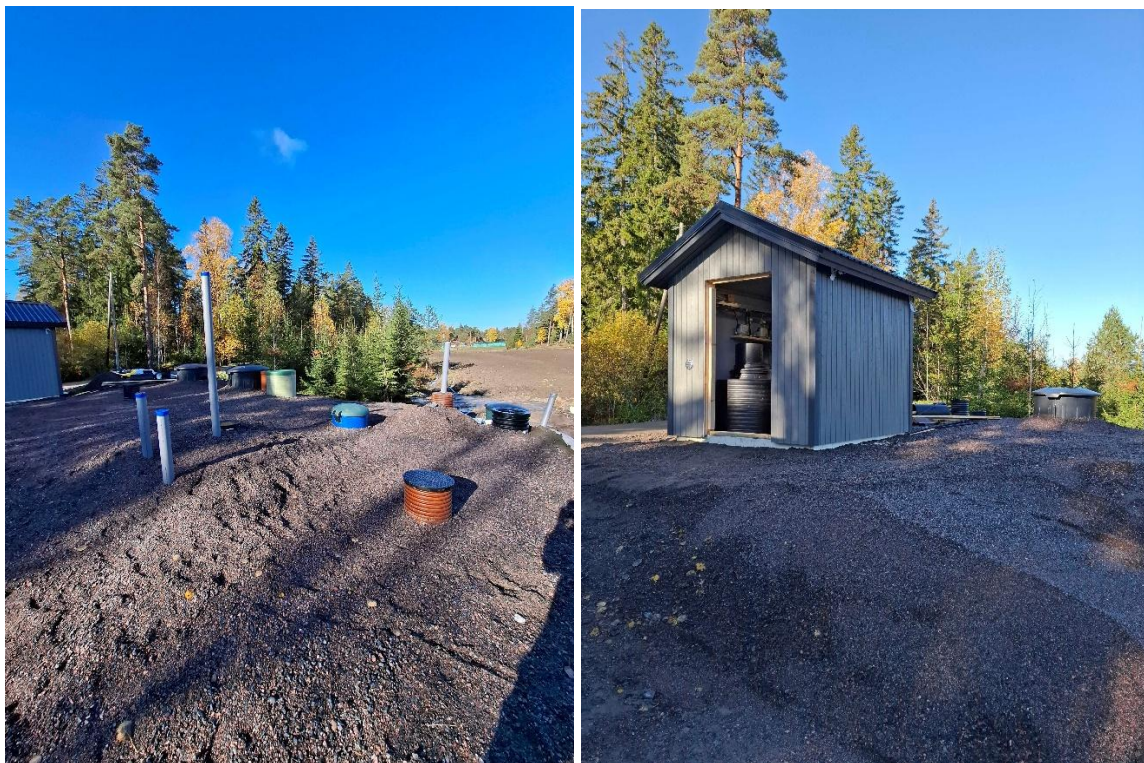
From early October through November 2025, the project entered an intensive commissioning and performance verification period. Biological process development, pH values, phosphorus removal efficiency and overall process functionality were closely monitored through inspections, operational checks and sampling activities. A project coordination meeting involving representatives of the contractor, supplier, supervisor and client was held at Inkoo Municipal Hall on 20 October 2025. The commissioning programme included process optimisation, implementation of automation updates, installation of the sludge recirculation pump, calibration of monitoring systems and continuous observation of overflow tank performance under varying hydraulic conditions.

Operator training formed an important part of the implementation process. The first user training session was organised on 28 October 2025 and a second, more comprehensive training session was conducted on 13 November 2025. Training covered routine operation, maintenance, process monitoring, alarm handling, measurements and adjustment of process parameters. During the latter training session, the treatment process, monitoring systems and operational settings were reviewed jointly with the client representative Johan Holmberg.

Performance verification continued throughout November. Sampling campaigns and operational monitoring demonstrated successful establishment of the treatment process. Results obtained during commissioning showed effluent quality levels of BOD 8.2 mg/l, total phosphorus 0.62 mg/l, CODCr 64 mg/l and suspended solids 27 mg/l, demonstrating effective treatment performance already during the start-up phase. Further optimisation continued during the trial operation period, including automation improvements, alarm system development, chemical dosing adjustments and verification of backup power arrangements. Final inspections, sampling activities and sludge removal operations were completed during November 2025.

The entire implementation process, from initial excavation works on 22 September 2025 to completion of commissioning and final verification activities in late November 2025, was carried out under continuous supervision by Lasse Åkerlund, Matti Talja, Antti Holopainen, Jorma Skyttä and project stakeholders. Detailed installation diaries, inspection records, commissioning reports, sampling results and training documentation were maintained throughout the approximately two-month construction and commissioning period, ensuring full traceability, quality assurance and compliance with project requirements.

A key element of good practice is the continuous documentation of construction progress, design adaptations, commissioning activities, and operational observations, providing full traceability and supporting the reliable long-term operation of the wastewater treatment system.



Picture 6. Installation work completed.

3.12. Automation, Remote Monitoring and Operational Support

A key component of reliable wastewater treatment plant operation is continuous monitoring and rapid response to operational disturbances. At the Barösund treatment plant, remote monitoring is provided through the LabkoNet service, which enables real-time access to process measurements, historical sensor data, and system alarms. The platform allows operators and maintenance personnel to follow plant performance remotely and identify potential operational issues at an early stage.

The treatment plant automation system is programmed using the Siemens TIA Portal environment. This platform has been used to configure the operational control logic, alarm management functions, and reporting tools required for daily operation and maintenance. Process alarms are automatically forwarded both to the maintenance personnel's mobile devices and to the remote monitoring platform, enabling rapid response to abnormal operating conditions.

The treatment plant is equipped with a local touchscreen user interface that allows operators to monitor process performance, adjust operational settings, acknowledge alarms, and control equipment functions on site. The system also generates operational and maintenance reports that can be downloaded on daily, monthly, and annual reporting intervals, supporting both routine plant management and environmental compliance reporting.

Data communication between the treatment plant and remote monitoring services is provided through a Labkom 800 communication unit. Together, the automation system, remote monitoring platform, alarm functions, and reporting tools provide a comprehensive framework for process supervision, troubleshooting, performance optimisation, and long-term operational reliability.

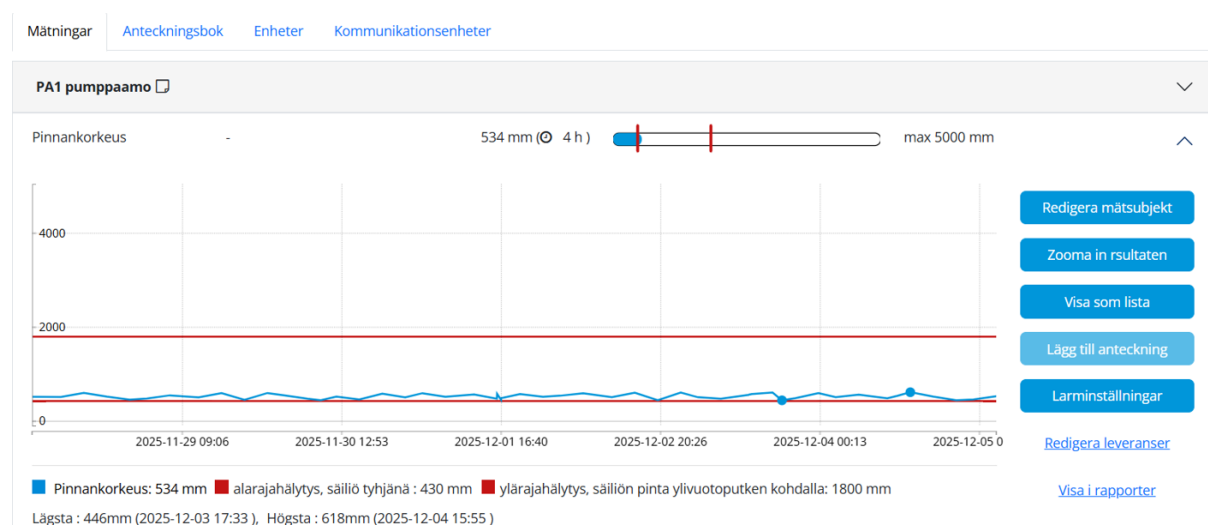


Figure 3. The Labkonet system displays the wastewater level as well as the low and high alarm limits.

The Barösund project demonstrated that robust automation, remote monitoring, and automated alarm management are particularly important in seasonal wastewater treatment systems, where operational problems may develop rapidly during changing loading conditions and where continuous on-site supervision is not always feasible.

3.13. Process Optimisation, Commissioning, and Performance Verification

Commissioning did not end with equipment installation. A critical success factor was the optimisation of biological and chemical treatment processes by the equipment supplier. During this phase, operating parameters were adjusted, instrumentation was calibrated, process stability was monitored, and treatment results were verified.

The supplier was responsible for confirming that the plant achieved the required treatment efficiencies and functioned effectively under actual operating conditions. Trial operation, testing, and performance verification formed an essential part of the acceptance process.

The environmental permit established stringent treatment requirements, including annual average effluent concentrations and minimum removal efficiencies for organic matter, phosphorus, suspended solids, and chemical oxygen demand. During commissioning in autumn 2025, treated wastewater was initially recirculated within the process while the biological treatment process was being established. Once monitoring results demonstrated compliance with the permit requirements, the discharge outlet to the marine recipient was opened and the plant entered normal operation.

However, the first full operating season in 2026 demonstrated that achieving permit compliance under highly seasonal conditions remains challenging. The treatment plant did not consistently achieve the treatment performance required by the environmental permit. According to the Municipality of Inkoo and the treatment plant monitoring group, the biological process remained unstable while both the quantity and quality of incoming wastewater varied considerably throughout the season.

Several operational challenges were identified during the monitoring period. A power interruption during spring 2026 affected internal process operation, and subsequent analysis indicated problems with the recirculation system. Low dissolved oxygen concentrations were observed for extended periods, suggesting insufficient oxygen transfer within the biological process. The monitoring group, comprising representatives of the Municipality of Inkoo, the Barösund Water Cooperative, LUVY, and Luke, identified excessive internal sludge accumulation and elevated oxygen demand as the most likely contributors to the reduced treatment performance.

The experience also highlighted the challenges associated with very low wastewater loading during off-season periods. Extended periods of low influent flow may weaken biological treatment performance, particularly in systems designed to handle much higher peak-season loads. In addition, lower-than-expected tourism activity during summer 2026 resulted in wastewater flows remaining substantially below the design flow for much of the season.

To support continued optimisation, the procurement contract places responsibility on the technology supplier to demonstrate compliance with environmental permit requirements during the two-year warranty period. Treatment performance must be verified through

accredited wastewater analyses conducted both during peak season and off-season conditions. Additional follow-up measures include optimisation of sludge management practices, improvements to process monitoring and alarm systems, and maintaining biological activity during low-load winter periods through controlled introduction of wastewater sludge from local holding tanks.

The Barösund pilot demonstrated that successful renewal of an undersized wastewater treatment plant requires considerably more than replacing equipment. Long-term success depends on process optimisation, continuous monitoring, reliable automation and alarm systems, effective sludge management, and maintaining biological activity under highly variable seasonal loading conditions. Furthermore, the case showed that while replacing an undersized treatment plant may be necessary, achieving stable operation and permit compliance in strongly seasonal environments can require an extended period of optimisation and operational learning.



Picture 7. Johan Holmberg, Managing Director of the Barösund Water Cooperative, is responsible for managing the wastewater treatment plant. During the summer, he gained practical experience in operating the Labcom 800 system and monitoring its performance.

3.14. Environmental Permit Monitoring and Compliance Reporting

Following commissioning, operation of the facility entered the environmental compliance phase. Monitoring requirements established in the environmental permit include regular wastewater sampling, receiving-water monitoring, laboratory analyses, and annual reporting.

To ensure independence and quality assurance, a separate procurement process was organized for monitoring and reporting services. The monitoring programme includes influent and effluent wastewater sampling, process monitoring, hygienic quality assessment, harmful substance monitoring, and marine recipient monitoring. Results are reported to both the municipality and supervising environmental authorities and transferred to national environmental databases when required. The procurement specification required quarterly wastewater monitoring through 24-hour composite samples, seasonal receiving-water monitoring at three marine sampling stations, hygienic quality assessments during the first operational years, and a one-time survey of hazardous and harmful substances. The service provider is also responsible for interpretation of results, preparation of sampling reports and annual summaries, and submission of monitoring data to national environmental information systems.

Following a competitive tendering process, monitoring and reporting services were awarded to Länsi-Uudenmaan vesi ja ympäristö ry (LUVY), a regional water protection association with extensive experience in municipal wastewater and marine monitoring programmes. Sampling is conducted by certified water and wastewater samplers, and laboratory analyses are performed by the FINAS-accredited LUVYLab Oy Ab laboratory in accordance with ISO/IEC 17025 requirements. The contract covers wastewater load monitoring, recipient monitoring, hazardous substance investigations, interpretation of monitoring results, compliance assessments against permit requirements, and annual reporting to environmental authorities.

This arrangement ensures independent verification of treatment performance and environmental impacts, supports regulatory compliance, and provides a reliable basis for operational optimisation and long-term assessment of the receiving marine environment.

Unfortunately, the official environmental permit monitoring results from 2026 indicated that the treatment plant did not achieve the required treatment performance. The March 2026 monitoring sample was taken after a power interruption and during a period when dissolved oxygen concentrations in the biological process had decreased. The July 2026 sample was collected when the biological treatment process was experiencing major operational challenges. The results demonstrated that maintaining stable biological treatment performance under highly variable seasonal loading conditions remained challenging despite the successful commissioning phase. Consequently, process optimisation and performance verification activities will continue during the warranty period.

3.15. Long-Term Operation and Continuous Improvement

The final stage of the project is the long-term operation, maintenance, and optimisation of the treatment plant. Operator training, maintenance inspections, remote monitoring, alarm management, routine maintenance, and compliance reporting are essential to support reliable operation and continuous improvement under highly variable seasonal loading conditions.

The first full operating season demonstrated that commissioning alone does not guarantee stable treatment performance. Although the plant achieved the required treatment levels during the commissioning phase in late 2025, the official environmental permit monitoring results obtained in 2026 did not meet the permit requirements. The biological treatment process remained unstable, while both the quantity and quality of incoming wastewater varied considerably throughout the season. Operational experience further highlighted the need for continuous monitoring, adaptive process optimisation, effective sludge management, and reliable alarm and monitoring systems throughout the lifetime of the facility.

Several corrective and development measures have been agreed upon to support long-term process stability and environmental compliance:

- Performance verification during the warranty period. According to the procurement agreement, the technology supplier remains responsible for demonstrating that the treatment plant complies with environmental permit requirements. Performance will be verified through accredited wastewater monitoring, including three sampling campaigns during the off-season and three during the peak season. The plant is covered by a two-year warranty period.
- Maintaining biological activity during low-load periods. To support the microbial community during the off-season, wastewater sludge from local holiday cottage holding tanks will be periodically introduced into the treatment plant. The objective is to maintain sufficient biological activity during winter periods when wastewater volumes are exceptionally low.
- Improved resilience to power interruptions and equipment failures. Additional safeguards have been introduced to minimise the risk of process disturbances caused by future power outages. Portable field instruments have also been acquired to provide independent verification of key process parameters and to support operations if online monitoring systems become unavailable.
- Optimisation of sludge management. Sludge removal frequency and operating procedures will be further optimised to prevent excessive sludge accumulation and ageing of sludge within the process. The aim is to reduce internal sludge loading, improve oxygen transfer, and support more stable biological treatment performance.
- Continuous process monitoring and adaptive optimisation. Treatment performance, oxygen levels, sludge characteristics, and operational parameters will continue to be

closely monitored. Regular follow-up meetings between the municipality, the water cooperative, the technology supplier, and environmental experts will support ongoing optimisation and troubleshooting.

Through careful planning, professional design, transparent procurement, effective supervision, rigorous commissioning, systematic environmental monitoring, and continued process optimisation, the Barösund Marina wastewater treatment plant renewal project provides a valuable practical example for small-scale coastal wastewater infrastructure projects. The project demonstrated that replacing an undersized treatment plant may be necessary when seasonal fluctuations exceed the capacity of existing infrastructure, but also highlighted that achieving stable biological treatment performance under highly seasonal conditions requires long-term commitment, monitoring, and operational learning.

3.16. Investment Costs and Financial Considerations

The Barösund Marina renewal project also highlighted the financial implications of replacing an undersized wastewater treatment plant. The selected solution required both investment in new treatment technology and significant site construction works. The final procurement included approximately €98,000 (excluding VAT) for civil engineering works and €287,000 (excluding VAT) for the wastewater treatment plant supply, resulting in a total investment of approximately €385,000 (excluding VAT).

The NURSECOAST-II pilot budget allocated to the Barösund demonstration was €250,000, demonstrating that full-scale infrastructure renewal may require additional financial contributions from municipalities, water cooperatives, or other stakeholders beyond project funding. In addition to capital investment costs, successful implementation required resources for environmental permitting, engineering design, procurement, commissioning, process optimisation, monitoring, and long-term operational support.

The experience demonstrated that while replacing an undersized treatment plant may be necessary to address severe seasonal loading challenges, project planners should account for the full life-cycle costs associated with infrastructure renewal. These include not only construction and equipment costs, but also monitoring, compliance verification, operational optimisation, maintenance, and technical support during the first years of operation. A two-year service and warranty agreement between the technology supplier and the Barösund Water Cooperative was therefore included to support commissioning, process optimisation, and performance verification under real operating conditions.

4. Lessons Learned

The Barösund pilot provided several important lessons for the planning, renewal, and operation of small-scale wastewater treatment systems exposed to strong seasonal variation.

- Replacing an undersized treatment plant is often necessary when seasonal peak loads substantially exceed the original design capacity. Optimisation measures alone cannot compensate for insufficient treatment capacity. The 2023 monitoring demonstrated that peak wastewater loads had increased far beyond the original design assumptions.
- Reliable design requires actual wastewater monitoring data. Seasonal wastewater systems should be dimensioned based on measured peak flows and pollutant loads rather than theoretical population estimates.
- Environmental permitting and procurement benefit from a strong evidence base. Baseline monitoring, technical studies, and market consultation helped define realistic performance requirements and reduce implementation risks.
- Commissioning should be viewed as the beginning of the optimisation process rather than the end of the project. Achieving permit compliance in a biological treatment process requires sufficient time for biological stabilisation and process adjustments under real operating conditions.
- Seasonal wastewater treatment systems face unique operational challenges. Very low winter loads and highly variable summer loads can affect biological activity and process stability, even when the treatment plant has been correctly sized.
- Continuous monitoring is essential for identifying operational problems at an early stage. Monitoring data were critical in detecting issues related to oxygen transfer, sludge accumulation, recirculation, and process stability.
- Clear contractual responsibilities support successful implementation. Assigning performance verification responsibilities to the technology supplier during the warranty period created an important framework for continued optimisation and problem solving.
- Long-term cooperation between the municipality, water cooperative, technology supplier, monitoring experts, and environmental authorities is essential for achieving reliable treatment performance and regulatory compliance.

5. Good Practice Recommendations

Based on the experiences gained in the Barösund renewal project, the following good practices are recommended for similar small-scale wastewater treatment projects:

- Conduct comprehensive baseline flow and load monitoring before selecting a treatment solution. Design criteria should be based on actual operating conditions, including peak seasonal loads.
- Evaluate alternative wastewater management solutions early in the planning process, including opportunities for sewer connection, decentralised solutions, demand management measures, and treatment plant renewal.
- Engage environmental authorities and key stakeholders from the early planning stages to support smooth permitting processes and regulatory compliance.
- Organise preliminary market consultations before procurement to understand available technologies, maintenance requirements, life-cycle costs, and supplier capabilities.
- Define clear performance requirements in procurement documents based on environmental permit obligations, including concentration limits, removal efficiencies, monitoring requirements, and performance verification procedures.
- Include commissioning, optimisation, monitoring, operator training, and warranty-period support as integral parts of the procurement, not as optional services.
- Establish an independent monitoring programme to verify treatment performance and provide reliable information for operational optimisation.
- Ensure robust automation, alarm systems, remote monitoring, and backup procedures for critical equipment and power interruptions.
- Develop operational strategies for maintaining biological activity during extended low-load periods, which are common in seasonal tourism destinations.
- Recognise that achieving stable operation in seasonal wastewater treatment systems may require a multi-year optimisation period. Adequate resources should therefore be allocated for monitoring, technical support, troubleshooting, and continuous improvement after installation.

6. Contribution to Sustainable and Regenerative Tourism

While sustainable tourism focuses on minimizing harm, regenerative tourism aims to restore and revitalize ecosystems and communities. In ecologically sensitive archipelago regions, this shift is particularly important. Nature-based wastewater solutions—such as constructed wetlands and nutrient recovery systems—can actively regenerate water cycles and marine habitats.

However, regenerative tourism must overcome challenges such as vague definitions, risks of greenwashing, and implementation barriers for small operators. Success depends on transparent frameworks, long-term investment, and community-led leadership.

6.1. Transitioning Toward Regenerative Tourism Through Wastewater Innovation

While sustainable tourism traditionally focuses on minimizing harm, regenerative tourism seeks to actively restore and enhance ecosystems and community well-being. In ecologically sensitive areas such as Finland's archipelago, this paradigm shift is particularly relevant. Upgrading wastewater treatment systems is not merely a compliance measure—it can become a catalyst for regeneration.

The new treatment plant reduces pollutant loads and safeguards aquatic ecosystems, aligning with Visit Finland's Sustainable Travel Finland (STF) criteria. However, regenerative tourism goes further: nature-based wastewater solutions, such as constructed wetlands or nutrient recovery systems, could actively restore water cycles, improve biodiversity, and even create habitats for local species. By integrating these approaches, tourism infrastructure can contribute positively to ecosystem health rather than simply avoiding damage.

This transition also strengthens community resilience. The permitting process already involves local stakeholders—landowners, fishermen, and property holders—ensuring transparency and trust. Regenerative models would deepen this engagement by co-designing solutions that deliver shared benefits, such as improved water quality for fisheries or educational opportunities for visitors.

Challenges remain, including vague definitions of “regenerative tourism,” risks of greenwashing, and financial barriers for small operators. Overcoming these requires clear frameworks, long-term investment, and community-led leadership. Yet, by embedding regenerative principles into wastewater management, destinations can move beyond sustainability toward a tourism model that actively heals and enriches the environment and society.

6.2. Conclusion

The Ingå case demonstrates how sustainable tourism principles can be effectively translated into action. Through local food systems, marina standards, and wastewater infrastructure improvements, the region is paving the way for responsible tourism. By embracing regenerative practices and addressing remaining gaps, Ingå can promote tourism that not only sustains but actively heals and strengthens the places we visit.



Picture 8. Jari Heiskanen from the Finnish Environment Institute (SYKLI) and Niklas Niemi from Keep the Archipelago Tidy at the Barösund stakeholder event on September 23, 2026.



Picture 9. The Barösund stakeholder event drew an audience of over 20 people. Piia Nordström, minucipal engineer, Municipality of Inkoo, shared the municipality's experiences regarding the implementation of the project.



Picture 10. Vestell representative and service technician Lasse Åkerlund demonstrated the unit's functions and current settings.



Picture 11. During the NURSECOAST-II project, Johannes Hannuniemi (SYKE) served as an external expert. Researchers Virpi Vorne and Frans Silvenius (Luke) discussed opportunities to improve the treatment efficiency of small-scale wastewater treatment systems and identified future research needs together with Johannes.