

**Operations Management  
and Facilities Services**

2019 Annual Report

# **Northport Leelanau Township Authority Wastewater Treatment Plant**



**Jacobs**

**Challenging today.  
Reinventing tomorrow.**

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## Introduction

Jacobs is pleased to present the Northport Leelanau Township Utility Authority (NLTUA) with this annual report. It is an overview of activities and accomplishments related to operations and maintenance (O&M) of the Northport wastewater treatment facility and collection system during the 2019 contract year.



# Partnering with the Village of Northport for more than 12 years

As NLTUA's operations and maintenance provider since 2008, we are keenly aware that the health of the Great Lakes is paramount to the vitality of this coastal community. Jacobs is proud to provide services to the NLTUA that have a direct impact on the health and wellbeing of the local environment. During this time, we have worked closely with the NLTUA and Village staff to operate the wastewater system safely and efficiently every day, helping to address challenges as they present themselves.

Exhibit 1 highlights the major milestones and accomplishments we achieved together during our partnership.

## Exhibit 1

### Major Milestones and Accomplishments

2008	Plant startup - Jacobs was awarded a competitive three-year contract to operate and maintain the Village of Northport's newly commissioned and unique waste water treatment facility and collection system.
2011	Jacobs was awarded a contract to operate and maintain the treatment plant and collection system, extending our partnership for an additional three years.
2013	Created a Biosolids Residuals Management Plan that allows the NLTUA to land apply accumulated biosolids that meet or exceed state regulations.
2014	Jacobs was awarded a contract to operate and maintain the treatment plant and collection system, extending our partnership five years.
2014	Submitted the Ground Water discharge permit renewal application on behalf of the NLTUA. New ground water permit was issued in 2015.



Plant startup 2008.

**2014**

Successfully inspected and cleaned the entire low- pressure force main portion of the collection system.

**2015**

Completed the facilities first biosolids land application, successfully land applying 53 dry tons of biosolids.

**2017**

Completed the facilities second biosolids land application, successfully land applying 52 dry tons of biosolids.

**2018**

Jacobs was awarded a contract to operate and maintain the treatment plant and collection system, extending our partnership 10 years.

**2019**

Installed new pumps at the Northport Point Road lift station, as part of our 2018 contract renewal the pumps were purchased by Jacobs at no cost to the NLTUA, saving approximately \$8,500.00.

# Overview of services provided by Jacobs

An overview of our scope with the Village is detailed in Exhibit 2.

## Exhibit 2

### Services Jacobs Provides to the Village

Item	Description	Jacobs Performance
<b>Scope: Wastewater and Collection System Operations</b>		
Staffing and Oversight	Operate, maintain and monitor the treatment facility and collection system 24 hours per day, 7 days per week.	Jacobs team is onsite Monday, Tuesday and Thursday each week, remaining days of the week are utilized if needed. On call 24 hours per day, 7 days per week.
Reporting	Provide weekly process reports and monthly operation reports summarizing activities performed and monthly financial status; annual report summarizing operations, maintenance, compliance, financials and other pertinent information.	Weekly and monthly reports are submitted to the Director of Public Works and the Village Clerk.
Meetings	Attend monthly Utility Authority meetings and meet with the client at least quarterly.	Jacobs attends NLTUA meetings to provide updates on activities, summarize reports and answer any questions posed by the Authority. Meet with the Village Clerk and DPW Supervisor on a quarterly basis with Jacobs local management team and Regional Manager.
Financial management and planning	Coordinate the procurement of spare parts, repairs and specialized contractors and supplies; advise and consult with the NLTUA on operational issues, capital improvements, major repairs and submit monthly itemized invoices.	Jacobs meets with the Utility Authority as needed to communicate facility issues and needs, so a plan of action to address them can be devised. Financial updates are provided as part of the monthly operations report.
Develop and follow the facility's state regulator approved Residual Management Program (RMP). Program details procedures for proper land application of biosolids	Submit annual report to regulator. Facilitate the disposal of biosolids generated at the facility in accordance with approved plan.	Annual reports are submitted annually and biosolids generated at the facility are disposed of in accordance with the approved biosolids management plan.
<b>Scope: Maintenance</b>		
Routine preventive maintenance (PM) and repair	Provide routine PM and repair of the equipment and buildings, consistent with accepted maintenance practices, best management practices (BMP), and manufacturer specifications and PM recommendations.	Refer to Exhibit 5.
Capital improvements	Facilitate capital improvement projects as identified in the Asset Management Program.	In cooperation with the Utility Authority, Jacobs facilitates the capital improvement projects specified in the Utility Authorities asset management plan. Jacobs acquires proposals, plans project and provides labor and/or oversight of subcontractors as directed by the Utility Authority.

Item	Description	Jacobs Performance
<b>Scope: Compliance</b>		
Effluent and Groundwater Quality	Manage, operate and maintain the treatment plant that allows the facility to meet or exceed its discharge permit requirements	See Appendix.
Biosolids Quality	Manage the facilities generated biosolids according to the state approved residual management plan. Facilitate biosolids hauls, ensure biosolids meet all regulatory requirements before land application, conduct sampling and analysis, field inspections and annual state required biosolids reporting.	The facility typically requires a biosolids haul every three to four years, with the most recent haul occurring in 2017.
Reporting	Compile, review and submit all required reports to the regulatory authority. Interface with regulator as directed by Authority.	Jacobs submits the monthly Discharge Monitoring Report, Annual Biosolids Report and meets with Regulator as required or directed by the NLTUA.
Sample and Analysis	Perform or contract and administer, all laboratory testing and sampling required by the discharge permit. Maintain a laboratory analysis program with a proper data management and Quality Assurance/Quality Control plan (QA/QC).	Jacobs collects and administers or performs all sampling and analysis required by the discharge permit. Any additional testing and sampling required by law, court order, or the NLTUA would be performed utilizing the contractual rates. All QA/QC performed either by Jacobs or contract lab is regularly reviewed for accuracy.

# Key 2019 performance highlights

We are always looking for opportunities to improve our performance by reducing compliance vulnerabilities, operational costs and the facility's carbon footprint; all while achieving operational excellence, acquiring and maintaining a highly-qualified staff and demonstrating a high standard of safety. An overview of our performance highlights is provided in Exhibit 3.

## Exhibit 3

### Key 2019 Performance highlights

Enhancement	Value
Installed new pumps at the Northport Point lift station	Jacobs was awarded a 10-year contract renewal in 2018, included in the renewal and at Jacobs expense, was the purchase of two new pumps to replace the significantly worn pumps at the Northport Point Road lift station. We took advantage of this opportune time to also rebuild the check valves and pump rail guides for each pump, helping to ensure a reliable lift station for years to come.
Improving residential grinder alarm notifications	Residential grinder pumps currently have a red flashing alarm light on the grinder pump control panel as the only source of alarm notification. In most cases this is enough, but some control cabinets are located in areas that are not easily visible to the homeowner. As a solution to this issue Jacobs started installing an inexpensive audible alarm to the control cabinet to help alert the homeowner, in addition to the visual alarm. The alarms are installed with the approval of the NLTUA.
Improved efficiency and lower cost	In 2019, at no cost to the NLTUA Jacobs purchased a new 6" bypass pump, this pump is available to provide bypass capabilities at the Northport lift stations and for maintenance at the waste water treatment facility. The pump was utilized to perform the annual settling basin cleaning project and eliminated the potential cost of rental equipment and decreased the amount of time it took to complete this task, saving labor hours.
Rebuild of main lift station pump #2	Jacobs presented several options to either replace or rebuild pump #2 at the main lift station, through Jacobs vast reach of resources we were able to source a reputable contractor to perform the rebuild of pump #2 at a significantly less cost than either rebuild performed by another contractor or purchasing of a new pump. Jacobs provided, at no cost to the NLTUA, a 6" bypass pump during the time pump #2 was out of service. The bypass pump was stored at the Village garage, providing emergency pumping capabilities in the event of a pump #1 failure. This significantly reduced compliance and health risk due to a station failure.
Water resource recovery technician (WRRT) certification	Many of our team members are working to achieve certifications through the Michigan Water Environmental Association (MWEA). In 2018-2019, four of our team members achieved their WRRT certification, and several more are working towards this certification. This certification and the knowledge and skills that come with it, enables our team to increase the application of sustainable practices in our treatment of wastewater.
Reliability centered maintenance approach and certification	Use of PM and BMP approach to increase the probability that an asset or item will perform its intended function for a specific period accomplishes the following: <ul style="list-style-type: none"> <li>• reduces vulnerabilities -optimizes operations</li> <li>• increases asset availability</li> <li>• reduces occurrence of unforeseen failures</li> <li>• reduces cost related to addressing unforeseen failures</li> <li>• results in a safer work environment</li> </ul> The staff completed a course in maintenance and reliability best practices. Maintenance Supervisor Andrew Waldron became a Certified Maintenance Reliability Leader, along with several additional team members becoming Certified Maintenance Reliability Technicians.
Completed manhole and air relief valve (ARV) inspections	Jacobs provided the NLTUA detailed reports of the annual manhole and ARV inspections identifying and reducing vulnerabilities.

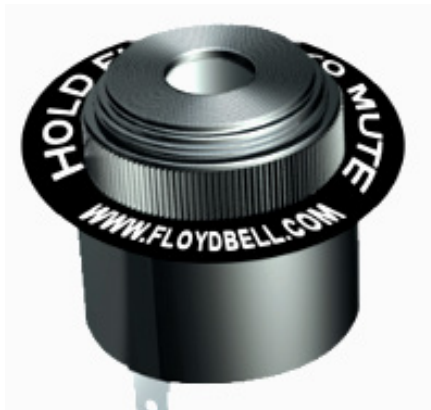




Old and new pump guide rails and bracket.



New lift station pumps.



Grinder pump audible alarm.

# Protecting Northport's citizens with superior permit management and regulatory compliance

In 2019, Jacobs provided flawless compliance performance saving the NLTUA from any costs or fines related to permit violations, while protecting the areas waterways.

A detailed summary of the NLTUA's performance, related to effluent quality in comparison with permit requirements, is provided in Appendix A.

In accordance with the Groundwater permit for the Northport wastewater treatment plant (WWTP), or as otherwise requested by the State, Jacobs completed and submitted the following reports to the Department of Energy, Great Lakes and Environment (EGLE):

- Monthly Discharge Monitoring Reports
- Annual Biosolids Report
- Annual Sara Title III Tier II Report

# Industry-leading safety program delivers no loss-time injuries for fourth consecutive year

Safety is a top priority for Jacobs and our partners. We bring proven processes and procedures to the O&M of the Northport WWTP including daily safety meetings, quarterly safety inspections and ongoing safety training for staff. As a result, the Jacobs Traverse City-based team has accumulated 1,326 days and counting (since September 2015) without a loss-time injury. This stellar safety record translates into peace of mind for the Village leadership and cost avoidance including but not limited to, risk-based insurance premiums and costs related to accidents or injuries. To recognize this accomplishment, we were awarded the 2019 Michigan Water Environment Associations (MWEA) Health and Safety Award for large treatment facilities.

In addition, we actively participate in the Jacobs' Culture of Caring. This philosophy includes the practice of *"if you see something, say something"*. We are also active participants in the Jacobs Positive Mental Health initiative. Our goal is to have at least one trained Positive Mental Health Champion (Mark Huggard) at each of our projects, and for everyone to be active observers looking out for one another's safety and wellbeing. In support of this culture, beginning in 2018, we partnered with the YMCA to offer team members easier access to tools that foster good physical and mental health at an affordable cost.



Jacobs Project Safety Team Leader Shane Wyatt (middle) accepting the MWEA Health and Safety award.

# Proactive asset management leads to a more cost-efficient and sustainable operation

Our sustainability philosophy extends to our approach of maintaining equipment. For decades, across the maintenance community the approach to managing assets (equipment) was to let them run to fail and then replace them, hopefully before they cause a catastrophic/unplanned failure. In more recent years, this approach has been replaced by using preventative maintenance (PM) to prolong the life of the assets. Today, we are focused on reliability-based maintenance, which involves the use of PM and best management practice (BMP) to increase the probability that an asset or item will perform its intended function up to, and in some cases exceeding the manufacturer's estimates for useful life (see Exhibit 4). Exhibit 5 shows the completed work orders (WO) for the last year. Improving the reliability of an asset through BMP reduces vulnerabilities, allows for the optimization of the operation of the facility, increases the asset's availability, reduces the occurrence of unforeseen failures, reduces expenses related to addressing unforeseen failures and results in a safer work environment all of which contribute to the facility's transformation to a water resource utility of the future.



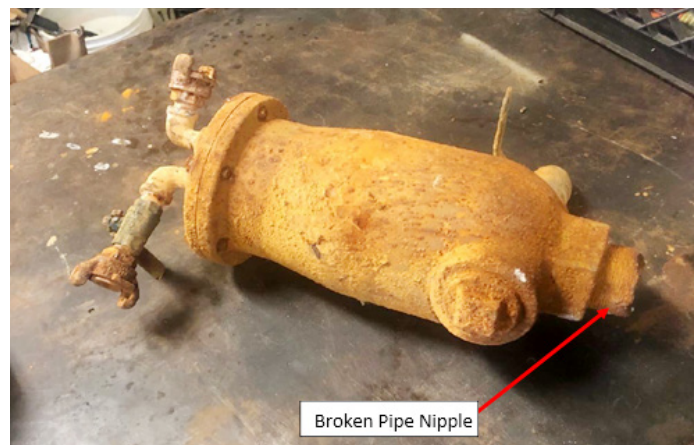
Fine screen auger brush replacement.



Annual basin cleaning.



Settling basin cleaning.



Failed air release valve identified during annual inspection.

# Proactive asset management leads to a more cost-efficient and sustainable operation

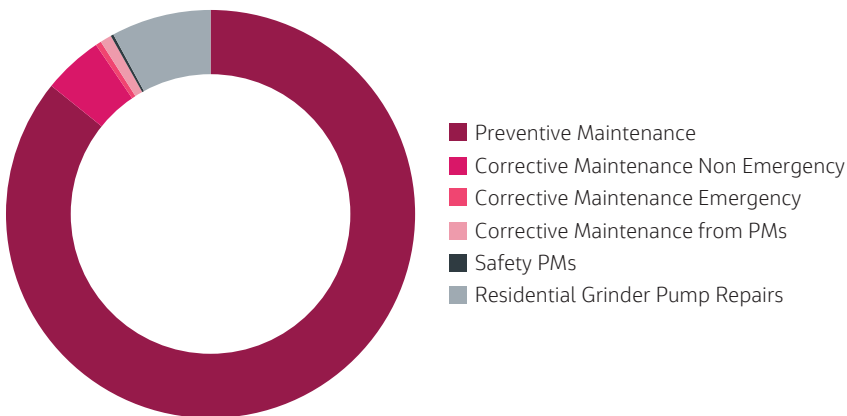
## Exhibit 4

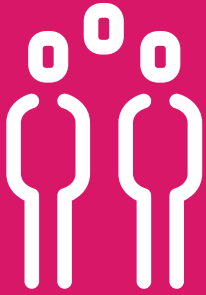
Examples of Reliability Based Maintenance Performed in 2019

Reliability Based Maintenance Focused Tasks	Purpose for Performing Task
Annual air relief valve inspections	Prevent air release valve failures that could create compliance or public health issues.
Annual manhole inspections	Enables us to identify potential structural and flow restrictions before a system surcharge or failure is encountered.
During each grinder pump response, we perform full system inspections	Identify and correct issues that may result in future failures.
Annual basin cleaning	Removes solids and debris that can contribute to system failures and/or compliance issues.
Fine screen brush replacement	Reduces the probability of mixed bed biofilm reactor tank screen plugs, which require significant manhours to clear.
Rebuild of main lift station pump 2 and replacement of Northport Point lift station pumps, check valves and guiderails	Ensures collection system continues to operate efficiently and dependably.

## Exhibit 5

Comparison of PMs and CMs





## Creating a lasting impact in our community

We care about the communities in which we work and live. As members and close neighbors of the NLTUA community, it is important that we give back and contribute to the community beyond simply meeting our contractual obligations. Throughout the year, we participated as shore ambassadors for Paddle Antrim, made donations to groups and organizations that share the Village's and our views to preserving our environment for future generations. We contributed to the following organizations in 2019:

- Served as shore ambassadors for Paddle Antrim 2019
- Sponsored, participated and donated to the Michigan Society of Professional Engineers (MiSPE) MATHCOUNTS competition
- Donated to the following organizations:
  - Grand Traverse Bay Water Shed Center
  - Paddle Antrim
  - Inland Seas Education Association



Shore Ambassadors Liz Hart and Mark Huggard at the 2019 Paddle Antrim.



Start of 2019 Paddle Antrim event.

# Fiscal summary



We understand that the NLTUA has many financial demands. As a result, we are focused on minimizing the financial impact of operating and maintaining the wastewater treatment plant and collection system has on the budget. As we care for your system, a core part of our mission is to help you avoid, manage and decrease costs. Results of our efforts are demonstrated in the following cost reconciliation.

## Base fee/direct cost overview

The NLTUA pays Jacobs a fraction of our base fee every month. Our base fee is the direct cost incurred in operating and maintaining the facility, plus our margin. Direct cost expenses include but are not limited to: consumable items used to maintain equipment (belts, oils, greases), expenses related to employee safety and training, laboratory expenses, office supplies and vehicle expenses. Exhibit 6 summarizes our 2019 reconciliation.

An overview of the reconciliation includes:

- Total direct costs were less than the annual limit and the NLTUA was refunded 50% of that cost for a total of \$4,369.06.
- Most of the reconciliation invoice was due to non-labor repairs, Exhibit 7 details repair expenses over \$500.
- The contractual repair labor hours limit of 300 hours was slightly exceeded by 21.25 hours. The NLTUA was billed at the contractual labor rate of \$50.00 per hour totaling \$1,077.50.

**Exhibit 6****Summary of 2019 Reconciliation**

	<b>Annual Limits</b>	<b>Total Expenses 2019</b>	<b>Reconciliation Expenses</b>
Repairs Non-Labor Invoice	\$8,000.00	\$40,857.61	\$32,857.61
Repairs Labor Invoice	300 hours	321.25 hours	\$1,077.50
Total Direct Cost (Less repairs and repair labor over 300. Costs under rebated 50%)	119,100.00	\$110,361.88	(\$4,369.06)
Less Overages Invoiced in 2019			(\$32,465.71)
Total Reconciliation Invoiced to Village			(\$2,899.66)
O&M Base Fee			\$158,115.00
<b>Total Fee Paid to Jacobs</b>			<b>\$184,781.39</b>

**Exhibit 7****Repair Costs Over \$500**

<b>Repairs</b>	<b>Cost</b>
Landia Mixer Repair SN#21959	\$8,641.40
Purchased 3 new residential grinder pumps	\$5,188.10
Northern A-1 – Cleared plug on low pressure force main	\$3,257.50
New pump guide rail parts for Northport Point lift station	\$2,304.44
Windemueller	\$1,785.00
• Ferric tank level transducer repair	
• Aeration blower control troubleshooting and alarm programming	
Purchased new reject pump, replace failed pump	\$1,751.63
Purchased spare reject pump for inventory	\$1,751.63
Topline Electric – PLC troubleshooting/repair	\$1,630.00
Landia mixer shipping costs – multiple mixers	\$1,444.52
2 - Residential grinder pump repairs	\$1,222.34
Purchased spare reject chamber check valves	\$825.78
Rebuild parts for Northport Point lift station check valve	\$898.34
Williams Pumping – Northport Point Rd. sewer repair	\$636.00
Treatment plant fine screen brush replacement parts	\$630.00
Purchased new float control switches for residential grinder pumps	\$613.19
Landia mixer repair parts	\$607.20

# Jacobs staff overview – bringing operational excellence to the NLTUA

Jacobs has 17 employees who are dedicated to the O&M of the Northport WWTP and Collection System 24 hours per day, seven days per week. Exhibit 8 details the Traverse City-based staff qualifications and our regional experts that provide some of the highest levels of performance in the industry. This resource-sharing delivery model provides NLTUA with world-class support for a very reasonable cost. The Traverse City-based team is supported by Manager of Projects Kevin Dahl; Sustainability Lead Duyen Tran; Business Manager Shelly Campbell; Administrative Specialist Maria Lenzi; Supervisory Control and Data Acquisition (SCADA) Systems Specialist Josue Escobar; Programmer Peter Niedzialek; Engineers Allen Gelderloos and Jim Fisher; Procurement Specialists Mariola Lizon and Kim Wilson; Health and Safety Manager J.D. Verbrugge and Compliance Specialists Jeff Heroux, Elizabeth Smith, Rebekka Maier and Ryan Vedrode. The expertise of our Jacobs family enriches our partnership with the NLTUA by allowing us to broaden our efforts beyond the scope of our contract, at no additional expense.

**Exhibit 8**  
Organizational Chart

Name	Position	Education/Certifications/Licenses
Kevin Dahl	Manager of Projects	<b>Degrees:</b> BS Civil Engineering and MS Environmental Engineering <b>Certifications:</b> New England Water Environment Association Class IV Wastewater Collection Systems Operator, Certified Maintenance Reliability Technician, Certified Reliability Leader, Connecticut Class IV Wastewater Treatment Operator and Rhode Island Class IV Wastewater Treatment Operator
Elizabeth Hart	Project Manager	<b>Degree:</b> BS Water Science <b>Certifications:</b> Wastewater A, L1, and L2, Water F4, Stormwater Certified and Certified Maintenance Reliability Technician
Mark Huggard	Assistant Project Manager	<b>Degree:</b> Associates Degree in Water Environmental Technologies <b>Certifications:</b> Wastewater A, L1, and L2, Water F4 and S4, Stormwater Certified, Certified Maintenance Reliability Technician and WRRT Certification
Andrew Waldron	Maintenance Supervisor	<b>Certifications:</b> Certified Maintenance Reliability Technician, Certified Reliability Leader and WRRT Certification
Justin Straub	Operations Supervisor	<b>Degree:</b> BS Biology/Conservation and Natural Resource Use
Joseph Brown	Lead Operator	<b>Degree:</b> Associates Degree in Water Treatment Technologies <b>Certifications:</b> Wastewater B and Certified Maintenance Reliability Technician
Andrew Peterson	Lead Operator	<b>Degree:</b> Associates Degree in Water Treatment Technologies <b>Certifications:</b> Wastewater B
Josh Lycka	Operator/ Industrial Pretreatment Program (IPP) Coordinator	<b>Degree:</b> BS Natural Resource Management <b>Certifications:</b> Wastewater D and Certified Maintenance Reliability Technician
James "Jeff" Kent	Operator-in-Training	None
Jacob Wanserski	Operator-in-Training	<b>Degree:</b> Associate's Environmental Engineering in Water and Wastewater Technology and BS in Water Resources <b>Certification:</b> Wisconsin Wastewater Certification - Subclass A1
Rick Shaw	Operator-in-Training	Certified Maintenance Reliability Technician
Zack Niec	Operator	<b>Degree:</b> BS Environmental Science
Alex Arnold	Laboratory Analyst	<b>Degree:</b> BS Physics/Mathematics/Computer Science
Shane Wyatt	Mechanic	<b>Certification:</b> Certified Maintenance Reliability Technician
Kerry Gensler	Mechanic	<b>Certification:</b> Certified Maintenance Reliability Technician
Raymond Kite	Mechanic	<b>Degree:</b> Associates Business Management and Automotive/Diesel Technology and Engineering
David Rybka	Mechanic-in-Training	None
Casey Park	Utility Worker	None



**Exhibit 8 (continued)**  
**Organizational Chart**

Name	Position	Education/Certifications/Licenses
<b>Support Staff</b>		
Maria Lenzi	Administrative Specialist	None
Shelly Campbell	Business Manager	<b>Degree:</b> Masters in Accounting
Duyen Tran	Sustainability and Operations-Envision Professional (ENV SP)	<b>Degree:</b> BS Chemistry <b>Certification:</b> Arizona Wastewater Class IV
Jim Fischer	Engineer	Professional Engineer
Allen Gelderloos	Engineer	Professional Engineer
Jeff Heroux	Compliance and Reporting Manager	<b>Certification:</b> Massachusetts Wastewater 7
Rebekka Maier	Compliance and IPP Coordinator	<b>Degree:</b> BS Environmental Engineering <b>Certification:</b> Idaho Wastewater Treatment Class 1
Ryan Vedrode	Compliance and Laboratory Coordinator	<b>Degree:</b> BS in Chemistry <b>Certification:</b> Michigan Wastewater A
Josue Escobar	SCADA-Systems Configuration Specialist	<b>Degree:</b> Engineering Technology, Navy Electrician "A" School
JD Verbrugge	Regional Safety Coordinator	<b>Degrees:</b> BA in Criminal Justice, BS in Zoology, MS in Environmental Studies

## The NLTUA's award winning operations

We are excited to report that Jacobs operator Lane Peterson was awarded the 2019 Michigan Water Environment Association (MWEA) Operations Professional of the Year Award. This award is given to an operator of a municipal wastewater treatment plant working on a daily basis in operations, displaying remarkable dedication to his/her employer and to the MWEA, excelling professionally, consistently generated good effluent, and publicly promoting the profession of the wastewater treatment operator. This award is a true testament to the level of service our team proudly provides to the NLTUA.



Lane Peterson receiving the MWEA Operator of the Year Award.

# Summary

As a result of Jacobs and the NLTUA's partnership we were able to accomplish the following and more to ensure the protection of our Great Lakes environment now and for years to come:

- Invested in the education of our staff in the areas of wastewater treatment, safety, compliance, maintenance and sustainability.
- Applied reliability centered maintenance practices to help reduce the financial burden of maintaining a WWTP.
- Delivered a flawless compliance record.
- Safely worked another year with zero recordable injuries.



## BeyondZero<sup>SM</sup>

**Five Years of Zero Recordable Injuries**

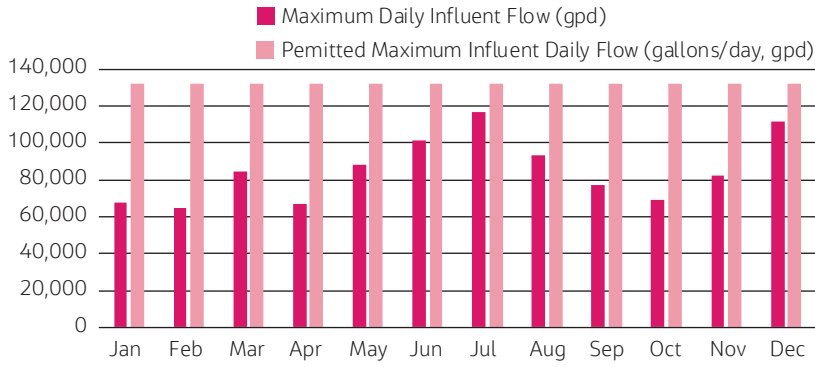
- Rebuilt main lift station pump #2 ensuring station reliability and reducing compliance risk.
- Installed two new pumps at the Northport Point Road lift station, pumps were purchased by Jacobs at no cost to the NLTUA, as part of our renewed partnership.
- Jacobs purchased a six-inch bypass pump that is available to the NLTUA for plant or collection system maintenance, eliminating the high cost of rental equipment.
- Improved our method of settling basin cleaning to reduce labor and contractor cost.
- Provided monetary and voluntary support to local organizations that share our passion in protecting the environment.

The accomplishments of the last year were made possible because Jacobs and the NLTUA share the same high expectations in delivery of service and protection of the environment. We appreciate the opportunity to serve the community of Northport and its citizens and look forward to our continued partnership.

# Appendix A

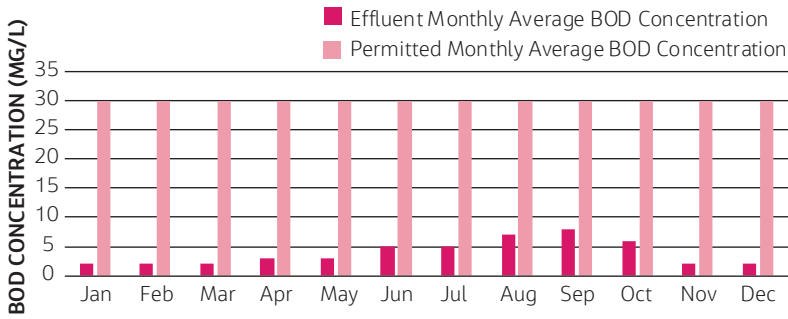
**Exhibit A1**

Maximum Daily Influent Flow



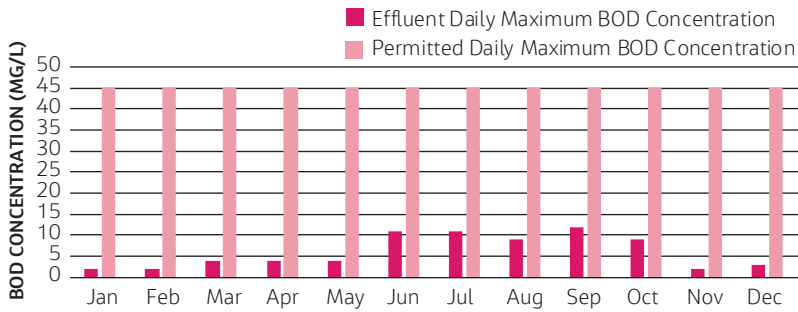
**Exhibit A2**

Monthly Average Effluent BOD Concentrations.



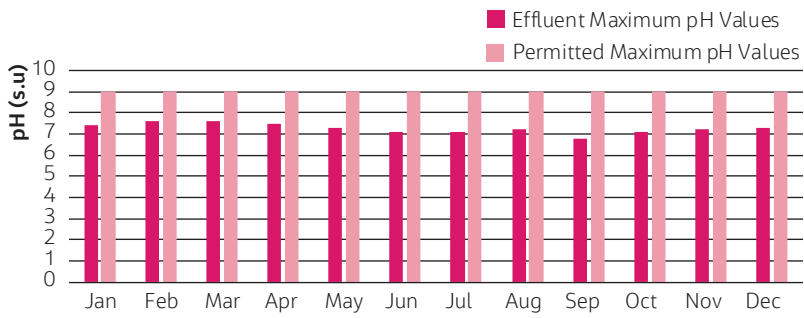
**Exhibit A3**

Effluent Daily Maximum BOD Concentration versus Permitted Daily Maximum BOD Concentrations



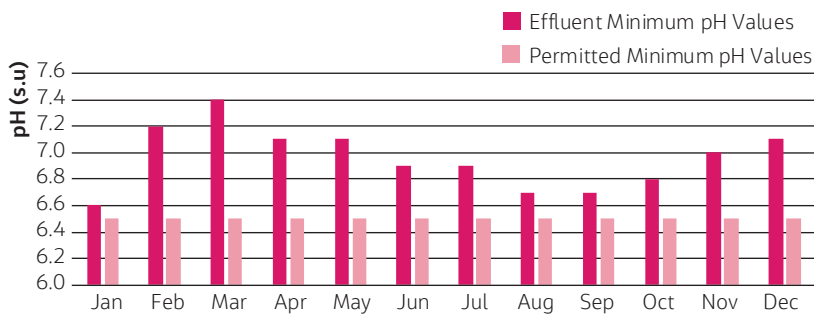
**Exhibit A4**

Effluent Maximum pH versus Permitted Maximum pH



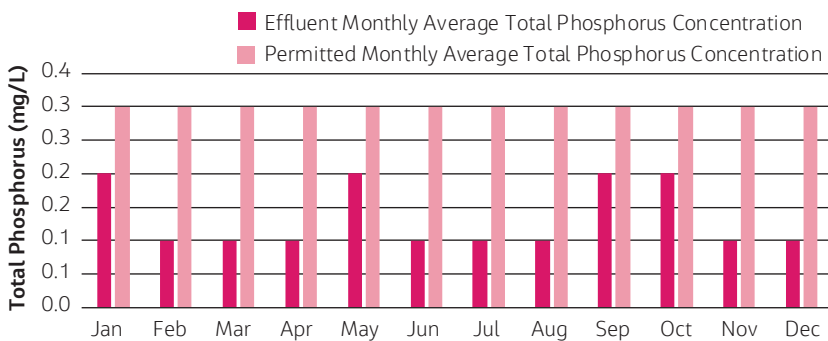
**Exhibit A5**

Effluent Minimum pH versus Permitted Minimum pH



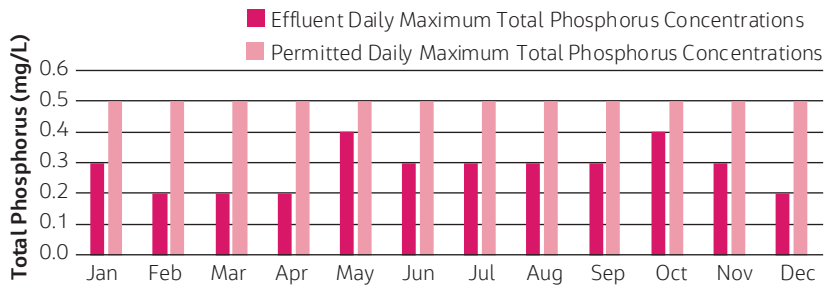
**Exhibit A6**

Effluent Monthly Average Total Phosphorus versus Permitted Monthly Average Total Phosphorus



**Exhibit A7**

Effluent Daily Maximum Total Phosphorus Concentration versus Permitted Daily Maximum Total Phosphorus Concentrations



**Exhibit A8**

Monitoring Well Minimum pH Values versus Permitted Minimum pH Values



**Exhibit A9**

Monitoring Well Maximum pH Values versus Permitted Maximum pH Values



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