Determining Total Volume of Grit within Bioreactor

I. Introduction

Bathymetry surveys were performed of two bioreactors at Wastewater Treatment Works to determine the total volume grit deposited. The survey methods applied during the bioreactors surveys comprised of bathymetric and topographic survey techniques.

This technical note gives a broad overview of the equipment and surveying techniques used during the survey process, as well as the methodology followed in developing surface elevation models and calculating total volume of grit in each bioreactor.

Fig. 1. Bioreactors.

II. Survey Control

A. Survey Equipment

The equipment chosen for the surveys consisted of two Global Navigation Satellite System (GNSS) Smart Antenna's (Hemisphere S321), CEE HydroSystems CEESCOPE with dual frequency echo sounder, rQPOD with autonomous navigation and Castaway CTD for salinity and temperature measurements. The software utilized during the surveys comprised of HYPACK® Hydrographic Survey and Carlson SurvCE software respectively.

GNSS

The base station GNSS Smart Antenna was setup over a known survey marker using tripod and tribrach shown in *Figure 2*. The base station was configured based on survey marker coordinates (MGA94) and elevation (AHD) and instrument height using SurvCE software.

The rover GNSS Smart Antenna was setup on either rQPOD or survey pole with the exact height of the GNSS antenna configured in the survey software.

Fig. 2. Hemisphere S321 Smart Antenna.

Echo Sounder

CEESCOPE and M195 Dual Frequency echo sounder from CEE HydroSystems shown in *Figure 3* was mounted on unmanned surface vehicle (USV) for the bathymetric component of the survey. The data was transmitted from the CEESCOPE to land based HYPACK® Hydrographic Survey software using CEE-LINK™ shore radio module.

Autonomous rQPOD was used for the USV for the bathymetric component shown in *Figure 4*. A special mounting was designed for the M195 echo sounder to fit into the existing instrument wet-well.

The line plan developed in HYPACK® Hydrographic Survey software was uploaded onto rQPOD. This enabled rQPOD to track the lines autonomously during the bathymetric survey ensuring much higher efficiency in performing the surveys.

Fig. 3. CEESCOPE & M195 Dual Frequency Echo sounder.

Fig. 4. Autonomous rQPOD.

B. Survey Control Design

The horizontal and vertical survey control for the bioreactor surveys were based on two survey markers shown in *Figure 5*. The position of the survey markers was selected based on on Real Time Kinematic (RTK) survey requirements.

Fig. 5. Location of Survey Markers.

C. Horizontal and Vertical Control

The two survey markers were established using Static Global Navigation Satellite System (GNSS) survey technique, collecting more than 2 hours of raw satellite data at each survey marker. The raw satellite data was collected using Hemisphere S321 (multi-GNSS, multi frequency) receiver, shown in Figure 2. The data collected during the static survey was converted to Receiver Independent Exchange Format (RINEX) format from where it was uploaded to the AUSPOS post processing facility on the Geoscience Australia website.

III. Bathymetry Survey

A. Survey Procedure

The topographic surveys were performed using Hemisphere S321 Smart Antennas and data collector shown in *Figure 6*.

Fig. 6. Top of Bank Survey.

The elevation of top of bank of both bioreactors compare very well with the information provided in as-built drawings. The average surface elevation from the topographic surveys performed is 6.874mAHD, in relation to the 6.9m provided in as-built drawings.

The bathymetric surveys were performed using CEE HydroSystem with dual frequency echo sounder, Hemisphere S321 and Hypack bathymetric software, shown in *Figure 7*. The dual frequency echo sounder comprised of 200KHz (high) and 33KHz (low) acoustic Doppler transducer.

Fig. 7. rQPOD Platform.

The reflection from the high frequency transducer was used to determine the surface elevation of the sludge. The low frequency can penetrate unconsolidated sediment / sludge and reflection was used to determine the surface elevation of grit.

B. Data Collection

The bathymetric survey comprised of predefined survey lines at each bioreactor developed within HYPACK® software. Individual measurement files containing all the raw data from the Hemisphere S321 and CEEHydroSystems echo sounder were created in Hypack for each of the planned lines.
The actual ship track of the autonomous rQPOD is shown in *Figure 8*.

The topographic survey comprised of the elevation of top of bank at fixed intervals, with a total of 142 points surveyed. Position and elevation of each point during the top of bank surveys were recorded using Hemisphere data collector and SurvCE software.
The individual points surveyed during the top of bank surveys are shown in *Figure 9*.

Figure 8: Bathymetric Survey.

Figure 9: Topographic Survey.

C. Water Elevation

The water elevation was relatively constant during the surveys in each of the respective bioreactors. Water elevation was surveyed at each bioreactor and the average elevation in meters AHD is supplied in *Table 1*.

Bioreactor	Surveyed Points	Elevation (mAHD)
1	6	5.850
2	5	5.531

Table 1: Water Elevation

D. Speed of Sound

CTD profile measurements (conductivity, temperature, and depth) were performed at each bioreactor before the start of the respective bathymetric surveys with CTD CastAway, shown in Figure 10.

The conductivity, temperature and depth measurements from each profile measurements were used to calculated speed of sound. Speed of sound is used to correct depth measurements from acoustic Doppler instrument.

CTD profile measurements were performed from the service bridges across each of the bioreactors.

The CTD instrument was lowered using a rope to perform the profile measurements, shown in *Figure 11*.

Fig. 10. Castaway.

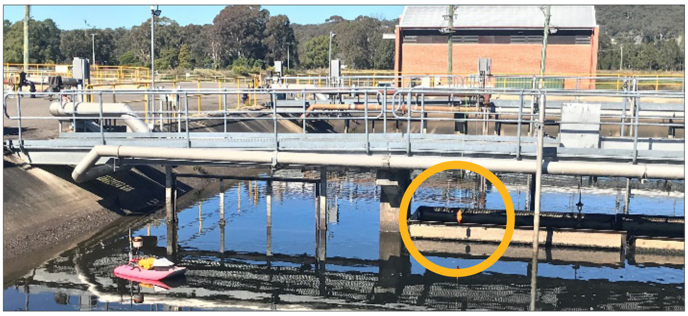

Figure 11: Location of Profile Measurements.

The temperature and conductivity measurements from the CTD casts for bioreactor 1 and 2 are shown in *Figure 12* and *Figure 13* respectively.

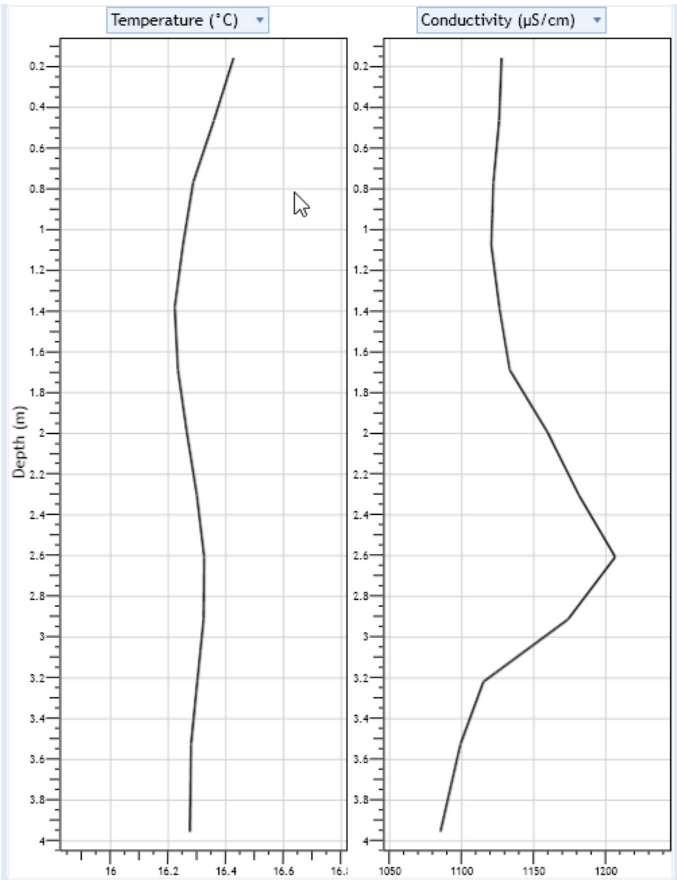

Figure 12: Bioreactor 1 CTD Measurement.

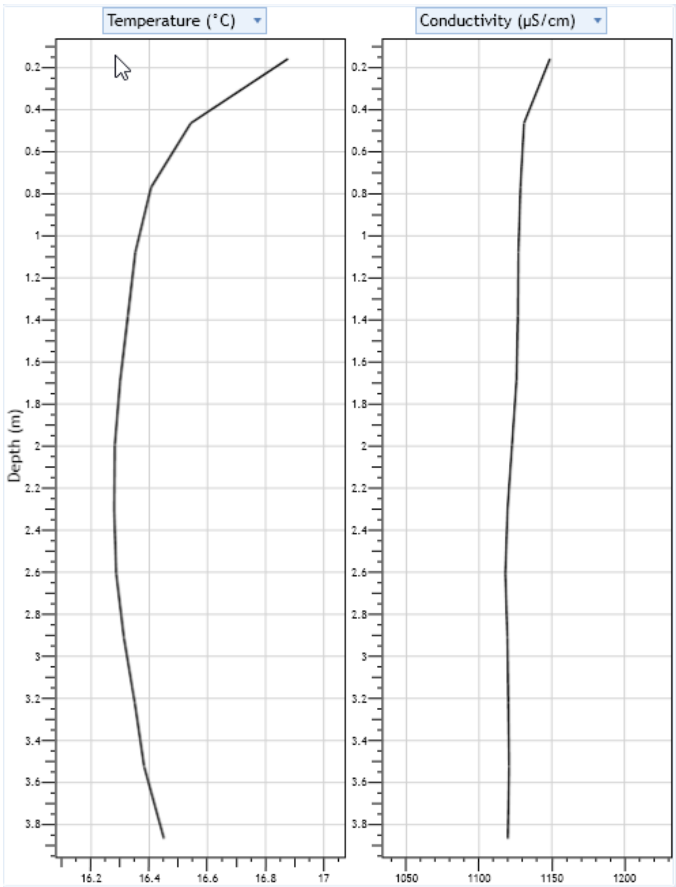

Figure 13: Bioreactor 2 CTD Measurement.

IV. Surface Elevation Model Development

A. Sludge

Sludge surface elevation models were developed for each of the respective bioreactors from the XYZ soundings of the high frequency echo sounder, topographic surveys, and as-built drawings.

3D Sludge surface elevation model of bioreactors is illustrated in *Figure 14*.

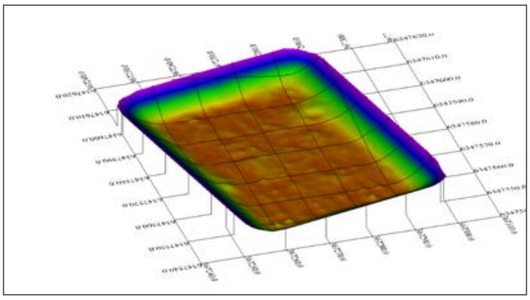

Figure 14: 3D Sludge Model.

B. As built

As-built surface elevation models were developed for each of the respective bioreactors from the XYZ soundings of the topographic surveys and as-built drawings, illustrated in *Figure 15*.

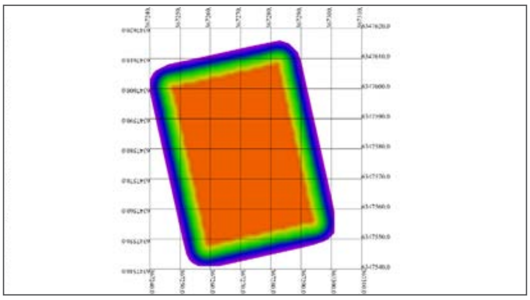

Figure 15 (A): As-built Model.

C. Grit

Grit surface elevation models (TIN Model) were developed for each of the respective Bioreactors from the XYZ soundings of the low frequency echo sounder, topographic surveys and as-built drawings.

The maximum elevation of the grit surface elevation models were restricted at 3m AHD. The restriction was implemented to assess the grit elevation in relation to the bed of the Bioreactor.

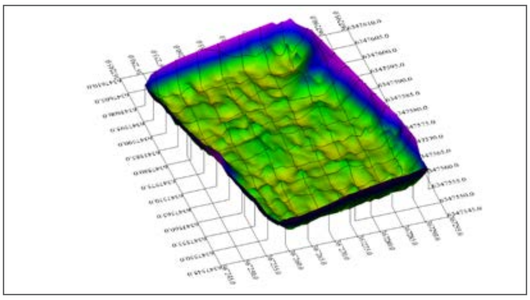

Figure 15 (B): 3D Grit Model.

D. Sludge Volume

Volume and Area calculation was performed between Sludge, Grit and As-Built Surface Elevation models for the two Bioreactors. The volume and area of total sludge and grit is summarized in *Table 2*.

Product	Bioreactor	Volume Above (m3)	Area Above (m2)	Volume Below (m3)	Area Below (m2)
Combined (Sludge + Grit)	1	906.400	3115.800	11.600	387.200
	2	627.400	3065.300	13.800	455.200
Grit	1	580.700	2083.700	11.200	113.800
	2	537.400	2149.700	4.100	46.300
Sludge	1	325.700	-	-	-
	2	90.000	-	-	-

Table 2: Sludge / Grit Volume and Area Calculation.

V. Conclusion

The survey equipment and methodology applied by Xylem Water Solutions to determine the total volume of sludge and grit within bioreactors 1 and 2 at the Wastewater Treatment Works was suitable. The following key factors need to be highlighted in relation to the surveys performed,

- The settling time of 1 hour is not sufficient for the suspended solids fully settle before the start of the bathymetry survey. This was evident from the survey results at bioreactor 1, where the first section of the bathymetry survey reported much higher surface elevation of the sludge. Bioreactor 2 survey started approximately 1 hour 20 minutes after the aeration process was stopped and the artificial high surface elevation of the sludge was not present. It is recommended that the settling time to be increased to 1.5 – 2 hours to ensure full settlement of suspended solids have taken place.
- The water depth in both bioreactors were sufficient for the low frequency of the dual frequency echo sounder to fully propagate through the water column. The minimum water depth required for the low frequency is between 2 -3m water depth.
- The infrastructure at both bioreactors impacted the use of the autonomous feature of the rQPOD remote control platform. The size of the bioreactors made it feasible to use the remote control instead of the autonomous feature to operate the rQPOD. The survey quality was not affected by manually controlling the rQPOD with a remote control and is a solution for future surveys.