



ON-SITE RAPID TESTING OF WATER SAMPLES FOR E. COLI AND TOTAL COLIFORM

Alberta Innovates File # G2019000955

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"Clear Water, Bright Future"

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1. PROJECT INFORMATION:

Project Title:	On-site Rapid Testing of Water Samples for E. coli and Total Coliform
Alberta Innovates Project Number:	G2019000955
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AI Project Advisor:	Ms. Jelena Sapkovskaja & Ms. Vicki Lightbown

2. APPLICANT INFORMATION:

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3. PROJECT PARTNERS

Roshan Water would like to acknowledge the project partners listed in the table on the following page and their important contributions to the success of our AI WIP project.



Organization Name	Nature of Support
University of Alberta	Provided laboratory facilities and office space through both the Mitacs and GreenStem programs through which the founders received support.
Technical Contractors	
Suissa Design	Provided design and fabrication expertise to produce the cartridge and device housing, usability testing, sourcing and managing component suppliers, and QA testing.
Taloron Technologies Corp	Provided electronics technical development for device.
NAIT CSSI	First technical partner; provided expertise to stabilize VeloCens v2.1 prototype.
Phase 1 and 2 Field Test Partners	
Yellowhead County	Provided access to facility managers, operators and sewage & surface water samples, phase 1 usability testing, and phase 2 field test site. Jennifer Lypkie, Utilities Supervisor, generously gave her time to present alongside Amir at the 2021 Alberta Water & Wastewater Operators Annual Seminar.
Town of Drayton Valley	Provided access to facility managers, operators, sewage & surface water samples, phase 1 usability testing, and phase 2 field test site.
Alberta Capital Region Wastewater Commission	Provided access to operators, in-house lab personnel, sewage and effluent samples, phase 1 usability testing and phase 2 field test site. Cory Pepper, Operations Supervisor, generously gave his time to present alongside Amir at the 2021 Alberta Water & Wastewater Operators Annual Seminar.
St. Mary River Irrigation District	Provided access to irrigation district managers and water operators, undertook phase 1 usability testing, and phase 2 field test site.
Sturgeon County	Provided access to facility managers and water operators, and phase 2 field test site.
Town of Edson	Provided access to facility managers and water operators, and phase 2 field test site.
J A Building Services (JABS)	Provided feedback from water services company perspective, phase 1 usability testing and phase 2 field test access to Piikani First Nation waterworks system, facility managers and water operators.
Environmental Laboratory Partners	
Bureau Veritas (BV) Labs	Provided standard laboratory testing services for side-by-side water sample testing. <u>Dr. Terry Obal</u> , Chief Science Advisor at BV Labs in Ontario provided lab testing expertise and scientific advice.
Element Edmonton-Environmental Lab	Provided standard laboratory testing services for side-by-side water sample testing.



A. EXECUTIVE SUMMARY

INTRODUCTION

Regular testing of drinking water samples for indicators, E. coli and Total Coliform, to confirm the presence of harmful microbes is a widespread best practice globally.

Standard laboratory methods have known drawbacks, including slow turnaround time and sample integrity issues. VeloCens™, our rapid, inexpensive, on-demand and on-site device to test E. coli and Total Coliform in water samples offers several advantages:

- Portable Device operated on-site
- Consumable and recyclable test kits
- Test results received in 1 hour – no sample shipment to central laboratory required
- Sample and results data automatically logged in central, user-controlled Cloud database
- Easy, step by step instructions

VeloCens™ can be used globally. Its portability and ease of use, without the need for expert operators, allows tests to be done “anywhere by anyone”. Based on internal and external (WaterNEXT, 2018) market assessments, our target markets in North America are: Water & Wastewater Treatment both Public and Private, Agriculture, Food & Beverage, and Military. Roshan Water™’s primary target market is municipal water and wastewater management operators who have the most pressing needs, are tightly regulated and seeking an on-demand testing solution that provides rapid results. Other secondary market segments include irrigation districts in agriculture areas and environmental water & wastewater management companies.

PROJECT OBJECTIVE & GOALS

Our overarching project objective was to “Accelerate the path to commercialization for VeloCens™” and the project goals are described below.

- 1) Advance the technology through further R&D, re-design and testing to a manufacturable VeloCens™ product.
 - a) Develop a cloud-based data platform to digitally capture and store water sample collection information and test results.
- 2) Develop stable test cartridge for E.coli and Total Coliform bacteria.
 - a) Develop Total Coliform cartridge
 - b) Obtain test cartridge performance characteristics (based on ISO 13843) for detection and enumeration of E.coli and Total Coliform, doing side by side testing with Bureau Veritas Labs and Elements Environmental Lab.



3) Advance towards regulatory approval of VeloCens™. Follow [US EPA Microbiological Alternate Test Procedures \(ATP\)](#) program, including researching and preparing a study design to do large-scale testing and results analysis.

4) Develop an IP strategy and formally protect Roshan Water™ IP assets including patents and trademarks.

KEY RESULTS

Device Hardware - With input from end users and working closely with experienced contractors through the R&D process, we designed manufacture-ready 3T (test) and 5T devices. Twelve (12) units including six 3T and six 5T were manufactured and will be field tested from May – July 2021. We also researched and purchased a storage suitcase that customers will use to store all components when not in use, and transport the system from location to location as required. Product specifications and component descriptions are provided in the attached Appendices.

Test Cartridges - Improved our E.coli and Total Coliform test cartridges including: addressed the leaking and frequent Si chip breakage issue, addressed performance characteristic gaps, manufactured cartridge molds in China to be used by Edmonton plastics manufacturer Flexcim Services to produce the cartridge housing locally. We also created a commercial packaging solution for our test kit consumables that includes all the sample preparation and reagents needed for one test (1 Total Coliforms + 1 E.coli test) on a water sample. Test kit component descriptions are provided in the attached Appendices.

Digital Data Tracking and Cloud Database – Through our VeloCens™ system, we have digitized much of the sample collection and results reporting process.

1) The Chain of Custody (COC) form is digitized in our system which allows customers to capture water sample collection information such as sampling time and location automatically, and in real time without having to write information on a paper form, thereby eliminating the potential for transcription errors. To facilitate this, a mobile app was developed that reads a barcode on the sample collection bottle and syncs the sample to a test kit and test cartridges (E.coli and Total Coliform).

2) Test results are available digitally and displayed on the device after the 1-hour test is completed.

3) Sample collection information and test results data are available through our Cloud database for 24/7 storage and data retrieval. The IoT backend and infrastructure communicates with the device and manages device operation including automatically capturing sample collection data, test result processing and post processing, and data analysis. Future commercialization plans include monetizing predictive data analytics such as providing customers with weekly water sample suggestion locations and automated jurisdictional test results analysis.

Implementing reuse/recycle program - One of the main pillars of Roshan Water is sustainability and maintaining a small environmental footprint. Since our test kits are disposable and contain single use plastic components, a reuse/recycle program was created. Customers will be able to return their used test kits to Roshan Water's Edmonton facility. We have identified which components of the test kit can be reused (cartridges and their internal components) and which ones will enter our recycle program. In the reuse program, strict cleaning and Q&A procedures have been developed to sanitize the used cartridges and ensure there is no carry-over of bacteria or cleaning agents from one used cartridge to



the next assembled one. The recycle program is currently being developed with a key focus on developing partnerships with companies that will take and recycle our single use components.

Performance Characteristics and Regulatory Approval Process - As US EPA is considered the gold standard of regulatory approvals and we know that provincial and national legislative bodies follow US EPA decisions, our strategy is to follow the US EPA Microbiological ATP protocol to obtain approval. There are two phases: 1) design and submit a Study Design to do a large-scale field test that includes working with an environmental lab to do 300+ tests , and; 2) submit the completed study report for regulatory approval.

In this AI WIP project, a significant amount of time has been spent understanding and mapping out the steps and processes required to obtain regulatory approvals for our new VeloCens™ test method. Initially, our goal was to obtain actual US EPA approval but we learned this was not feasible and a project scope change was made to remove this activity from the workplan.

Our short-term market entry goal is to convince prospective customers and partners that VeloCens™ is a useful and viable testing system to add to an organization's water management toolkit for on-demand and on-site testing. VeloCens™ testing would not replace legislated testing until we obtained regulatory approval. When we have this approval, our goal is to convince government legislative bodies that our system is an alternative solution to regulated standard laboratory testing.

Field Testing & Market Development – Our successful Phase 1 Usability tests with field test participants in September 2020 led to important insights and product features that were incorporated into VeloCens™ v3.0. Our follow-on Phase 2 Field Testing will take place from May to July 2021. We have field test participant agreements in place with four rural municipalities, one regional wastewater commission, one irrigation district in Southern Alberta and two private companies that provide water monitoring services to first nations and private residential communities. These organizations fall into our key target markets; public drinking water and wastewater management, private on-site water and wastewater monitoring and management, and our secondary market, agriculture irrigation district management.

Over the duration of this project, Roshan Water has been focused on increasing awareness of our solution. Most recently, we had a virtual booth at the 2021 Alberta Water and Wastewater Operators Association (AWWOA) virtual annual seminar and trade show. This event was very successful for us and we plan to execute a marketing campaign early fall reaching out to the 120 + people we connected with during this event.



LEARNINGS

There are a number of key learnings from this project.

- 1) Shortly after Roshan Water co-founders left for a trip to Iran in February 2020, the COVID 19 Pandemic was declared, and they were not able to return until August 2020. As with the rest of the world, we learned that we could still carry on our work and moved to digital platforms immediately. Fortunately, key contractors were located in Alberta and were able to continue with their tasks. To our pleasant surprise, we were able to by and large maintain our project plan schedule. We did experience some supply chain related delays ultimately resulting in a delayed start of our phase 2 field test.
- 2) The cumbersome process of transporting samples to labs located hours away from waterworks systems and time delays of 3-5 days to receive test results has been felt for many years by our target end-users. We have learned that in an effort to strive for operational excellence, the timing is right for water treatment industry operators to add on-demand testing to their operational toolkit. This will enable data based decision-making and real-time process adjustments in the water and wastewater industry, saving time and costs when bringing systems back to operation status.
- 3) The use of paper-based Chain of Custody (COC) forms that require manual transcription of sample information has been an on-going issue for end-users. This is due to: a) errors in manual transcription and subsequent rejection of samples by laboratories; and, b) potential forging of information and malpractices to which paper COCs open the door. Automating and authentication of sample collection and results provides a direct link between the two and ensures water sample testing is auditable and completed correctly. With an ability to digitally link sampling and test results, the door is opened to make changes to water monitoring practices.
- 4) The regulatory approval pathway in North America for new water testing methods starts with the [US EPA Microbiological Alternate Test Procedures \(ATP\)](#). After obtaining the approval from US EPA, the decision to a new microbiological test method such as VeloCens™ is made by provincial or state government bodies such as Alberta Environment and Parks. Through our research of the required procedures, expertise and facilities, and email discussions with US EPA representatives, our understanding of the process was clarified and we were able to more confidently chart a path to regulatory approval.
- 5) On-going discussions with end-user participants over the course of this project revealed that they prefer to have multi-test capability but with a device that is still portable. Our original plan to make a small handheld device capable of running a single test was modified based on this feedback. Our VeloCens™ product line includes both a 3T (test) and a 5T unit.
- 6) We have always focused on sustainability and maintaining a small environmental footprint as a key pillar of our company. With the Canadian government announcement in 2019-20 to ban the use of six single-use plastic items and phasing them out across the country by 2022, our commitment to recycling/ reuse of our consumable test kit components was strengthened. We developed our vision for a reuse/recycle program and plan to implement it from outset of commercial operations. We are removing the burden from our customers to dispose of plastic waste by providing them with packaging that enables them to return used test kit supplies to Roshan Water's facility in Edmonton. This has been met very favorably by all prospective customers.

**PROJECT OUTCOMES AND OUTPUTS**

Metric	Original Project Target	Project Actuals
<i>Early Customers</i>	Secure 5 early adopter municipalities agree to purchase VeloCens	Eight (8) Phase 2 field participants secured who are purchasing a 10 pack test kit unit (total= \$2800 + GST)
<i>Commercial-ready VeloCens system</i>	1) Dual and 10 measurement Reader design complete and ready for production 2) Cartridge design ready for volume production 3) Cartridge & sample testing packaging ready for volume production 4) Fully functional and tested Cloud-based data center (available in Canada and US)	1) Production of six 3T (Test) and six 5T devices. These will be used by Phase 2 Field test participants and some will be available for purchase by early adopters. 2) Cartridge injection mold manufactured in China and delivered to Flexim Services (Edmonton) for cartridge manufacturing 3) Test kit consumables sourced and received to do +150 tests. Recycle and reuse program framed out and spent consumables will be sent back to Roshan facility in Edmonton. 4) Mobile barcode scanning app and fully functional Cloud data centre available in Canada and the US completed.
<i>Complete Large Scale Field Tests</i>	US EPA Study Plan - Perform 500 field tests in Canada and US according to ISO 13843 and US EPA guidelines NOTE: This metric was removed as a project metrics with a formal scope change. With delays resulting from the COVID pandemic and learning more about the magnitude of this process, we realized it was not possible to achieve within the project timeframe.	Expanded Phase 2 Field test - 8 participants will generate results from 80 tests done at their facilities on-site

PRESENTATIONS & INTERVIEWS

- 1) AWWOA 2019 Water Week Conference, November 9, 2019; technical presentation introducing VeloCens by Amir Sohrabi
- 2) Alberta On-site Wastewater Management Association Annual (AOWMA) 2020 Convention & Trade show, Feb 6, 2020; technical presentation introducing VeloCens by Amir Sohrabi
- 3) Alberta IMPACT: Technology for Clean and Safe Water - Roshan Water™ Solutions - University of Alberta; February 2020; founder Parmiss Moijir-Shaibani interviewed by Bruce Lambert
- 4) Alberta Innovates Water Innovation Connect Series: Webinar - Digital Innovation Meets Water Management December 10, 2020, presenter was Amir Sohrabi
- 5) AWWOA 46th Annual Operators Virtual Seminar March 9-11, 2021; a) technical presentation entitled “Beyond Compliance Towards Operational Excellence: A Panel Discussion on Use Cases of VeloCens™” given by Amir Sohrabi with panelists Jennifer Lypkie, Utilities Supervisor Yellowhead County and Cory Pepper, Operations Supervisor at Alberta Capital Region



Wastewater Commission. b) Roshan Water™ Virtual Trade Show Booth at which we obtained 120 leads which we target in a marketing campaign in the fall 2021.

PITCHES, ACCELERATORS & AWARDS

- 1) Foresight Cleantech Accelerator – 2020-2021 participant in the [Pan-Canada waterNEXT WaterTech Support Program](#)
- 2) Threshold Impact Venture Mentor Service (VMS) – May 2020
- 3) [Alberta GreenStem program](#) - secured Fellowship for Amir Sohrabi and capital to support Roshan Water- July 1, 2020 to June 30, 2022; GreenStem Fellow is Amir Sohrabi
- 4) Great Alberta Pitch Marathon Clean Tech and Energy stream hosted by GreenStem and ACTia July 30, 2020
- 5) ACTia’s Virtual Clean Tech Pitch and Matchmaking Event September 16, 2020
- 6) Startup TNT GreenStem Pitch Night Jan 21, 2021
- 7) BusinessLink First-Ever Pitch Competition Mar 23, 2021 - Roshan Water Solutions: [Winner Immigrant Youth](#)

WEBSITE

[Roshan Water™](#) launched a demand generation website in February 2021. It will be used to drive internet traffic through our sales process. Included on the website is a downloadable 16,000- word article presenting a comprehensive and concise guide to understanding contamination of water sources, especially by pathogens and microbes. It paints a global picture of water contamination and its consequences and delves directly into various pathogens that can be present in water and how they can harm us. Standard water management strategies to solve the issues associated with poor drinking water are described. Special attention has been given to the concept of water quality monitoring and the different tests that have been developed to characterize water samples. Towards the end of this article, standard methods for detection and quantification of E.coli and Total Coliform as standard indicators of microbiological contamination of water are explained. Finally, it describes strategies and requirements for more efficient water quality monitoring, and how new technologies that can deliver water test data onsite and in real-time can revolutionize water quality monitoring programs.



B. INTRODUCTION

Roshan Water™ is a technology provider in the growing E. coli testing industry. Water and foodborne diseases are on the rise globally and E. coli has been identified as one of the major causative organisms of water and foodborne diseases in underdeveloped and developing nations. The global E. coli testing market (both human and environmental) is projected to expand at a CAGR of 7.5% from 2019 to 2027 reaching US\$ 2.675B by 2027.¹

Public Drinking Water Systems

Across North America, municipalities and other public water management operations are legislated to undertake regular *E. coli* and *Total Coliform* testing of drinking water. VeloCens™ can be added to the operations toolbox to do on-demand testing on-site.

- Make faster decisions to alert citizens of unsafe drinking water and recreational water
- Initiate or lift drinking water advisories on waterworks systems faster
- Minimize downtime and return water systems to good operation as quickly as possible after infrastructure incidents such as water line breaks;
- Reduce time and cost to transport water samples to collection points within the region or directly to labs located in larger centres
- Eliminate water sample collection related errors with automated digital location and day/time tracking using our smart sampling bottles

Several years ago (mid-2018), Roshan Water™ engaged [WaterNEXT](#) to do a primary market assessment covering drinking water and wastewater management, agriculture, military and food & beverage sectors in North America. WaterNEXT's research provided insights on the quantity of water sample tests performed. Small Canadian rural municipalities with populations between 7-10,000 and 100,000 in population or medium size municipalities (between 100,000 and 400,000) perform less than or about 500 tests each per year. In the US, mid to larger municipalities (population greater than 400,000) perform as many as 4000 tests per year. Roshan Water estimates include an initial 1500-2000 primarily rural municipalities across North America that fit our public drinking water customer profile.

Public Wastewater Treatment Systems

Wastewater treatment facilities must adhere to strict guidelines in the release of wastewater effluent whether treating sanitary sewage from homes, businesses, institutions and industries or storm water that is generated from rain or melting snow that drains off rooftops, lawns, parking lots, roads and other urban surfaces. The ability to do on-demand and rapid microbiological testing, offers new solutions to move beyond compliance and towards operational excellence.

- Test effluent being released more frequently and proactively and get results in 1 hour to measure in real-time how much bacteria (*E.coli*) is present
- Incorporate rapid microbiological test results into decision-making to adjust your wastewater treatment processes and operations in real time

¹ E. coli Testing Market: Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2019–2027. <https://www.transparencymarketresearch.com/pressrelease/e-coli-testing-market.htm>; 2019.



[Statistics Canada](#) reports (2016) that regional and municipal governments in Canada owned over 1,200 wastewater treatment plants, more than 6,000 wastewater pump stations, nearly 5,000 wastewater lift stations, over 1,200 lagoon systems and almost 700 wastewater storage tanks. In the United States, over 16,000 centralized wastewater treatment plants serve approximately 74% of the population (Environmental Protection Agency [EPA], 2004).

Private On-Site Water and Wastewater Systems

Drinking water for a third of Canada's population comes from groundwater sources and includes 80% of Canada's rural residents (6,960,780 people in 2019), who get their drinking water from groundwater sources primarily through dugouts and wells. Statistics published by the National Ground Water Association, US, indicate that over 44% of the population of the U.S. depends on private ground water sources for drinking water. It is estimated that more than 13 million households rely on private wells for drinking water (US Census American Housing Survey 2017). Across North America, these same households have private wastewater management systems.

Private well owners are responsible for the safety of their water and are asked to follow water quality testing guidelines but are not regulated. To ensure that water from private water systems is safe to drink, they must be properly designed and regularly tested, treated, and maintained. Similarly, improperly functioning on-site wastewater treatment systems pose a risk to drinking water supplies and the environment. This is why applicable testing and inspections must be carried out during construction and commissioning of private water and wastewater systems.

A convenient on-site, rapid microbiological testing system such as VeloCens™ enables monitoring companies to maintain water quality standards for private owners of on-site water and wastewater systems.

- Implement and maintain regular testing of microbiological parameters as per Health Canada recommendations in on-site private water systems such as wells and cisterns to prevent or treat contamination in water supplies.
- Reduce costs by commissioning wastewater treatment systems faster and saving staff time by not driving water samples to a lab. Obtain microbiological test results on-site and within 1 hour using VeloCens™.

[Environmental XPRT](#) is a global environmental industry marketplace and information resource which provides online product catalogs, news, articles, events, publications & more. Using this database to search for companies, we estimate there are 2,351 companies [across Canada](#) and 11,000 [across the US](#) providing private on-site water and wastewater related services.

Secondary Market - Agriculture Irrigation Systems

For farmers growing crops in irrigation districts, managing water is a vital part of farming practices. Avoiding surface water collection in planted or ready to be seeded fields, is a pressing concern when there are significant precipitation events. Surface water must be tested for harmful bacteria before it can be removed from fields. And, to protect agriculture crops from contamination, farmers can monitor water quality and identify water sources that may contain pathogens. Using an on-demand, portable microbiological testing system provides accurate data to enable faster decision-making.



- Regular monitoring regime leads to identifying problem water sources and use of only water that is free of pathogens for crop irrigation.
- Microbiological testing of surface water can be done onsite and within 1 hour so farmers can avoid water collection in fields and irrigation districts can adhere to regulations on pumping surface water to water bodies.
- Water quality standards are upheld by irrigation districts to protect the rivers, lakes and streams from contaminated water runoff.

Context of Current Challenges with Water Testing

Regular testing of water samples for E. coli and Total Coliforms is an integral part of water safety globally; used as an indicator to monitor the presence of other more harmful microbes. The current standard for testing water samples for harmful bacteria relies on well-equipped laboratories (such as ProvLab, Bureau Veritas or another private laboratories) often located in larger urban cities with expert technicians on staff.

In the current scheme of testing, the samples are collected in containers with preservatives that maintain water sample quality during shipment to a centralized lab which must happen within 24 hours of sample collection, and the tests themselves take at least 18-24 hours to obtain results. For many municipalities, especially in rural areas, it takes 3-5 days to actually receive the test results. This means that these municipalities can be in a state of uncertainty regarding the safety of their drinking water sources. Moreover, the procedure for collecting water samples includes manual transcription of the sample information (date, location, etc.) and test result data onto Chain of Custody forms and log sheets.

In summary, the three main problems identified with the current scheme for testing water for harmful bacteria are:

- Long delays between actual water sampling and lab test results
- Inefficient and slow data logging and test result communication to all necessary authorities
- Regular occurrence of re-sampling due to sample properties changing during shipment to the lab

Technology Gap

VeloCens™ was developed to address these problems in the water testing industry. A key benefit of the technology is that results are obtained in only 1 hour. In the sampling stage, our smart barcoded sample bottles allow for automatic logging of all important information including sample location and time, directly to our Cloud data center, thereby eliminating potential errors. In addition, the Cloud-based data center enables automatic logging, tracking and retrieval of test results.

Standard lab equipment that performs E.coli and Total Coliform tests is available at laboratories. In addition, there are several new technologies that are either a miniature version of standard laboratory tests or new portable devices that do not offer rapid testing. VeloCens™ bridges the gap by enabling on-site and on-demand bacteria testing and delivering test results in one hour.

The main competing products to VeloCens™ that have established market traction are listed and compared in the table below. Companies selling/ manufacturing these products are also described below.



Name	Rapid	Simple	Accessible/ Portable	Time to results
IDEXX Colilert®	✗	✓	✗	18-24 hrs
Aquagenx CBT®	✗	✓	✓	20-48 hrs
HACH Portable Lab Kit	✗	✗	✓	18-24 hrs
TECTA™ B16	✓	✓	✗	4-18 hrs
VeloCens™	✓	✓	✓	1 hr

IDEXX: Colilert Quanti-Tray System and Reagents

Multinational corporation headquartered in Maine, US, engaged in the development, manufacturing, and distribution of products and services for the companion animal veterinary, livestock and poultry, water testing, and dairy markets.

Aquagenx: Compartment Bag Test (CBT) EC+TC

Technology developed by Dr. Mark D. Sobsey, an international authority in environmental health microbiology and virology and in water, sanitation and hygiene. The water quality test kits are used for field-level testing in low resource areas as no labs, electricity, expensive, complicated equipment or cold chain are needed.

Hach: m-ColiBlue24® Broth & MEL/MPN Total Coliform and E. coli Laboratory

Hach is a manufacturer and distributor of analytical instruments and reagents for water testing and water quality analysis headquartered in Colorado, US and is a wholly owned subsidiary of Danaher Corporation (NYSE: DHR) based in Washington, DC.

TECTA-PDS: TECTA™ B16 System

Originally formed in 2003 as a direct result of the Walkerton disaster in Ontario, Canada, TECTA-PDS markets the world’s first, automated EPA-approved microbiological water quality monitoring system. There are over 270 systems around the world and it is adopted as the method to test water in over 25 countries.



C. PROJECT DESCRIPTION

Technology Description

The heart of the VeloCens™ rapid testing method is based on a very well-known electrochemical method known as Light Addressable Potentiometric Sensor (LAPS). LAPS, similar to many electrochemical methods, is a three-electrode system where traditionally the working electrode is a silicon (Si) substrate, the reference electrode is silver/silver chloride (Ag/AgCl) and the counter electrode is platinum (Pt). Conventionally, LAPS was used for the detection of changes in the solution pH level. Fundamentally, a light is illuminated to the backside or front side of the Si substrate and a sweeping voltage is applied between the Si substrate and the reference electrode. The outcome of LAPS is the photocurrent which is then plotted against the sweeping voltage applied. Any change in the solution pH on the surface of the Si electrode results in the change in the position of the curves. There are several innovative aspects in VeloCens™ that distinguish it from its predecessors in the LAPS family which enables the detection of bacteria in one hour, and which is protected in our foundational patent.

Project Objectives and Updates

The four main project objectives and updates to these are described below. Although individual tasks were adjusted over the course of the project by being moved from one milestone to another, our key project objectives did not change nor was our overall commercialization goal adversely affected.

Objective 1 - Advance through further R&D, re-design and testing to a manufactured VeloCens™ product and cloud-based data platform.

The milestone tasks for this objective were by far the largest component of this project. By and large, the project progressed according to milestone tasks however several changes, considered non-material, were made along the way.

Changes to Contractors

We made the decision to develop the new electronics in-house rather than purchase units (Rodeostat made by [Rodeo. IO](#)) to lower our device cost and provide better control of in-house manufacturing volumes. NAIT did not have the required skill set in house and Edmonton based Taleron Corp was contracted to do the work.

Cartridge Manufacture Delays

There was a delay in production of the mold for plastic injection molding of the cartridges and production of 500 cartridges. Due to the temporary shutdown of Chinese facilities in January 2020 and the closure of Flexcim's facility in Edmonton due to the Covid-19 pandemic, the completion of this work was reported to be delayed to mid-July 2020 at the earliest. In the end, this work was completed in Q1 2021.

Test Kit Component Suppliers

Identifying suppliers for items in test kits and purchasing required supplies for 500 test kits had to be rethought. Due to the current Covid-19 pandemic, we had to reconsider where we were going to purchase consumables. This activity involved finalizing orders from 6 suppliers in China and 1 in Canada, and the total cost was more than forecasted. Given the uncertainty at the time of how long the Covid-19 pandemic



would last and without using new suppliers, we would not have been able to procure the materials within our planned timeframe. All ordered supplies were received by Summer 2020.

Field Test Program

We expanded our field test program as the project progressed in terms of the types of end users (rural municipalities, wastewater management, and irrigation district partners) and we also took the time to ensure we had the required feedback before embarking on the development of our commercial version of VeloCens v3.0. Through phase one which was completed in September 2020, we gained extensive usability feedback which was incorporated into the design and development of our 3T (test) and 5T products. In the second field test phase, the product will be used by end-users on-site to perform 10 tests (1 test = E.coli & Total Coliform) each. Users will also send water samples to standard laboratories as per their required legislated testing, and side by side results comparison will be done with VeloCens™.

Roshan Water has executed eight (8) formal field test agreements with four rural municipalities, two environmental monitoring and management companies, one wastewater management commission and, one irrigation district. The phase 2 field test program will start May 31, 2021 and be completed by the end of July 2021 so the results are not included in this WIP final report. Our field test participants are all very keen to test VeloCens™ and have expressed interest in purchasing our commercial system.

Objective 2 - Obtain test cartridge performance characteristics (based on ISO 13843) for detection of E. coli and Total Coliforms, doing side by side testing with Bureau Veritas Labs.

Following ISO 13843, extensive testing was performed to calibrate our prototype device for detecting E.coli and obtaining performance characteristics. The same testing was done to calibrate the device for detecting Total Coliform. The majority of the performance characteristics were very close or better than the reference standard method. One key parameter that needed more research was the False Positive rate which needed to be reduced. The milestone tasks were updated to include internal research to identify how to improve this result. A second round of performance characteristic testing was also added as a task to milestone 3.

Objective 3 - Map the regulatory approval landscape, identify the necessary testing conditions and procedures required to prepare a US EPA regulatory application.

As US EPA is considered the gold standard of regulatory approvals and we know that provincial and national legislative bodies follow US EPA decisions, our strategy has always been to follow the US EPA Microbiological ATP protocol to obtain approval. There are two phases: 1) design and submit a Study Design to do a large-scale field test that includes working with an environmental lab to do 300+ tests, and; 2) submit the completed study report for regulatory approval.

Amidst a major global economic downturn relating to the COVID-19 pandemic, Roshan Water reported in its Milestone 2 report that there would be a delay in the submission of our US EPA ATP Study Design Plan as the improvement of several performance characteristics are important to resolve first. Planning conservatively, we thought this might be moved to the end of October 2020. Due to unforeseen delays related to the COVID-19 pandemic, company founders were not able to return to Canada from Iran until Aug 17, 2020 at which point, they had been in Iran for 6 months. So as of Sept 30, 2020, we removed from this AI WIP project the sub-objective to submit and perform the required field tests for the US EPA Alternative Test Procedure (ATP) study plan by March 31, 2021.



This activity was independent from our product development work so we were still able to progress with user testing and final design work. At the same time, we decided instead to expand our Phase 2 Field Test program to include more end users.

Objective 4 - Develop IP strategy and formally protect IP including patents and trademarks

In the summer 2019, Roshan Water retained Gowlings WLG as its IP firm. Since this time, Gowlings has helped us a great deal and been very responsive on all matters. The work building our IP portfolio has gone very well and the achievements have gone beyond our original plan. We accelerated the submission of our Canadian Trademark registration applications for VeloCens™ and Roshan Water™. The decision was made to complete these registrations in Q1 2020 rather than wait as it strengthened our IP portfolio which we know will be beneficial as we seek additional funding and begin to reach out to potential strategic partners. Below are a few key dates we are anticipating.

- With the WIPO determining the patentability of our invention, it also opened the door to use the Global Patent Prosecution Highway (GPPH) to fast track the national-entry application in our target countries. Through the GPPH, a national-level entry application was submitted to the Canadian Patent Office and it is expected that a “notice of allowance” will be received by summer 2021.
- Trademarks have been registered in Canada and the US for VeloCens and Roshan Water and we await final award notification.

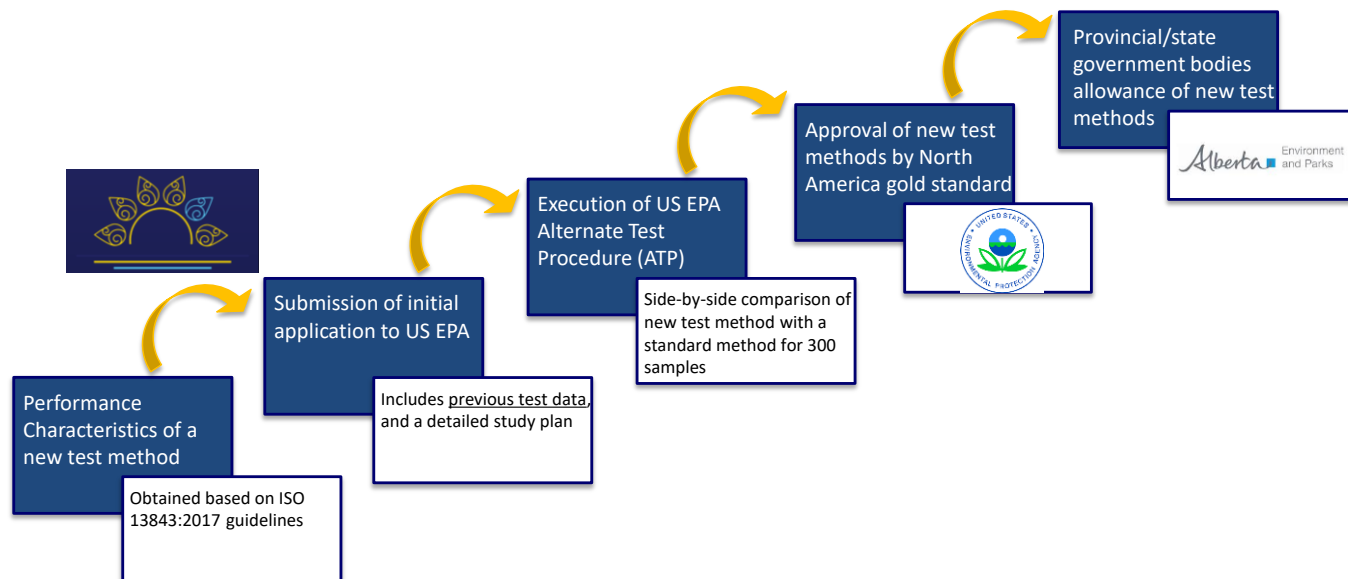
PROJECT RESULTS

Key results are elaborated on in the Executive Summary. In this section, we summarize notable project results. The milestones in our project were a continuation from one to the next to achieve our final project objective “Accelerate the path to develop on-site rapid testing of water samples for E. coli and Total Coliform.”

Regulatory Pathway: At the beginning of this project, we did not have a detailed understanding of the potential pathways to obtain regulatory approval at a provincial, national and international level. At the completion of this project, we not only have a clear pathway which includes obtaining US EPA regulatory approval following ISO13843, but we have also progressed along this path to perform two rounds of Performance Characteristics with promising results.



The timeline below charts our path to gaining international regulatory approval and legislated use in Alberta.



Development of a Commercial VeloCens™ Unit: At the start of this project, we were working with VeloCens™ prototype v2.1 which was able to test a single cartridge (for either E.coli or Total Coliforms), needing a USB connection to a tablet or computer to operate. At the completion of this project, we have stand-alone devices that can run either 3 samples (6 tests) or 5 samples (10 tests) at the same time. These devices have internal computing system and are connected to our Cloud Data Center.



VeloCens™ MVP v3.0

Features	VeloCens™ Version	
	v2.1	v3.0
Number of tests per hour	1	10
Portable	✓	✓
Stand Alone	✗	✓
Connection to Cloud-based Data Center	✗	✓
Automatic Sample Information Tracking	✗	✓
Water Proof	✗	✓



VeloCens™ Digital Backend: At the start of this project, our digital backend was limited to a code script that could run tests on a computer. The backend data centre development commenced in September 2019. Roshan Water hired a new employee; an experienced software developer, to develop the data centre and communications backend. The goal initially was to develop all the necessary backend file structures for running the tests, communications and storing the results in the Canarie DAIR cloud server.

At the completion of this project, there are three main digital components incorporated into our digital infrastructure.

- 1) A true digital chain of custody (COC) that uses barcoded sampling bottles and allows end-users to capture important sampling information such as time and location of sampling completely automatic;
- 2) Device backend that allows the data to be transferred to a Raspberry Pi inside the unit and communicate with our Cloud data center; and,
- 3) A Cloud data center that collects all the sample information and test results, with 24/7 secure access for authorized users.

Performance characteristics: Extensive testing was performed to calibrate our prototype device for detecting E.coli and obtaining performance characteristics following. Each water sample tested by VeloCens™ was also submitted to BV Labs (Bureau Veritas Labs formerly Maxxam Analytics) for side-by-side analysis of E.coli, Total coliform and Heterotrophic Plate Count (HPC). The majority of the performance characteristics were very close or better than the reference standard method. One key parameter that needed more research was the False Positive Rate which needed to be reduced.

This research was done in Milestone 2 & 3 and led us to adjusting the formulation of our reagents as well as adjusting the assembly process. The second complete round of performance characteristics tests were done in November/ December 2020 due to the founders unexpectedly being out of country until August 2020 as a result of the Covid pandemic. Side by side testing was done by Elements Lab. The second round of performance characteristics tests using the new adjustments showed a decrease in our false positive rate from 30% to about 8-9% which is comparable to the false positive rate of the standard test method used in laboratories (5%).

Below is a table illustrating the performance characteristics as of March 2021.

No.	Performance Characteristic	Formula	VeloCens™-E.coli	VeloCens™-Total Coliform	ISO 9308-1 (MF)	UNICEF Project
1	Sensitivity	$a/(a+b)$	88.20%	95.93%	90.5%	-----
2	Specificity	$d/(c+d)$	99.68%	93.08%	98.3%	-----
3	False Positive Rate	$c/(a+c)$	7.95%	9.08%	5.0%	<10%
4	False Negative Rate	$b/(b+d)$	0.50%	3.07%	3.3%	<10%
5	Selectivity	a/n	3.56% (??)	40.25%	23.8%	-----
6	Efficiency	$(a+d)/n$	99.22%	94.27%	96.3%	-----



PROJECT SUCCESS METRICS

Project Success Metrics			
Metric	Project Target	Project Actuals	Comments
<i>Complete Large Scale Field Tests</i>	500	80	<p>US EPA Study Plan - Perform 500 field tests in Canada and US according to ISO 13843 and US EPA guidelines</p> <p>This metric was removed as a project metrics with a formal scope change. With delays resulting from the COVID pandemic and learning more about the magnitude of this process, we realized it was not possible to achieve within the project timeframe.</p> <p>Phase 2 Field test - 8 participants will generate results from 80 tests done on-site</p>
<i>Regulatory approval</i>	1	0	<p>Final Report to US EPA</p> <p>Same comment as above.</p>
<i>Early Customers</i>	5	8	<p>Secure 5 early adopter municipalities agree to purchase VeloCens for a total of 6000 tests per year.</p> <p>Eight (8) Phase 2 field participants are purchasing a 10 pack test kit unit (total= \$2800 + GST)</p>
<i>Commercial-ready VeloCens system</i>	<p>1) Dual and 10 measurement Reader design complete and ready for production</p> <p>2) Cartridge design ready for volume production</p> <p>3) Cartridge & sample testing packaging ready for volume production</p> <p>4) Fully functional and tested Cloud-based data center (available in Canada and US)</p>	<p>1) Production of six 3T (Test) and six 5T devices. These will be used by Phase 2 Field test participants and some will be available for purchase by early adopters.</p> <p>2) Cartridge injection mold manufactured in China and delivered to Flexim Services (Edmonton) for cartridge manufacturing</p> <p>3) Test kit consumables sourced and received to do xx tests. Recycle and reuse program framed out and spent consumables will be sent back to Roshan facility in Edmonton.</p> <p>4) Mobile barcode scanning app and fully functional Cloud data centre available in NA completed.</p>	



D. METHODOLOGY

PROJECT MANAGEMENT APPROACH AND STRUCTURE

Roshan Water uses an Agile Project Management (APM) methodology that allows the development and testing of VeloCens™ to occur by iteration. For instance, under this methodology the development of the device prototypes occurred in two phases. In the first phase, more urgent improvements were tackled to have a stable MVP v3.0. Concurrently, Roshan Water staff worked on developing the Total Coliform test cartridge which was required for Phase 1 Usability testing. The second phase saw development of VeloCens™ commercial v3.0 with components undertaken by contractors and simultaneous internal R&D work done on performance characteristics and other activities.

Roshan also uses a hybrid project management structure which is 80% comprised of Project-Based Organization Structure and 20% Functional Organizational Structure. This structure is chosen due to the variety of tasks and partners included in this project and the capabilities of Roshan's staff. Applying this hybrid structure to this project means that each of the Roshan's staff will assume the lead in a group of tasks and utilize the help of others when needed.

USE OF SUB-CONTRACTOR EXPERTS

Four contractors and three manufacturing partners have been involved in this project.

- 1) [Suissa Design](#): Located just outside of Edmonton, Suissa is our main industrial design contractor responsible for the modifications of the cartridge design, design development for cartridge plastic injection molds, design development of our MVP v3.0 and commercial v3.0 deployable units, design development of the extrusion mold for production of the unit housing, and the user design of the initial UI for our device and user journey map.

AutoCAN was used to do all design work. The initial cartridge prototypes were 3D printed and used extensively for design evaluation. For the devices, the initial design was translated to a physical form using foams and tested with end-users for user experience.

- 2) [Taleron Technologies](#): This contractor is responsible for the design and development of custom-made electronics for our VeloCens™ commercial v3.0 units. Until this point, the electronics inside the VeloCens™ unit were purchased from a small company in US with limited manufacturing capabilities ([IO Rodeo Smart Lab Technology](#)). These purchased circuit boards were large, expensive and have high power consumption. Taleron's work was focused on development of small circuitries, with improved performance. Having the design in-house will allow Roshan Water to control manufacturing volumes. Taleron also worked on the firmware of the new circuit boards, in particular changing the data communication protocol from USB connection to more robust TX/RX protocol.
- 3) **Laboratory Partners**: We have worked with both BVLabs and Element Environmental Lab in Edmonton. These laboratories provided side-by-side testing services with standard laboratory test methods for our Performance Characteristics testing.



- 4) [Flexcim Services](#): Flexcim is our manufacturing partner in Edmonton that worked on the cartridge injection mold. Through their existing partner in China, the mold design was completed and the initial batch of test cartridges was tested. Flexcim will be Roshan Water’s toll manufacturing partner for production of VeloCens™ test cartridges.
- 5) [Metra Aluminum](#): Metra is a manufacturer based in Laval, Quebec that produced our VeloCens™ device housing through an aluminum extrusion process. We worked with Metra extensively to design and approve the extrusion mold, with the goal to produce parts that are easy to assemble. We received one shipment of extruded parts from Metra that contains 40 housings for 3T and 5T VeloCens™ models.
- 6) [Karma Machining & Manufacturing](#): Based in Edmonton, Karma completed the machining of the extruded housings and finished the exteriors through an anodizing process.

Facilities

Most of Roshan Water’s internal R&D work for this project was undertaken at the University of Alberta, with the help of [Advanced Water Research Lab](#) located in the Nanotechnology Research Building. However, after the declaration of the Covid-19 pandemic, Roshan Water decided to establish a small R&D facility in Edmonton (in the founders basement), in response to access restrictions and limitations imposed by the government on the U of A facilities.

E. OUTCOMES AND IMPACTS

The tables below compare the targeted Clean Energy and Program Specific outcomes developed at beginning of the AI WIP project with actual outcomes including explanatory comments.

Clean Energy Metrics					
Metric	Project Target	Commercialization / Implementation Target	Project Actuals	Commercialization / Implementation Target FINAL REPORT	Comments FINAL REPORT
<i>\$ in Data-Enabled Innovation</i>	\$ 70,000	Post project monthly costs TBD - Cloud hosting post Canarie DAIR access	\$ 75,000.00	Post project costs are \$334/ month for MS Azure and \$60,000/ annually for FT salary	Cloud Computing and Communication Technology: Roshan developed and launched: 1) Mobile app for sample collection location & data tracking 2) Cloud database to host water sample and test result data accessible 24/7
<i>\$ in Clean Technology</i>	\$ 389,735		\$ 474,475.00		Total cash + in-kind for Roshan AI WIP Project (minus Data-Enabled portion)



Clean Energy Metrics					
Metric	Project Target	Commercialization / Implementation Target	Project Actuals	Commercialization / Implementation Target FINAL REPORT	Comments FINAL REPORT
# field pilots/demonstrations	5		Phase 1 Usability - 4 orgs; 5 different groups Phase 2 - 8 orgs; 80 VeloCens tests		<u>Phase 1 Usability Tests Sept 2020</u> - Roshan obtained insights and feedback that was used to complete design of VeloCens v3.0. <u>Phase 2 On-site VeloCens 3.0 testing May to July 2021</u> - 8 participants representing different target market segments will perform 10 tests each
# of Publications	3		4 technical presentations		<u>Technical Presentations</u> - 2019 AWWOA Water Week Conference - 2020 AOWMA Convention & Trade Show - 2020 Alberta Innovates Water Innovation Connect Series: Webinar-Digital Innovation Meets Water Management - 2021 AWWOA Virtual Annual Operator Seminar & Virtual Trade Show Exhibitor
# Sector HQSP trained	3		2FTE		HQSP Trained - 1FT Software Dev & Data Architect - .5 PT market development - .5 PT CTO/ R&D
# new jobs created from project	3		1.5 FTE		New staff positions include; FT Software Developer and PT staff R&D Scientist
# projected new jobs created from future deployment		7		7	7 to 10 new jobs created in Alberta over next 5 yrs
# Patents filed	1	2	1 International PCT 1 Canadian Patent	2 patents 4 trademarks	See IP Assets Table in Benefits Section
# New policies created		1		1	Target to file US EPA regulatory application for Alternate Test Procedure (ATP) when US EPA ATP Study Plan is completed (exact date TBD). Possibly influence GoA water quality monitoring policy.



Clean Energy Metrics					
Metric	Project Target	Commercialization / Implementation Target	Project Actuals	Commercialization / Implementation Target FINAL REPORT	Comments FINAL REPORT
Partnership agreements / MOUs?		1		1	Distribution partnership to grow market access. We are in discussions with several international large watertech companies. US EPA regulatory approval required before VeloCens will replace legislated tests in Canada and the US. Market entry strategy is focused on indicator, on-demand use.
# New products/services created	4		4		1) E.coli and Total Coliform cartridge redesign/ performance characterization 2) Cloud computing data centre 3) Water Sample Test Kit 4) 3T (Test) Device 5) 5T Device

Program Specific Metrics					
Metric	Project Target	Commercialization / Implementation Target	Project Actuals	Commercialization / Implementation Target Update	Comments
% Improvement of overall water use efficiency	Water Quality Protection Efficiency: 12-fold reduction in TAT for pathogen test results	Health Outcomes: Increased efficiency and action-taking when testing for harmful bacteria to mitigate health impacts.	Water Quality Protection Efficiency: 12-fold reduction in TAT for pathogen test results	Health Outcomes: Increased efficiency and action-taking when testing for harmful bacteria to mitigate health impacts.	Reduce turn-around-time (TAT) by 12X for water bacteriological test (E. coli and Total Coliforms), thereby reducing time for waterworks operators and jurisdictions to take appropriate action to ensure water safety.

PROJECT OUTPUTS

Intellectual Property assets and conference presentations are listed below. In addition, please refer to the Knowledge Dissemination section for other outputs include pitch and award competitions, accelerators and mentorship programs.

**Intellectual Property Assets**

No.	Asset	Status	Description
1	National-Level Entry Application to CIPO WO 2020/223802.	Filed on November 12, 2020	PORTABLE DEVICE AND SYSTEM FOR RAPID DETECTION OF A BACTERIAL CELL IN FLUID SAMPLES
2	PCT International Application CA2020050593	Received favorable review from WIPO on August 8,2020	PORTABLE DEVICE AND SYSTEM FOR RAPID DETECTION OF BACTERIAL CELL IN FLUID SAMPLES.
3	US Provisional Patent No.62/844,406	Application May 7, 2019	PORTABLE DEVICE AND SYSTEM FOR RAPID DETECTION OF BACTERIAL CELL IN FLUID SAMPLES.
4	US Trademark Application 88958035	Application June 10,2020	Application for VeloCens(TM)
5	US Trademark Application 88958045	Application June 10,2020	Application for Roshan Water(TM)
6	CA Trademark Application 2,014,534	Registration Application Feb 27,2020	Application for VeloCens(TM)
7	CA Trademark Application 2,014,535	Registration Application Feb 27,2020	Application for Roshan Water(TM)
8	Software Source Code	Copyright	VeloCens(TM) operating and Cloud Data Center

Conference Presentations

1. AWWOA 2019 Water Week Conference, November 9, 2019; technical presentation introducing VeloCens by Amir Sohrabi
2. Alberta On-site Wastewater Management Association Annual (AOWMA) 2020 Convention & Trade show, Feb 6, 2020; technical presentation introducing VeloCens by Amir Sohrabi
3. Alberta Innovates Water Innovation Connect Series: Webinar - Digital Innovation Meets Water Management December 10, 2020, presenter was Amir Sohrabi
4. AWWOA 46th Annual Operators Virtual Seminar March 9-11, 2021; a) technical presentation entitled *“Beyond Compliance Towards Operational Excellence: A Panel Discussion on Use Cases of VeloCens™”* given by Amir Sohrabi with panelists Jennifer Lypkie, Utilities Supervisor Yellowhead County and Cory Pepper, Operations Supervisor at Alberta Capital Region Wastewater Commission. b) Roshan Water™ Virtual Trade Show Booth at which we obtained 120 leads which we target in a marketing campaign in the fall 2021



F. BENEFITS

Alberta Innovates support for our project was instrumental in moving VeloCens™ closer to commercialization, and our business close to generating “first revenue”. Below are the project benefits outlined by subheadings of Economic, Environmental, Social and Building Innovation Capacity.

ECONOMIC

1. “Made in Canada Solution” – Roshan Water retained local contractors for the duration of the project – Suissa Design, Taron Technologies Corp, Flexim Services, Metra Aluminum (Montreal based) and Karma Machining & Manufacturing.
2. Water industry benefit: E.coli / Total Coliform tests can be performed on-site and on-demand, and test results reported in near real time for less cost than current lab testing.
 - a) 0-50% lower recurring water test cost
 - b) Equal or much lower upfront costs (\$2,500-3,000)
3. Establishment of Roshan Water’s advanced manufacturing, assembly and distribution facility in Edmonton, Alberta and hiring of 7 -10 staff over next 5 years.
4. Raising of capital investment of \$500K
5. Sale of VeloCens™ readers and test kits to early adopter customers; securing first revenue of \$100K within 12 mos. after product is commercially available
6. In the span of five years after the completion of this project, Roshan will not only increase customers for VeloCens™ in North America, but also expand its operations and export our product to other countries.
 - a) Response to [UNICEF’s RFP for a Rapid E.coli Detection Tests](#) and follow up meetings
 - b) Execution of NDAs with several large water-tech companies could lead to joint projects in global markets
7. The vision for VeloCens™ is to create a suite of products which are similar in fundamentals but have many different applications. Future research is focused on developing new cartridge sensors that will enable the detection and enumeration of other bacteria species such as Salmonella, Listeria and Legionella with expansion of applications in food & beverage and industrial manufacturing units with cooling towers.

ENVIRONMENTAL

Roshan Water’s vision is to facilitate providing safe, clean drinking water while protecting the environment.

1. Using VeloCens™ allows rural jurisdictions to save on fuel consumption, vehicle wear and tear and operator time. Fuel consumption associated with transporting samples to local health units, and local health units transporting the same samples to laboratories in larger cities equipped to do bacterial testing could be eliminated in the mid-longer term (depends on provincial legislation allowing on-site use of VeloCens™).
 - a) For example, in Yellowhead County, Alberta where water sampling in different jurisdiction areas is routinely done on Tuesdays, the transportation of samples to health units is estimated to be on average ~ \$20,000 per year (including fuel costs) and these savings can be applied to other counties.



2. Using VeloCens™ will allow utilities operators in rural municipalities to test water samples onsite and report the results in near real time. This represents a much higher efficiency both in terms of reduced time to perform the tests and obtain results and also, as mentioned in the first point, reduce the operators' time to drive water samples to central sample collection sites or larger laboratories.
3. Paper-less Chain of Custody (COC) forms and error-free water sample information collection - Water sample collection information is gathered and automatically transcribed digitally using our barcoding system. Data is accessible 24/7 and secured access can be given to authorized users.
4. Implementation of reuse/recycle of sampling bottles and test kit consumables from day 1 of business operations will ensure reduction of plastics waste.

SOCIAL

1. Powerful tool to address rural municipality and indigenous community water security issues, and significantly improve response times to implement and lift boil water advisories.
2. Increase citizen confidence in safety of drinking water and environmental monitoring of wastewater effluent and recreational water.
3. Enable prompt and efficient communication of E.coli and Total Coliform test results to all necessary authorities.
4. Owners/operators of regulated waterworks, recreational water bodies, and unregulated (private) water sources can test water samples more frequently and strive for operational excellence in water quality monitoring.
5. More tests can regularly be performed. In many rural communities, drinking water supplies are tested weekly. This is influenced by the reality that there is a scheduled delay in receiving test results due to demands of lab services. Using VeloCens™ on-site would enable these communities to perform more tests much quicker ensuring the quality of the drinking water and the health of residents with up-to-date results.
6. Under the current testing system, lifting boil water advisory would take at least a week or two due to the lag in reporting test results. This puts the residents under pressure to ensure their own safe drinking water. Significantly reducing the time needed for lifting boil water advisories would be a relief for these communities.

BUILDING INNOVATION CAPACITY

1. During this project 1.5 FTE staff members were hired - Systems Architect and Back-end Developer who received on the job training related to the water industry; CTO/ R&D Lead critical to carrying out the testing cartridge and reuse/ recycle related tasks.
2. HQPs - It is expected that post-project, 7-10 new HQPs will be trained in various areas such as the production of nanotechnology-based testing chips in large quantities, optimized assembly line, regulatory approval processes and the supply chain related to bacteriological testing of water, etc.
3. Links to existing research facilities at Alberta post-secondary institutions - Research infrastructure, laboratory facilities and office space was provided at the University of Alberta through both the Mitacs and GreenStem programs through which the founders received support. The NanoFAB facility provided important support and equipment to help resolve repeatability issue in the cartridges stemming from the electrical contact between the working electrode (Si chip) and the copper trace.



4. Securing Roshan Water™ intellectual property (see table in Outcomes section). It is also expected that there will be future IP protected, especially when other cartridges are developed to test for different bacteria.

G. RECOMMENDATIONS AND NEXT STEPS

Roshan Water has identified four important next steps that are fundamental to our business operations.

1. Establishing and testing our reuse/recycle program: Our reuse/recycle program is one of the fundamental aspects of our product packaging that was developed during the course of the AI WIP project. It forms part of our circular manufacturing and assembly plan v1. Initial research on operational and Q&A procedures for the reuse and recycle pathways have been completed. In the next two years, these procedures need to be developed, tested, evaluated and refined.
 - a. For the reuse pathway, a cleaning protocol has been developed. We need to work with a laboratory partner to perform a QA/QC analysis (bioburden analysis and residual toxicity test). For each component undergoing the reuse pathway, we envision submitting 20 samples before cleaning procedure, and 20 samples after cleaning procedure for each of the bioburden and toxicity tests.
 - b. For the recycle pathway, discussions are ongoing with different potential partners to determine the initial options.
2. Manufacturing and Assembly Scaleup: We plan to advance the preparations and capability of Roshan Water to controllably manufacture VeloCens™ test analysis devices and test kits, to enable us to ramp up sales into regional markets. Working with a coach/ consultant through the ERIN Coaching Program, we will be developing a systematic approach to manufacturing the devices and test kits on a sustained basis including:
 - a. Plan to create a modest-capacity in-house Product Manufacturing Assembly Line: Roshan Water intends to build test kits and analysis units in-house from purchased components, materials, and certain sub-contracted modules. A plan will be created to guide implementation of a suitable product manufacturing and assembly line to meet company needs cost effectively through 2024.
 - b. Supply Chain Mapping: Roshan Water's supply chain includes suppliers to provide customized cartridge molding, chemical reagents, electronics, software, equipment cases and packaging. To proactively manage our supply chain, supply chain mapping will be introduced as an on-going management tool, and an initial supply chain map will be created.
 - c. Preliminary Plan for Product Quality Management: In due course, Roshan Water will establish a quality management system (such as ISO 9001) to control the consistency of its manufactured products and related documentation. As an initial step, a check list of manufacturing quality control test points will be identified, measurement procedures outlined and performance boundaries established, all aimed to ensure that the final product is fully functional and ready for shipment.
 - d. Approach to Delegate Product Assembly Line Implementation: A step-wise approach will be created to delegate the implementation effort to Roshan staff, yet maintain management oversight.



- 3. Executing a US EPA ATP study plan: Initial study of the US EPA ATP protocols was completed during this project and a condensed summary of the steps required has been developed. In the next two years, the initial application will be made to the US EPA that includes the detailed comparability study plan. Upon the approval of the study plan by US EPA, execution of the plan with laboratory partners will be done and will include 300+ side-by-side tests.
- 4. Further modifications to VeloCens™ electronics: The electronics developed during this project are being used to manufacture the first commercial units. The main criterion in this development work was quick production of custom-made electronics that satisfy our operational needs. However, during the work, several improvements have been identified that will lower the cost and size of the electronics. These improvements will be incorporated into a new design for v4.0 with the goal of scaling manufacturing and assembly.

H. KNOWLEDGE DISSEMINATION

We believe our VeloCens™ technology has the potential to have a significant impact on the water quality monitoring industry, and could lead to a [potential policy change in Alberta and Canada over time](#). In terms of [water management practices](#), the outcomes of this project can potentially inform provincial policies to move towards more stringent bacteriological testing of water samples as VeloCens™ enables higher testing frequency due to faster response times.

According to the [Canadian Drinking Water Quality Guidelines](#) set by Health Canada, the following are the recommended minimum number of the samples per month for bacteriological testing, based on the population:

Minimum recommended number of water samples by Health Canada	
Population served	Minimum number of samples per month
Up to 5,000	4
5,000-9,0000	1 per 1,000 persons
Above 90,000	More than 90 (1 per 10,000 persons)

The fact that VeloCens™ allows municipalities to perform more frequent E-coli and Total Coliform tests onsite at a reduced cost compared to current standard lab tests opens the door for provincial authorities to revisit existing drinking water monitoring policies which seem to be set at a bare minimum level. There is an opportunity for Alberta to be a leader in creating more responsive water monitoring guidelines.

Roshan Water founders gave numerous presentations and interviews and participated in multiple pitch and award competitions over the past 2 years as listed below.



PRESENTATIONS & INTERVIEWS

- 6) AWWOA 2019 Water Week Conference, November 9, 2019; technical presentation introducing VeloCens by Amir Sohrabi
- 7) Alberta On-site Wastewater Management Association Annual (AOWMA) 2020 Convention & Trade show, Feb 6, 2020; technical presentation introducing VeloCens by Amir Sohrabi
- 8) Alberta IMPACT: Technology for Clean and Safe Water - Roshan Water™ Solutions - University of Alberta; February 2020; founder Parmiss Mojjir-Shaibani interviewed by Bruce Lambert
- 9) Alberta Innovates Water Innovation Connect Series: Webinar - Digital Innovation Meets Water Management December 10, 2020, presenter was Amir Sohrabi
- 10) AWWOA 46th Annual Operators Virtual Seminar March 9-11, 2021; a) technical presentation entitled “*Beyond Compliance Towards Operational Excellence: A Panel Discussion on Use Cases of VeloCens™*” given by Amir Sohrabi with panelists Jennifer Lypkie, Utilities Supervisor Yellowhead County and Cory Pepper, Operations Supervisor at Alberta Capital Region Wastewater Commission. b) Roshan Water™ Virtual Trade Show Booth at which we obtained 120 leads which we target in a marketing campaign in the fall 2021.

PITCHES, ACCELERATORS & AWARDS

- 8) Foresight Cleantech Accelerator – 2020-2021 participant in the Pan-Canada waterNEXT WaterTech Support Program
- 9) Threshold Impact Venture Mentor Service (VMS) – May 2020
- 10) Alberta GreenStem program - secured Fellowship for Amir Sohrabi and capital to support Roshan Water- July 1, 2020 to June 30, 2022; GreenStem Fellow is Amir Sohrabi
- 11) Great Alberta Pitch Marathon Clean Tech and Energy stream hosted by GreenStem and ACTia July 30, 2020
- 12) ACTia’s Virtual Clean Tech Pitch and Matchmaking Event September 16, 2020
- 13) Startup TNT GreenStem Pitch Night Jan 21, 2021
- 14) BusinessLink First-Ever Pitch Competition Mar 23, 2021 - Roshan Water Solutions: Winner Immigrant Youth

WEBSITE

Roshan Water™ launched a demand generation website in February 2021. It will be used to drive internet traffic through our sales process. Included on the website is a downloadable 16,000- word article presenting a comprehensive and concise guide to understanding contamination of water sources, especially by pathogens and microbes. It paints a global picture of water contamination and its consequences and delves directly into various pathogens that can be present in water and how they can harm us. Standard water management strategies to solve the issues associated with poor drinking water are described. Special attention has been given to the concept of water quality monitoring and the different tests that have been developed to characterize water samples. Towards the end of this article, standard methods for detection and quantification of E.coli and Total Coliform as standard indicators of microbiological contamination of water are explained. Finally, it describes strategies and requirements for more efficient water quality monitoring, and how new technologies that can deliver water test data onsite and in real-time can revolutionize water quality monitoring programs.



I. CONCLUSIONS

Our overarching project objective was to “Accelerate the path to commercialization for VeloCens™”. While the detailed results of this project have been discussed, we summarize the most important outcomes, learnings and future steps in this section.

KEY RESULTS

Overall, the global trend in the water industry and more specifically in water testing segment is moving towards real-time decision making using onsite/inline, rapid testing of water samples. Moreover, the digitization of the industry has been brought into focus especially due to the limitations and restrictions imposed by the Covid-19 pandemic. This project has advanced scientific and technological fronts of water testing industry in all the aforementioned aspects in the following ways:

1. The underlying test method used in VeloCens™ is a very well-known electrochemical test known as Light Addressable Potentiometric Sensors (LAPS). While LAPS has been studied in scientific articles, this project allowed us to enhance the application of nanotechnology for LAPS and improve its testing characteristics to adhere to standard norms of microbiological testing (1 CFU/100ml level of detection, less than 10% false positive and false negative rates, etc.)
2. LAPS has been used in laboratories using standard electrochemical laboratory equipment. There are a small number of studies for transforming the test method into a product. However, this project allowed us to engage with end-users, understand their needs and the general needs of the industry, and advance the manufacturability of a LAPS test method. While the project started with a simple, handheld concept, the completion of the project marks commercial ready units, that are portable and can test multiple samples at the same time.
3. This project also resulted in significant advancements in how the industry currently captures data. While the current norm uses paper-based chain of custody (COC) forms and manual transcription of data and results, this project allowed us to develop a digital, smart COC and backend database. With the product package that VeloCens™ offers, end-users can make sure all necessary sample information and test results are captured automatically, with little room for error.

KEY LEARNINGS

The main two learnings that formed the direction of the product development in this project are:

1. When the project started, our initial assumption was that most of our end-users will benefit from a handheld unit that they can use in field testing. During this project and, as a results of many customer interviews, it was realized that that end-users are interested in a device that is portable, and more importantly, a device that can test multiple samples at the same time. That is why the current commercial ready products are designed to test either 3 or 5 water samples for E.coli and Total Coliforms at the same time.
2. We knew capturing the test results in a Cloud-based Data Center was critical since, overall, the water industry is moving towards digitization. This project enables us to better understand the needs within the industry and helped us to build out digital tools by adding smart sampling bottles



and truly digital COC forms. With this digital package, every single piece of information about a water sample is captured digitally automatically and available for 24/7 post-test access.

FUTURE STEPS

Although the end of this project marks the completion of our commercial ready VeloCens™ package, we have already identified near and long-term future steps to further improve the product and scale applicability globally.

1. Our current commercial ready units use Raspberry Pi as the central computing system. This option was selected to accelerate the development of the version 3.0 commercial ready products. However, we know the circuitry inside a unit can be redesigned to reduce the cost and power consumption of the system. This future work includes eliminating the Raspberry Pi from the system and evaluating and developing every component of the circuitry ourselves.
2. One of the most important future goals of the company is to deploy VeloCens™ in developing and under-developed countries where contamination of water with bacteria is a major issue. This can only happen if we are able to decrease the costs, especially our cost of the test kits. While the costs will decrease with higher manufacturing volumes, one specific component in the test cartridges is the focus of future R&D. At the moment, Screen Printed Electrodes inside cartridges are purchased and they represent about 30% of the cost of one cartridge. Our future work will entail R&D, developing the knowhow and engaging the required resources to produce these electrodes in-house.
3. The long-term plan of Roshan Water is to undertake the R&D to engineer the cartridges and reagents for detection of other bacteria such as Salmonella, using the same test method platform. In this project, we have obtained invaluable knowhow about how to approach learning processes in the water quality monitoring industry and this can be applied to other industries. This learning will help us in our efforts to develop future testing solutions for different applications such as the Food & Beverage industry.



APPENDIX

VeloCens' Specifications – March 2021

Marketing / Product Infographic – March 2021

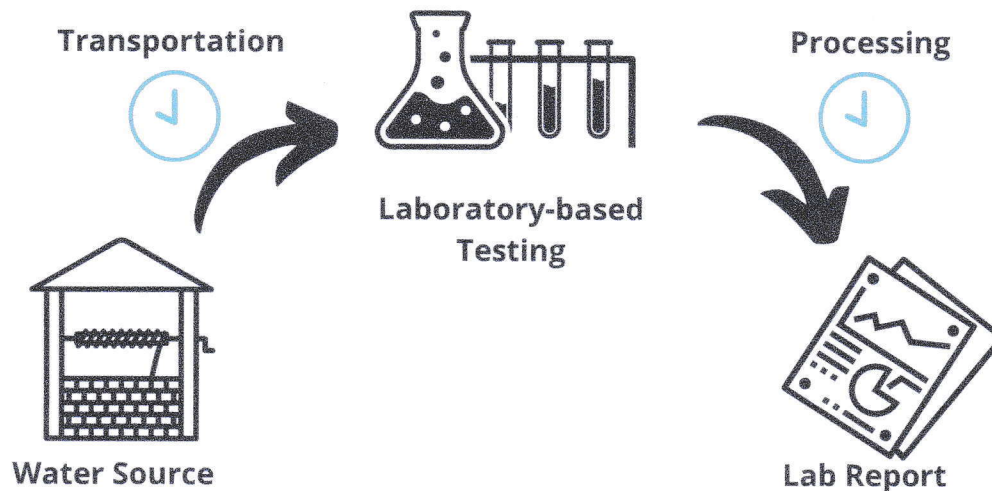


Roshan Water™ Solutions

Clear Water, Bright Future

How E.coli and Total Coliform Tests in Water are Done

Current Solution



Challenges



Delays

24 hours to 1 week to receive test results



Transportation

Of samples to centralized lab



Paper-Based COC

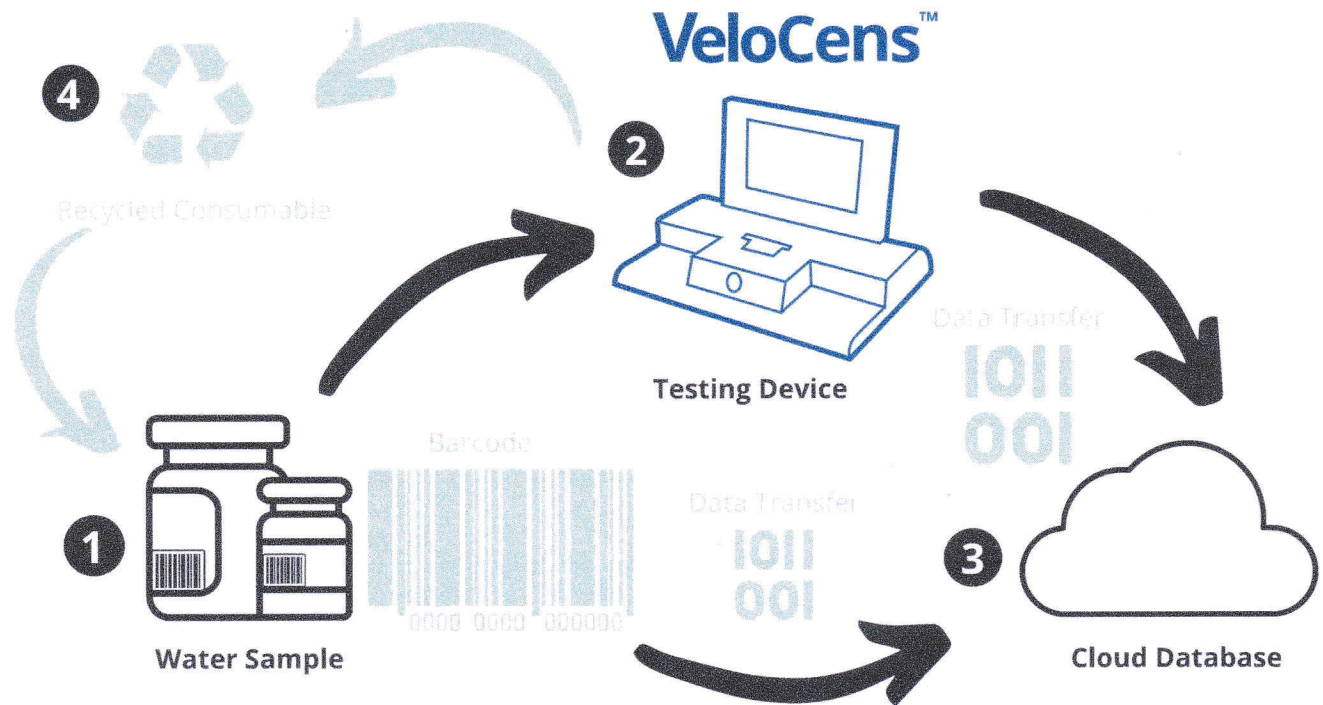
Takes operator time to complete and can lead to errors

- Delays in: communication of potential health risks to citizens; making process adjustments in facilities; and, sign off on infrastructure/repair projects to return systems to operation.
- Risk of compromising sample integrity when not delivered to lab within specified timeframe, due to bad weather or unforeseen travel delays.
- Transcription errors on Chain of Custody (COC) forms lead to sample rejection and requirement of repeat tests.



VeloCens™ Portable Water Testing Lab

Three Easy Steps Let You Know in 1 Hour How Much Bacteria is in Your Water



- 1** Collect samples: Automatic logging of information including date, time and sample collection location.
- 2** On-site, Rapid Testing: Easy to follow instructions to prepare samples for on-demand *E.coli* and *Total Coliform* tests that provide enumerated results in 1 hour.
- 3** On-line Results: Log in to your data center account 24/7 to see all test locations and results.
- 4** Reuse and Recycle: Return all consumables to us with the return shipping label we provide and we will take care of the rest!

Want to know more about how VeloCens™ works?
Get in touch with us!



VeloCens™ 3-T

ITEM	DESCRIPTION
# Simultaneous Tests	3
Dimensions	When display is fully open (LW x H): 40.64cm (16") x 22.86cm (9") x 24.13cm (9.5") When the display is closed (H): 11.43cm (4.5")
Weight	4.20kgs (9.25lbs)
Detection Level (<i>E. coli</i> & <i>Total Coliform</i>)	1 CFU/100 ml
Material	Anodized Aluminum
Input Voltage	9-18 VDC
Input Power	35.5 W
Lifetime	7-10 years
Standards Alignment	IP66
Touchscreen	29.46cm (11.6") Capacitive Touchscreen (Resolution: 1920 x 1080)
Internet Connectivity	Both Wifi and LAN

SETUP COMPONENTS	DESCRIPTION
Carrying Case	The device and test kit supplies are shipped and stored in this case. Dimensions: 82.5cm (32.5") x 53.3cm (21") x 31.2cm (12.28") Weight: 13kg (28.6lbs)
Mat	Set up the equipment and supplies on the mat in pre-labelled spots. Dimensions: 47cm (18.5") x 104.1cm (41")
Syringe Holder	During the preparation stage, large and small syringes are placed on the holder to ensure they are not contaminated during handling. Dimensions: 20cm (7.9") x 10cm (3.9") x 4cm (1.6")



VeloCens™ 5-T








ITEM	DESCRIPTION
# Simultaneous Tests	5
Dimensions	When display is fully open (LWH): 60.96cm (24") x 22.86cm (9") x 24.13cm (9.5") When the display is closed (H): 11.43cm (4.5")
Weight	4.54kgs (10lbs)
Detection Level (<i>E. coli</i> & <i>Total Coliform</i>)	1 CFU/100 ml
Material	Anodized Aluminum
Input Voltage	9-18 VDC
Input Power	35.5 W
Lifetime	7-10 years
Standards Alignment	IP66
Touchscreen	29.46cm (11.6") Capacitive Touchscreen (Resolution: 1920 x 1080)
Internet Connectivity	Both Wifi and LAN

SETUP COMPONENTS	DESCRIPTION
Carrying Case	The device and test kit supplies are shipped and stored in this case. Dimensions: 82.5cm (32.5") x 53.3cm (21") x 31.2cm (12.28") Weight: 13kg (28.6lbs)
Mat	Set up the equipment and supplies on the mat in pre-labelled spots. Dimensions: 47cm (18.5") x 104.1cm (41")
Syringe Holder	During the preparation stage, large and small syringes are placed on the holder to ensure they are not contaminated during handling. Dimensions: 20cm (7.9") x 10cm (3.9") x 4cm (1.6")



Test Kit Components

Replacement Test Kit supplies for the VeloCens™ unit are ordered in groups of 10 and stored on-site. Used Test Kits are returned to Roshan Water™ for recycle and reuse.

Test Kit Components	
<p>Test Kit Box Dimensions (LWH): 22.9cm (9") x 10.2cm (4") x 7.6cm (3")</p> 	<p>Water Sample Collection Bottle (x1)</p> 
<p>Test Cartridge (x2) - One for E.coli - One for Total Coliform</p> 	<p>Eyedropper (x2) - One contains Solution B-E - One contains Solution B-T</p> 
<p>Large Syringe (x2)</p> 	<p>Small Syringe (x2)</p> 
<p>Syringe Filter (x2)</p> 	<p>Vial (x2) - One contains Solution A-E - One contains Solution A-T</p> 