Bathymetry Projects: Hydrographic Survey or Land Survey Approach?

Shallow water bathymetric surveys with single beam echo sounders are typically undertaken with two generic types of equipment setup, that we broadly classify as either "Hydrographic Survey" or "Land Survey". The hydrographic approach provides better quality control, reduced opportunity for error, and more detailed results but with a more complex setup. The land survey approach is lower cost, can be easier, but can leave more uncertainty in the finished survey. The process overview and strengths and weaknesses of each methodology are discussed here.

Surveyors undertaking bathymetry surveys, especially those coming from a land survey background are naturally attracted to methods that involve maximum commonality with existing land survey procedures and equipment. This reduces expense, user training requirements, and likely minimizes the survey duration (caveat: if everything goes to plan), however compromises are inherent when acquisition of bathymetry data is simplified. With new CEE echo sounder performance enhancements aimed at this user group there are now hybrid approaches that can bring some of the quality control of conventional hydrographic surveys to a stripped down "land survey" approach.

We have categorized single beam bathymetry into four methods that a land surveyor might consider when looking to undertake hydrographic projects. Available options may be constrained by the brand and operating system of existing GNSS and acquisition devices:

Land Survey	Collecting points in GNSS software. No sonar-based QC.
Land Survey Plus	Collecting points in GNSS software. Real time sonar QC echogram.
Hydro Survey Lite	Collecting data in hydrographic software on GNSS data collector.
Hydro Survey	Conventional PC based data acquisition with hydrographic software.

While the main points in this discussion are not just relevant for CEE equipment, the categories are mostly referenced with respect to the CEE-LINE™ pole-mounted echo sounder. The CEE-LINE™ can uniquely fulfil the role in all four scenarios. However other echo sounders such as the CEE ECHO™ and CEESCOPE™ are alternatives especially for the conventional "Hydro Survey" approach. The CEE-LINE™ is a 20Hz USB-powered single beam echo sounder with dual frequency 200 / 33kHz capability using professional passive transducers.

Figure 1. CEE-LINE™ pole mount kit.

Land Survey

For surveyors who already own GNSS or total station survey acquisition systems, it is attractive to use this equipment for bathymetry too. Most (but not all) GNSS / survey software has incorporated supplemental data inputs from echo sounders. Trimble Access, Leica Viva / Captivate, Carlson, Topcon Magnet Field all allow connection of an echo sounder through a Bluetooth or cabled interface.

For use with GNSS data collectors in a simple setup, the CEE-LINE™ echo sounder is a useful choice. The CEE-LINE™ uses a dedicated echo sounder processor and professional passive transducer – and not a “Smart” active transducer, so it can offer high grade bottom tracking. This is important as this approach relies on the acquisition software recording a “digital only” point data output – basically the echo sounder digitizer is doing all the work picking out the bottom from the echo response. The operator can’t validate depth points without performing manual level rod checks.

The CEE-LINE™ may be connected to the GNSS data collector using a direct USB cable or a Bluetooth interface; the data collector takes a position shot at the designated interval in a “continuous topo” mode. The last received depth value from the echo sounder is co-registered with this GNSS point to give the bottom elevation and data are recorded just like for land surveys. After setting up the peripheral device appropriately, adding the right offsets, and making sure the echo sounder communication is good and depths are being received, surveying is simple. If the acquisition device is running an Android operating system – such as a Trimble TSC510 then this is the only available option out of the four presented here to collect echo sounder data.

Land Survey Plus

If the acquisition device has a full Windows operating system then the benefits of an advanced echo sounder such as the CEE-LINE™ can start to be realized, even in a simplified acquisition mode. While still running the GNSS software to collect points, the CEE-LINE CONNECT™ app may be loaded onto the data collector to allow fine control of the echo sounder and importantly to allow viewing of a high-definition water column echogram for internal sonar quality control. The echogram shows the intensity of the sonar return from the surface through the bottom allowing validation of good depth data and identification of contaminating features such as vegetation.

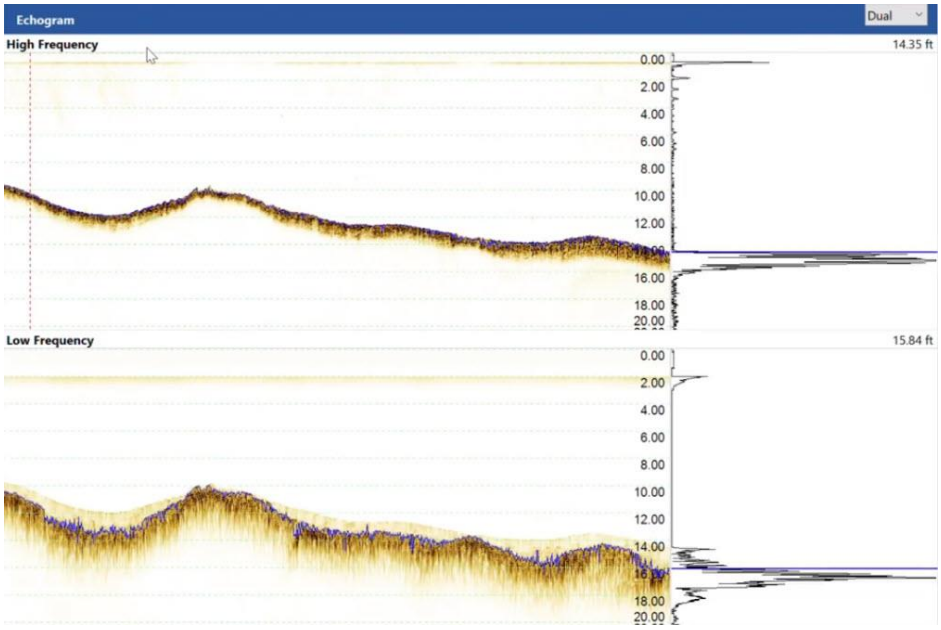

Figure 2. Example dual frequency echogram shown in CEE-LINE CONNECT™.

As the CEE-LINE™ has two comms ports, both the CEE and GNSS software can run simultaneously to allow detailed viewing of depth traces while points are acquired in the background. The echogram trace cannot be permanently recorded as the GNSS software has no way to access this high-definition data stream from the CEE-LINE™.

Land Survey Approach – Pros:

Simplicity: Survey geodesy is managed by the GNSS software on the data collector so datasets will be seamless with surrounding land survey data. There is no requirement for training on new software and basic echo sounders in general are typically less complex in operation. Indeed, the CEE-LINE™ is designed to have no buttons – just plug it in and it is pinging.

Cost: No extra software or equipment other than the echo sounder itself is required.

Land Survey Approach – Cons:

Survey management: GNSS software does not allow detailed survey planning and execution. As the position shots are taken relatively infrequently, say 1 or 2 per second on continuous topo, data density is low. If edits are required, datasets can become thin and gaps in coverage will appear.

Quality control: Care must be taken with digital depth-only echo sounder data, as the output is simply the depth from the bottom tracking calculation, which must be trusted as accurate. The real time echogram available in the Land Survey Plus approach partly alleviates this limitation but still data processing may only be based on collected digital depth points with no water column data.

Dual Frequency: While possible to use a dual frequency echo sounder in this approach, the GNSS software packages are poorly set up to record these data. We typically don't recommend it. Some may only be able to record a single channel at a time. In all cases, not having an echogram recorded to put the two traces in context during processing makes interpretation of diverging data difficult.

Latency: Although not an issue for the 20Hz CEE LINE™, slower echo sounder output rates can degrade accuracy. As depth and position data are not tied together by any time stamp, the GNSS data collector can only record the last available depth when it takes a position measurement. For the CEE LINE™ this may only be 0.05s before the position shot but for a slower echo sounder at, say, 2Hz this is up to 0.5s before the GNSS measurement. On a moving boat, this could introduce a sounding position error as high as 2m (6.5ft). This error can be minimized by reducing the boat speed.

Hydro Survey Lite

With the wider introduction of portable Windows tablet PCs for field data acquisition, surveyors can load hydrographic acquisition software for data collection instead of using GNSS software. While some hydrographic packages are still too complex for use on a relatively small screen Windows field data collector, some like Eye4Software Hydromagic work well. The upgrade of collection devices with full Windows and larger screens combined with the implementation of the detailed water column echogram in the CEE-LINE™ output offers a potentially huge improvement in the quality control and overall bathymetry survey product achievable while still using a convenient and compact field setup.

Loading Hydromagic on a field data collector such as Trimble TSC7, Topcon FC6000 or Leica CS30 allows visualization and recording of the digital depth points at the CEE-LINE's native output rate (up to 20Hz) plus the water column echogram that may now be used in editing. This approach offers the ability to plan survey lines before the survey, load background images, view depth profiles and then transfer collected data to a separate office PC for review and editing. Crucially, the full water column echogram is displayed and recorded, unlike when just using the CEE-LINE CONNECT™ app, providing a detailed view of what the echo sounder is "seeing".

Soundings can be later corrected should digital depths misrepresent the "real" bottom, for instance if thick vegetation is present. In the extreme example below, the unedited data (right side) would be

similar to the results from any digital only “Land Survey” approach in a high vegetation location. The echogram and editing capability of the “Hydro Survey Lite” approach allows re-digitization to the true bottom, as shown on the left. This quality control can be documented and serves as a record for any future survey scrutiny by clients, in addition to building confidence in the survey data for the operators. Challenging surveys impossible to undertake when using basic GNSS software for acquisition can now be completed with much more confidence.

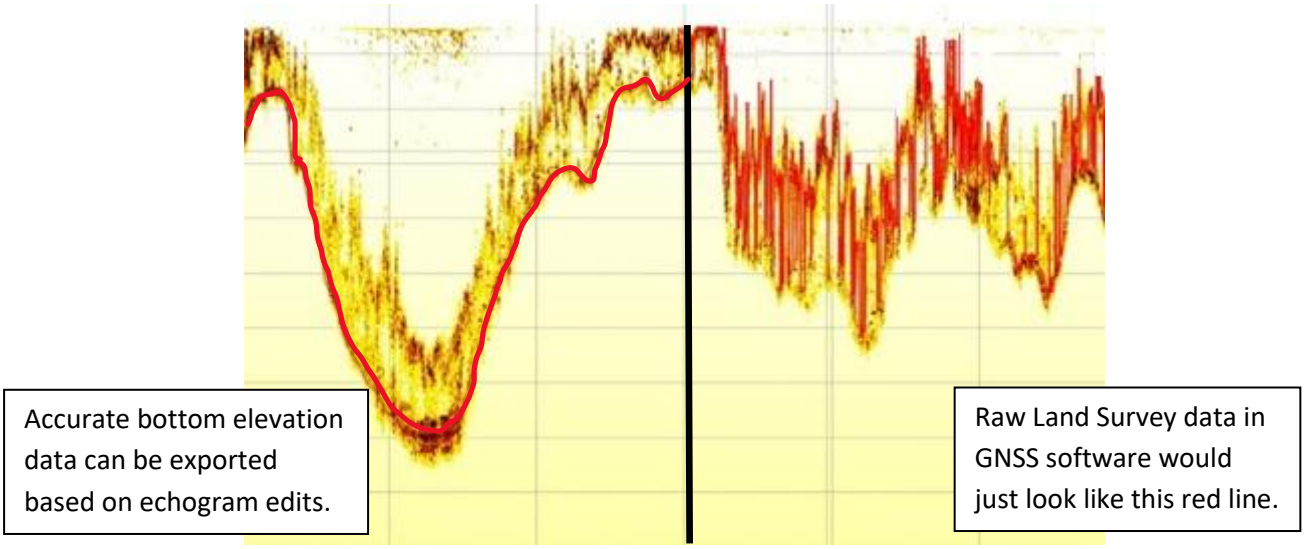

Figure 3. Example Hydromagic water column echogram showing dense vegetation (edited – left, unedited – right).

The survey geodesy is handled entirely inside Hydromagic, with position data received directly from the GNSS receiver – usually via Bluetooth. This is the most significant departure from the land survey method with field operators now having to learn and trust a new software setup. So the data quality payoff needs to be reviewed versus the cost of adoption of this method.

As the water column echogram is available, now the addition of dual frequency may be more useful. Separate high and low frequency (hard / soft bottom) depth datasets may be generated in Hydromagic with the soundings edited using the context provided by the sonar intensity data that will extend through the bottom and into the sub bottom region.

Hydro Survey Lite Approach – Pros:

Quality Control: Crucial 20Hz detailed water column data may be used to ensure final product soundings are accurate when collected using the CEE-LINE™.

Survey Visibility: The real time view of the survey boat track with bathymetry data available in map and profile view greatly reduces the possibility of collecting bad data and leaving the site. Problems can be identified, and surveys can be adjusted “on the fly” to account for bathymetry results.

Dual Frequency Operation: Using a dual frequency transducer to obtain results related to sedimentation is only properly managed with hydrographic acquisition software to understand the context of the high and low frequency data.

Hydro Survey Lite Approach – Cons:

Training and New Workflows: A new software package requires user training even if only online and the adoption of a new set of work procedures that are not as closely consistent with land survey work.

Hydro Survey

For surveyors requiring a more robust hydrographic capability, using a GNSS data collector for acquisition is not adequate. A laptop PC can better run any hydrographic software package and access the quality control features of conventional echo sounders such as the CEE ECHO™ and CEESCOPE™ that are typically used in this approach.

Figure 4. CEESCOPE™ manned boat survey setup.

The “Hydro Survey” approach still allows the surveyor to use existing GNSS equipment, but the receiver is used to output position data into the echo sounder before being combined with depth data and sent to the acquisition PC. The data collector is no longer required except for initialization or (unusually) to supply corrections data. Survey geodesy is managed by the hydrographic software, which will afford pre-loaded coordinate systems to exactly match land survey software as well as the ability to generate local / construction grids. Elevation is managed through geoid models loaded as required.

For users wishing to use existing GNSS receivers, the CEE ECHO™ is an echo sounder-only and takes the NMEA0183 output from the GNSS, through Bluetooth or RS232 cable as below.

Figure 5. CEE ECHO™ with external GNSS receiver.

The CEESCOPE™ has a fully integrated (RTK) GNSS so no third-party GNSS equipment is required. It can connect directly to a UHF base station through its own built-in radio, or access cell phone / VRS corrections.

Hydro Survey Approach – Pros:

Quality Control: As with the "Lite" approach internal sonar QC is a significant benefit.

Maximum Accuracy: The CEE ECHO™ and CEESCOPE™ mesh GNSS and depth data and apply a precise millisecond time stamp used in the software. Soundings are recorded at up to 30Hz for great detail and resilience under challenging conditions.

Survey Visibility: The larger screen size and various hydrographic survey software options allow comprehensive survey planning and execution.

Dual Frequency Operation: A wide range of dual frequency transducers with a low frequency channel from 24-33kHz may be selected.

Hydro Survey Approach – Cons:

Upfront Investment: The greater flexibility derived from more advanced and featured echo sounder equipment requires a larger capital investment to derive benefits over the long term, taking longer to pay back the initial hardware / software cost.

Training: Except for the CEE-LINE™, the echo sounders are more complex and there are more facets of their operation that need to be properly understood to maximize the benefits of their use. However the equipment remains a small component of the overall training demand, with the acquisition software representing most of the requirement.

Overall Summary

In short, there is no "right" or "wrong" choice. Users must be aware of the shortcomings of the simplified "Land Survey" approach to determine whether a greater investment is needed to reach their project goals. For sure, the "Hydro Survey" approach will in every case lead to a better survey, but this may not necessarily be warranted considering each project requirements and realistic budget limitations.

Method	Setup	Quality Control	Best Use Case
Land Survey	GNSS Controller	**None** (Digital depth only)	Simplest ponds/lakes
Land Survey Plus	Windows Controller	**Real-time** (Visual only)	Sanity checking data in the field
Hydro Survey Lite	Windows Tablet + Hydro Software	**High** (Recorded Echogram)	Professional results, highly portable gear
Hydro Survey	Laptop + CEE ECHO™ / CEESCOPE™	**Maximum** (Full Suite)	Engineering-grade / Contractual work.