Determining Total Volume of Sludge in Wastewater Ponding Lagoons

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I. INTRODUCTION

Surveys were performed of three Wastewater Ponding Lagoons and a TWM storage lagoon at Kalgoorlie-Boulder Wastewater Treatment Plant (WWTP) to determine the total volume of sludge. The volume of sludge at each lagoon was calculated based on surface elevation model developed from land survey and as-build drawing.

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 sludge in the respective wastewater ponding lagoons.

II. SURVEY CONTROL

A. Survey Equipment

The equipment chosen for the surveys consisted of two Global Navigation Satellite System (GNSS) receivers, CEE HydroSystems CEESCOPE with dual frequency echo sounder and rQPOD with autonomous navigation. The survey software utilized during the surveys consisted of HYPACK® Hydrographic Survey and Carlson SurvCE software respectively

GNSS

Base Station: Hemisphere S321 Smart Antenna was setup precisely over a known survey marker using tripod and tribrach shown in **Figure 1**. The coordinates and elevation of the survey marker and height of GPS Antenna was entered into the SurvCE software to reference the survey against known datum.

Rover: Hemisphere S321 Smart Antenna was setup on either rQPOD or survey pole with the exact height of the GPS antenna entered into the survey software.

Fig. 1. Hemisphere S321 Smart Antenna

Fig. 2. CEESCOPE & M195 Dual Frequency Echo sounder

Echo Sounder

CEESCOPE and M195 Dual Frequency echo sounder from CEE HydroSystems shown in **Figure 2** 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 3**. 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 track the lines autonomously during the bathymetric survey ensuring much higher efficiency in performing the surveys.

Fig. 3. Autonomous rQPOD

B. Survey Control Design

The horizontal and vertical survey control for the bathymetry surveys at Kalgoorlie-Boulder WWTP was based on two survey markers, 101 and 103 shown in **Figure 4**. The position of the survey markers was selected based on requirements for Real Time Kinematic (RTK) survey technique that was used for both topographic and bathymetric surveys.

Fig. 4. Location of Survey Markers

C. Horizontal and Vertical Control

The two survey markers were established using Static 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) Smart Antenna. The data collected during the static surveys were converted to RINEX format from where it was uploaded to the AUSPOS post processing facility on the Geoscience Australia website.

D. Survey Localization

The results obtained from Geoscience Australia of the static surveys performed at the survey markers showed a higher accuracy in position and elevation at survey marker 103. Based on the higher accuracy survey marker 103 position and elevation was used to localize the entire survey.

III. BATHYMETRY SURVEY

A. Survey Procedure

The survey procedure at each of the lagoons comprised of a topographic and bathymetric component. The topographic component consisted of surveying the top of bank and water elevation and the bathymetric component consisted of surveying the sludge elevation.

The topographic survey was performed by surveying elevation at top of bank and water level every 10 steps.

The bathymetric survey area was defined by a boundary based on actual measurements from where a line plan was developed at 10m grid intervals shown in **Figure 5**

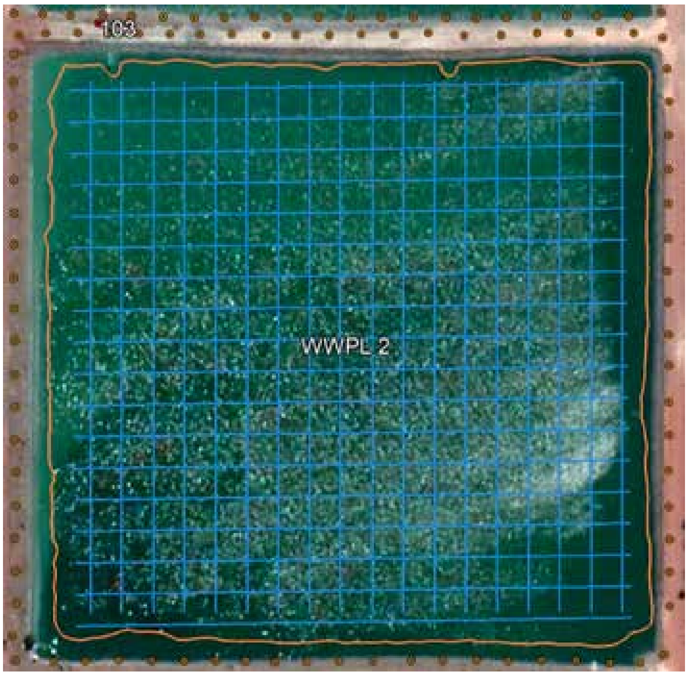

Fig. 5. Border and Line Plan

Fig. 6. Fig. 6. rQPOD Platform

The topographic and bathymetric surveys was based on RTK survey technique, using Hemisphere S321 Smart Antenna's.

The bathymetric survey was performed using CEE HydroSystem with dual echo sounder and HYPACK® Hydrographic Survey software. The survey vessel consisted of rQPOD remote control platform with autonomous feature shown in **Figure 6**.

B. Water Elevation

The water elevation was relatively constant during the surveys in each of the respective lagoons. The inlet and outlet gates was completely open, ensuring that any inflows that may occur is discharged. Water elevation was surveyed at each lagoon and the average elevation in meters AHD is supplied in **Table 1**.

TABLE 1: WATER ELEVATION

Lagoon	Surveyed Points	Elevation (mAHD)
WWPL1	80	334.825
WWPL2	94	332.591
WWPL3	97	332.578
TWM	41	333.421

IV. MODEL DEVELOPMENT

A. TIN Model

TIN Models were developed for each of the respective lagoons in HYPACK® Hydrographic Survey software. The models were based on the XYZ soundings from both the bathymetric (dual frequency echo sounder), topographic surveys and as-build drawings.

The TIN Models developed was the main source for all generated outputs in HYPACK® Hydrographic Survey software. Wastewater Ponding Lagoon 1 sludge surface elevation TIN Model is illustrated in **Figure 7**.

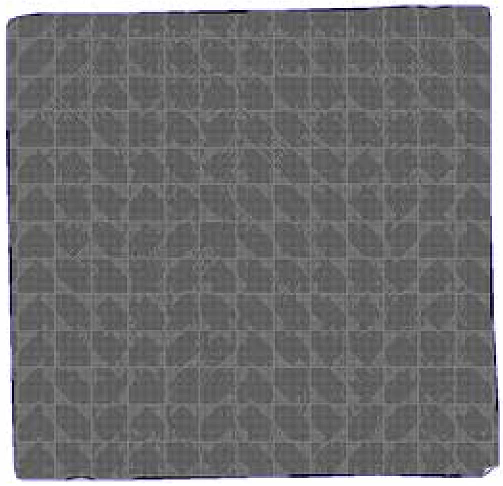

Fig. 7. TIN Model

B. Sludge Surface Elevation

Sludge surface elevation were developed from the respective TIN Models for each of the lagoons shown in **Figure 8**.

Elevation color scheme range of 330.50 – 337.00m AHD was adopted for all four lagoons. This clearly shows the difference in elevation of the sludge surfaces between the four lagoons

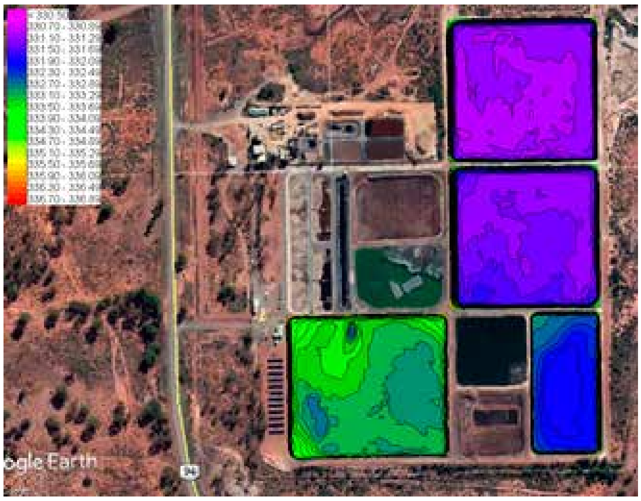

Fig. 8. Sludge Surface Elevation

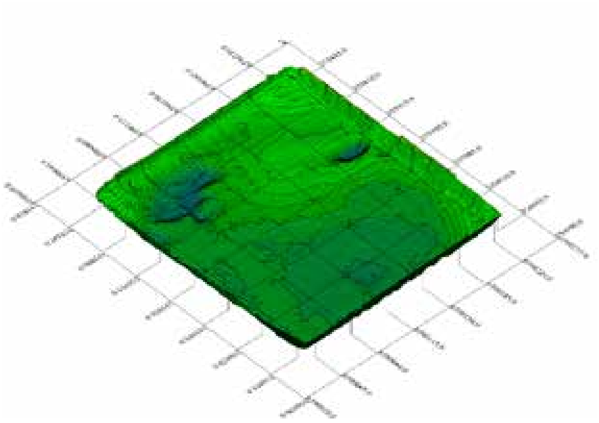

Fig. 9. 3D Sludge Surface Elevation

3D Sludge surface elevation of Wastewater Ponding Lagoon 1 is shown in **Figure 9**.

The discharge locations into Wastewater Ponding Lagoon 1 is clearly evident from the scoured locations within the lagoon.

C. As-build Surface Elevation

As-build surface elevation were developed from the respective TIN Models for each of the lagoons shown in **Figure 10**.

The floor level of the respective ponds are summarized in **Table 2**

TABLE 2: FLOOR LEVEL

Lagoon	Floor Level (mAHD)
WWPL1	332.74
WWPL2	331.34
WWPL3	331.34
TWM	331.89

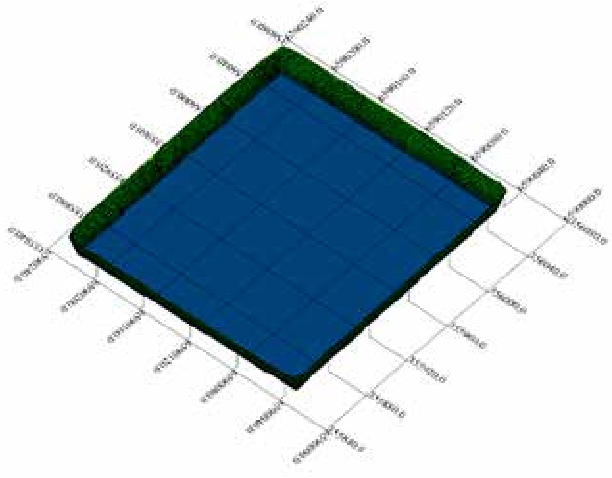

Fig. 10. As-build Surface Elevation

D. Sludge – As-Build Elevation

Section across the width of Wastewater Ponding Lagoon 1 in line with the discharge point shown in **Figure 11**. The difference in elevation between the sludge surface and as-build shows the scouring taking place at discharge location

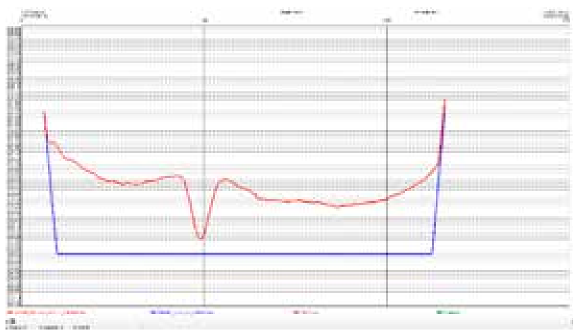

Fig. 11. WWPL 1 – Width Cross Section

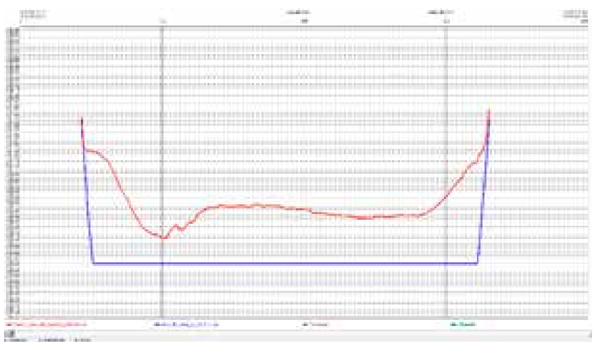

Fig. 12. WWPL 1 – Diagonal Cross Section

Section diagonally across Wastewater Ponding Lagoon 1 shown in **Figure 12**.

The buildup of sludge is evident compared to the as-build elevation in the lagoon.

E. Sludge Thickness

The sludge thickness was determined by developing an elevation model for Sludge Surface and the As-Build drawings of the lagoons. The difference in elevation between sludge surface and as-build elevation models resulted in the total thickness of the sludge at each of the lagoons. The total sludge thickness at Wastewater Ponding Lagoon 1 is depicted in **Figure 13**.

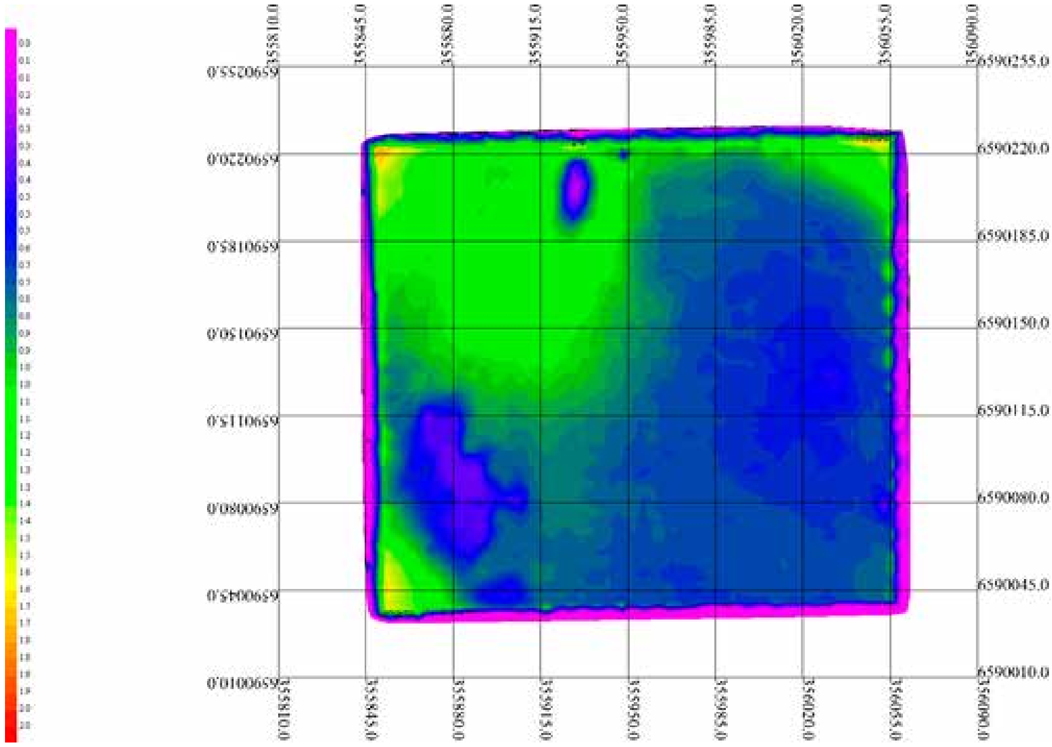

Fig. 13. WWPL 1 – Sludge Thickness at Wastewater Ponding Lagoon 1

F. Sludge Volume

Volume and Area calculation was performed between the difference of the Sludge Surface Elevation and As-Build models for the three Wastewater Ponding Lagoons and TWM storage lagoon. The volume and area of total sludge is summarized in **Table 3**

TABLE 3: SLUDGE VOLUME AND AREA CALCULATION

Lagoon	Volume Above (m^3)	Area Above (m^2)	Volume Below (m^3)	Area Below (m^2)
WWPL1	31761.9	41781.4	282.3	1047.2
WWPL2	10851.4	35830.6	240.3	1462.9
WWPL3	3144.6	28132.5	750.2	10404.3
TWM	7594.5	17120.1	173.0	635.5

The volume and area above is the total amount of sludge above the floor level supplied in Table 2. The volume and area below is the total volume below the floor level.

The volume below for WWPL1, WWPL2 and TWM could be a combination of the actual floor level and the accuracy of as-build model developed. WWPL3 was the only lagoon that showed clear difference in the actual floor level and the as-build elevation and the reason why the volume below is more than the other lagoons.

V. CONCLUSION

The integration between HYPACK® Hydrographic Survey software, CEE HydroSystems and rQPOD makes it an ideal package for general and specialized bathymetric surveys. The hardware setup and software configuration is very simple, which shows that the integration between the different products is perfect.

Stunning sunset, event at wastewater treatment plant

Let's Solve Water

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