H20 RESOLUTIONS LLC

Project no:		01	
Registration title: (Max 150 characters)		Design and development of the new software system	
Date updated:		15 September 2014	
Project manager:		John Smith	
Start Date:	01 July 2013	**Finish date:**	30 June 2014

1. Hypothesis and technical objectives **(Max 4000 characters)**

H20 Resolutions LLC ("H20 Resolutions") is an America-based engineering consultancy. The company specializes in water engineering and offers a comprehensive range of world-class engineering solutions for water management.

WWHS is a desktop software system developed by H20 Resolutions that simulates real-world operations of water systems. The system runs on a model that requires user-established operational rules for simulation. That is, the user inputs data that they have recorded over a period of time as operational rules or parameters for the model to work. The simulation model is used to quantify how forecast weather conditions may affect both natural and industrial/mine water resource systems, aiding technicians and managers in planning site operations.

The issue with the WWHS system was (1) the accuracy or sensitivity of the forecast is reduced because it is based on only historical data and (2) the system requires manual collection and input of data.

In FY13, two key components were developed with purpose of enabling the WWHS system to provide more accurate and useful forecast by developing a simulation model that interfaces with external systems that collected real-time data to produce real-time analysis of that data, based on the user's requirements. These components were developed separately:

- Technology for the continuous simulation of natural streamflow — which was a project that investigated the potential of linking the WWHS with a real-time data database, leveraging the capabilities of both systems to develop a platform upon which users can generate sensitive future possibilities of what might occur.
- Forecast of operational windows with real-time data — which was a project that investigated the potential of creating a system that works with real-time continuous simulation of stream flows combined with some forecasting to keep mine operators informed of likely scenario of circumstances, well ahead of the suitable release window, giving mine operators adequate time to prepare mine-affected water (i.e. readjust the quality of water) for release into the receiving water environment.

In FY14, the two development streams converged and development was conducted on the WWHS system as a whole to ensure that the key components are compatible with each other and will be able to function as one product suite.

The main technical objective is to design and develop the WWHS as a risk-based management platform that can forecast operational windows on a risk based platform with real-time adaptation.

Specific technical objectives pertain to the key areas of development:

- Create a command line 'language' to allow silent control/ operation of WWHS from an external concurrently running software application.
- Develop the technology and methodology to automatically adapt the operation of WWHS in response to real-time data inputs provided by an external data source (real-time adaptive simulation).
- Prove up and implement a prototype a cloud-based type application server for WWHS
- Development of a methodology to best utilize Bureau of Meteorology spatial forecasts of

rainfall (both percentage of chance data, or raw ensemble type data sets)

- Develop a technique to feed back WWHS simulation outcomes to an external concurrently operating software application.
- Integrate the technology for the continuous simulation of natural streamflow into the WWHS software.
- Quantifying the net "skill" of the system in comparison with existing industry practice.

2. New knowledge generated **(Max 4000 characters)**

The main item of new knowledge is in the form of the WWHS as a risk-based management platform that can forecast operational windows on a risk based platform with real-time adaptation.

Specific items of new knowledge generated from undertaking the project are listed below. They pertain to the knowledge required to design and develop this new system:

- Understanding of how to design and develop an interface that will automatically input real-time data from an external system into the WWHS system.
- Understanding of methods to allow real-time communication between WWHS and an external database to allow automatic adaptive simulation and outcome forecasting.
- Understanding of how to utilise Bureau of Meteorology spatial rainfall data for the purposes of real-time adaptive simulation and confidence based forecasting
- Understanding of methods to allow turn-key interfacing with an external monitoring database for the purposes of providing automatic simulation and forecasting services with flexibility and simplicity
- Understanding of how cloud-based type access to software like WWHS can increase utilization and assimilation of real-time data and forecasts for management and operational decision making purposes

As a result, new knowledge is also generated in the form of the improved management of industrial/mine operations, as the ability to consider potential climatic situations will allow site managers to decide with more certainty what activities they can conduct (operational windows) based on the climatic situation(s) that may occur.

3. Unknown outcome **(Max 2000 characters)**

Besides the lack of comparable systems available, the outcomes of the core activity in this project could not have been known or determined due to a number of specific technical challenges:

- Ability to enable WWHS to interface with an external system in a turnkey manner.
- The accuracy and integrity of forecast using real-time, continuously changing data; i.e. the adaptation of data between model simulation and actual occurrences to produce sensitive forecasts with varying degrees of confidences.
- The accuracy and integrity of forecast using data from an external source that collects data from disparate sources. For example, in using the data from the Bureau of Meteorology (BOM) the challenge is in enabling the system to interpret a foreign set of data (to the WWHS) in a rational way, as BOM is known to have two sets of data; i.e. best estimate data and conservative data.
- Integration challenges: How to interface the time-stamp calculations with the incoming data feed, and accommodating for the variable times in which users may want the information (or reports) sent to them.
- The net "skill" of the system, when applied to real world systems, meets with industry expectations.

4. Research and development activities

The company believes the new WWHS system can be achieved by conducting the following stages of experimental activities:

- Background research to evaluate current knowledge gaps and determine feasibility.
- Design and development of a series of prototypes to achieve the technical objectives.
- Trials and analysis of data to achieve results that can be reproduced to a satisfactory standard and to test the hypothesis.
- Ongoing analysis of customer or user feedback to improve the prototype design.

R&D activities description (Max 2000 characters)	**Start date** (Original)	**End date** (Expected)
Background research for the development of WWHS system • Literature search and review of relevant, existing technology. • Consultation with industry professionals and potential customers to determine the level of interest and commercial feasibility of such a project. • Preliminary equipment and resources review with respect to capacity, performance and suitability for the project. • Examination of key environmental database systems to determine the factors that may inform the design of the interface/capacity required to interface with those systems.	**Jul 2013**	**Jun 2014**

R&D activities description (Max 3000 characters)	**Start date** (Original)	**End date** (Expected)
Development and testing of WWHS's real-time assessment capabilities **Hypothesis:** If the system can be developed to interface with external systems that collected real-time data, it will be able to provide more accurate and useful forecast. **Activities:** Data acquisition testing was conducted with a test partner. The intention was test the system's ability to undertake adaptive simulation on a discrete time-step basis while keeping it aligned with the real-time data that is being feed into the system from the external database. The system was designed to connect to large system and process data at about 1-hour intervals. However, the test partner wanted the system to be connected to a smaller system (flue instead of dam system). **Key observations:** • Observed that the data collection and data analysis process were out of synch with each other. • In connecting with the smaller system, data had to be processed at an interval of 1 min. • The synchronization issue was identified as a problem with the system's communication interface protocol. Further development to tighten up the communication process was required. The solution was to make WWHS produce status reports that the external software can look into if it wanted to. This solution is enabled by developing shorter time stamps. • The main difficulty in this process was trying to interface the time-stamp calculations with the incoming data feed, and accommodating for the variable times in which users may want the information (or reports) sent to them. **Conclusions:** • The time-stepping techniques of the software have been adapted, so that it can work from a wide range of time stamps (from 1 min to 1 day). • Testing of WWHS's full real-time assessment capabilities must be conducted by connecting the full system up to another system that manages the acquisition of the data and see if they can communicate in a meaningful way. The planned staged testing process involves: o Laboratory trials, where the system is connected to equipment that monitors the water that flows between two tanks. Anticipated development post laboratory testing is the fixing of implementation errors and issues; and then o Field testing on a system that is in use in the real world.	**Jul 2013**	**Jun 2015**

Development of the WWHS system for a cloud-based environment
 	
Hypothesis: Whether such an intricate system can be developed for remote accessed over the internet, without any human involvement.
 	
Activities:
 	
• Proved up and implement a prototype a cloud-based type application server for WWHS. Key considerations:
  ○ The main software is protected by encryption key and licensing that is provided through a physical dongle. Whether the same level or perceived level of security can be achieved in the cloud.
  ○ Whether the communications will be stable over a range of internet networks.
• Development of user interface using Windows.
 	
Key observations/conclusions:
 	
• User testing revealed poor responses to perceived level of security. Potential solutions to be considered:
  ○ Installation of software in a third-party data center; or
  ○ Enable the system to be offered via cloud access or installation onto client server.
• Licensing component of the system is still provided through a dongle. This may be a problem if there is a lack of a USB port.
	Jul 2013	**Jun 2015**

Development of an additional trial feature
 	
Hypothesis: Whether the system can be enabled to extrapolate historical data to produce probabilities that are lower than those typically afforded by the available historical data.
 	
To compare data, the system must be able to statistically analyze the output, which is the historical data. Therefore, probabilities produced are contingent on the amount of historical data available. If 100 years of data is available, a 1 out of 100 probability may be calculated, but no lower.
 	
This feature is designed to extrapolate simulated outcomes for the lower probabilities.
 	
Activities:
 	
• Development of user interface using Windows, as this feature is enabled as part of the user interface. No current issues with user interface; however, the existing Windows software may not have enough capacity or functionality to support system's increasing capabilities.
• Development of feature involved the testing of several methods, including:
  ○ The annual exceed probability technique, which involves picking out the highest value in every year.
  ○ Confidence analysis, which involves creating a time-series envelope from the available data. This gives the user the confidence that the real value will not be any more than what is encompassed by the envelope (i.e. under the curve). This method is a different angle at looking at the data, which has not been applied in this context.
	Jul 2013	**Jun 2015**

Key observations/conclusions: • The confidence analysis provides more feedback in terms of interpretation. Rather than just picking up peak value of the year, it assesses how those values change over the year. This method is selected as the more accurate option. • In FY14, we tried to extrapolate the limited available data from a NT dam to produce a probability of 1 in 1,000,000. The technique appeared to be able to provide the client the type of information required. • Further trials required to determine accuracy of probabilities produced for similar situations, as well as the method's effectiveness in other scenarios.		
Development of simulated rainfall **TBA – FY15 development**	**Jul 2014**	**Jun 2015**

R&D activities description (Max 2000 characters)	**Start date** (Original)	**End date** (Expected)
Feedback R&D of the WWHS system • Ongoing analysis and testing to improve the efficiency and safety of the project: ○ Development of tutorial document to assist in the users in using the new system. • Ongoing development and modification to interpret the experimental results, and draw conclusions that serve as starting points for the development of new hypotheses. • Commercial analysis and functionality review.	**Jul 2013**	**Jun 2015**
Relationship with core activities • The feedback is necessary to evaluate the performance capabilities of the new design in the field. • The feedback is necessary to improve any flaws in the design.	Directly related	

5. Plant and facilities

The research and development is undertaken at H20 Resolutions' facilities in XXXXX, USA.

6. Substantiation

Please be aware that, under the current legislation, you must be able to provide evidence to substantiate your R&D activities. In the event of an IRS audit, this documentation may be required to prove that the R&D activities were eligible and took place in a systematic progression of work. We strongly recommend that you store this evidence in a safe place.

Please confirm which of the following documents you have available.

You do not need to send us any of these documents.

Yes / No / Not applicable	Type of substantiation
No	Literature review
Yes	Background research
Yes	Meeting notes or minutes or progress reports
Yes	Project records / laboratory notes
Yes	Design documents for system architecture and source code
Yes	Conceptual sketches
Not Applicable	Design drawings
Not Applicable	Photographs / videos of various parts or components
Not Applicable	Photographs / videos of various stages of build / assembly / testing
Not Applicable	Photographs / videos of initial or intermediate prototypes
Not Applicable	Photographs of completed models
Not Applicable	Prototypes
Yes	Screenshots of various build versions / final version
Yes	Testing protocols
Yes	Results or records of analysis from testing / trial runs
No	Records of resource allocation / usage logs
Yes	Staff time sheets
Yes	Tax invoices
Not Applicable	Patent application number