MOBILE DATA COLLECTION FOR BOREHOLE LOGGING USING A PERSONAL DIGITAL ASSISTANT OR TABLET COMPUTER

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ABSTRACT

Collection of environmental and geotechnical data (e.g., soil boring, soil sampling, and groundwater sampling information) has traditionally relied on hand-written entry of field observations and data into hard-copy logbooks by geologists, engineers, and field technicians. This antiquated system of data collection requires the manual transfer of the hand-written data to computer systems for storage, processing, and evaluation using a variety of software applications. The inherent problems resulting from the manual transfer of data to an electronic format include inefficiency, inaccuracy, inconsistency, and possibly invalid interpretations of data.

In an effort to improve this process of field data collection for borehole logging, Bechtel National Inc., Idaho National Engineering & Environmental Laboratory (INEEL), and Bechtel Nevada, Inc. (the BecLogger Team), are collaborating on a software application that will assist in capturing field data electronically on a personal digital assistant (PDA) or Tablet PC. The software application, named BecLogger, allows data to be transferred directly to the geologist's or engineer's software in the office. In addition to developing software for data capture, the BecLogger Team is testing the usability of this application at current environmental sites and has created metrics for comparison of the traditional method of data collection and the use of software and technology.

Traditionally, field borehole logs and other manual forms of field data entry require several revision/correction cycles prior to evaluation and publication in reports or as permit submittals. This conventional method places a great strain on the number of technical hours (budget) required solely for electronic data capture. In addition, due to the technical content of the field data, highly skilled staff is required for manual data transfer and verification of data entry. The accuracy, consistency, quality, completeness, and cost-effectiveness of environmental evaluations and deliverables will improve when the technical staff and stakeholders can rely on high quality data collected for an environmental site.

INTRODUCTION

Phase I of the BecLogger project focused on identifying software requirements, delineating work processes and types of information gathered while logging boreholes, and creating beta-test

software to run on a hand-held PDA. Discussions with potential users highlighted several issues and requirements that needed to be addressed in developing and evaluating the digital process of data collection. These issues and the assumptions made are presented in detail. In addition, the BecLogger Team began tracking the current manual process to establish a cost metric for assessing the development and addition of the technology and software for use at an environmental site.

The beta-test version of the mobile data collection process was tested at a large CERCLA site. Initial results of the test are presented to demonstrate the application. Data verification steps, built into the software, and final products indicate that transition from manual to electronic capture of field data and data export was successful. Cost metrics gathered to compare manual versus electronic data capture indicate an increase in data quality and a concomitant significant cost savings. It was concluded that new mobile technology is allowing for an improvement in the quality of field operations, more effective use of staff resources, and ultimately better evaluations and deliverables.

Further development is underway to improve the usability of the application. Phase II of the BecLogger project focuses on added functionality (e.g., integration of wireless connectivity, live client-server computing, global positioning system [GPS] based location capture, verbal and script annotation, and capture of digital photographs).

PROCESS MAPPING

The upper-level process map (Fig. 1) depicts the current borehole logging data capture process:

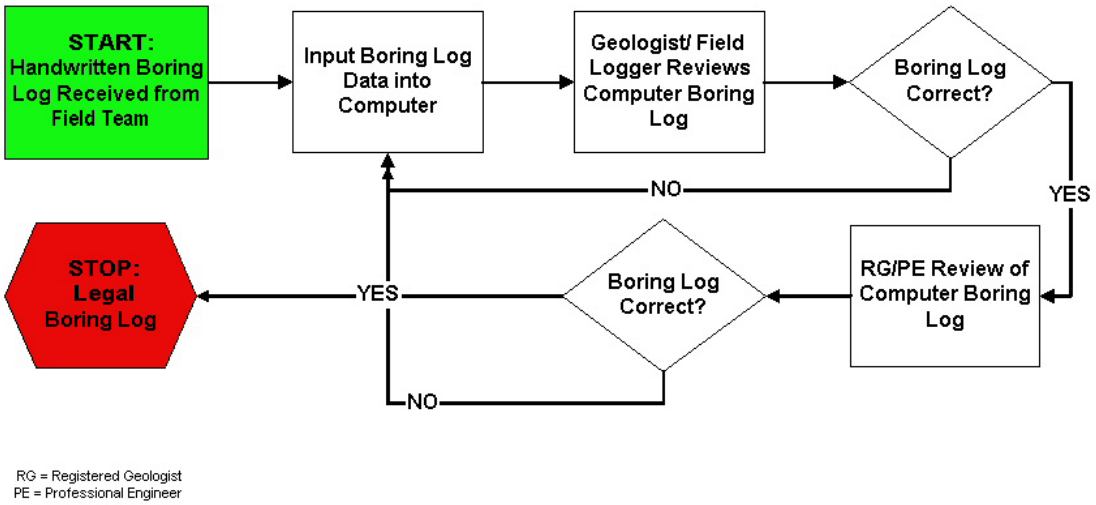

Fig. 1 Current upper level process map for generating final boring logs

By analyzing the borehole logging data capture process, the BecLogger Team confirmed that most errors and time delays were a result of hand entering the data into the borehole logging software. The secondary non-value added step in the process includes multiple review cycles per borehole log. The review cycles include confirming the electronic content by the field geologists

as well as formatting and style requirements in subsequent reviews. In addition, if the field geologist was not a Registered Geologist or Professional Engineer, then an additional review cycle is required to finalize the product. Ultimately, the goal of the BecLogger Team is to create a more efficient process and remove the no value added review cycle times that would result in a direct transfer of the field borehole log into an acceptable electronic format (Fig. 2).

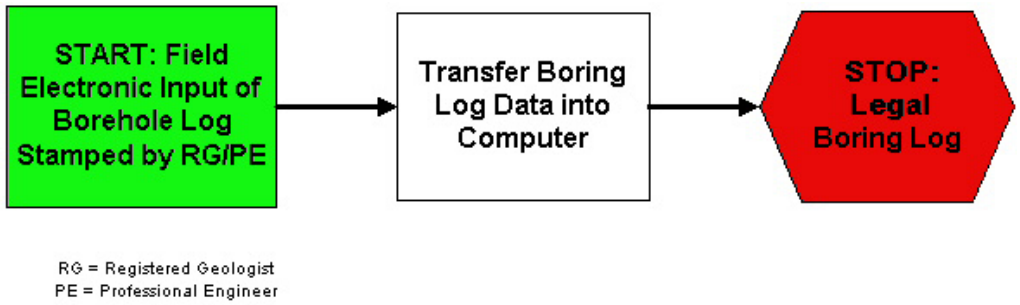

Fig. 2 Future proposed borehole-logging data capture process

COST METRICS

The current cost of processing a borehole log from raw handwritten field data was estimated using a representative environmental project for 92 borings (Table I). The BecLogger Team captured the time it took to hand-enter, review, and complete a boring log until it was legally stamped by a Registered Geologist or Professional Engineer. Capturing all the costs involved in this process is difficult, however, since the cost metrics do not quantify the time lost transferring data from one cycle to another nor the time lost waiting for the data to be analyzed for inclusion in a report. In addition, a non-weighted hourly rate of $55/hour was used to estimate the actual cost of labor. Therefore, the calculated cost of approximately 6 hours/boring or approximately $330/boring (45-feet) is a conservative value for the amount of time spent on processing of boring logs (Table I). Bechtel Global Business Units process approximately 4500 borings/year. Using the conservative values in Table I, improving this process could result in approximately $1.2 Million/year of cost savings assuming an 83% reduction in process cost.

Table I. Cost of Data Capture Based on Project With 92 Boring Logs Processed.

No. of Borings	Total Footage	Total Process Hours*	Hours/Boring	Billing Rate/Hour	Cost of Process $/Boring
92	4309	549	6.0	$55.00	$328

BECLOGGER – PHASE I AND II REQUIREMENTS

The BecLogger Team was formed to capture the mobile technology being developed at Idaho National Engineering and Environmental Laboratories (INEEL) and apply it directly to current Bechtel projects, while enhancing the key technology capabilities at INEEL.

Converting from the current process of field borehole logging data on paper to an automated electronic system requires careful design, planning, and deployment. A summary of BecLogger

requirements for hardware, software and enhanced functionality expected from the field mobile system are presented on Table II.

Table II Phase I and II BecLogger requirements

Hardware Requirements	Software Design	Additional Requirements:
Inexpensive	Standard Operating Procedures	Provide consistent high quality data
Field Durability	ASTM D-2488 (Standard Practice for Description and Identification of Soils – Visual Manual Procedure)	Provide real-time data transfer through wireless/cellular wireless technology (Phase II)
Field Portability	Support multiple functions: digital camera, GPS, bar coder or RFID (Phase II)	Minimal training requirements
Enhanced Functionality	Ergonomic and intuitive	PDA and Tablet PC portability (Phase II)

Phase I of software development focused on capturing the current work process and logic in an interface design that includes pull-down menus, look-up tables and non-linear data entry forms (Fig. 3). The Microsoft®.NET software platform was used to develop BecLogger for the HP iPAQ™ running Pocket PC 2003. The interface was designed to fit on the 2.5 x 3.5 inch PDA screen. Phase II of the BecLogger software development increased the logic functionality between fields required by the ASTM D 2488 method for the Standard Practice for Description and Identification of Soils, Visual Manual Procedure, as well as modifying the interface for the larger 10.4-inch Tablet PC screen.

The key to a functional interface design has been following standard work practices as guided by the ASTM D 2488 for Standard Practice for Description and Identification of Soils that includes:

- Unified Soil Classification System
- Color
- Odor
- Moisture
- Cementation
- Structure
- Fine-grained description criteria
- Coarse-grained description criteria

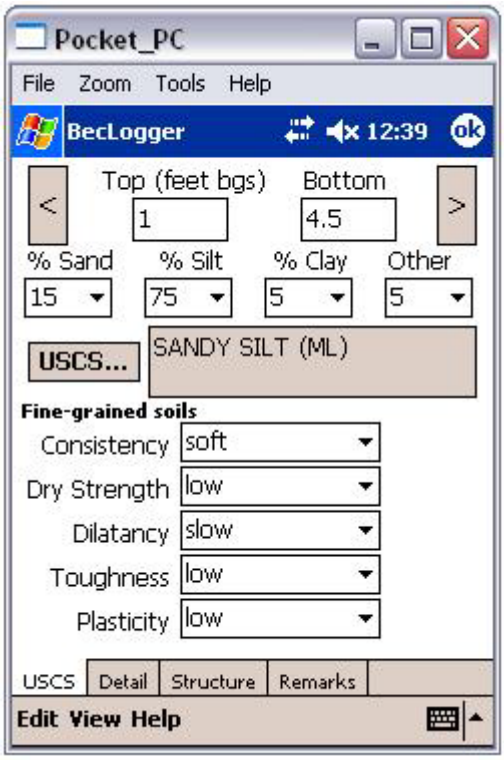

Fig. 3 BecLogger PDA screen depicting the unified soil classification system

Many of the criteria for soil description, including fine and coarse-grained characteristics have been transferred into pull-down menu selections. However, since fieldwork and soil descriptions may require unusual descriptions, a Remarks tab is included to capture any additional non-standard data entry requirements.

One of the requirements of environmental field processes is tracking when and who makes changes to field data. Data changes and final logs must be electronically signed and dated. BecLogger includes the capability of capturing a digital signature using the Tablet PC/PDA's pen tool. The digital signature is electronically saved with the borehole log (Fig. 4).

Fig. 4. BecLogger PDA signature capture screen

MOBILE-ENHANCED TECHNOLOGY

One of the great advantages of using current mobile technology is the additional functionality and tools that can enhance the quality of fieldwork. As part of the Phase II BecLogger software development, the following functionality has been added:

- Field GPS data collection
- Digital Camera
- Barcode and/or RFID (Radio Frequency Identification Products) capability
- Voice Recognition
- Wireless/cellular connectivity
- Electronic Mail
- Mobile network conferencing

The wireless and/or cellular connectivity is one of the exciting aspects of the BecLogger development tool that has potential to change the way data is transferred, processed and analyzed.

The ultimate goal of electronic data capture is to be able to collaborate and send data wirelessly through the use of 802.11x and/or cellular technology. This allows the field crew access to experts in various fields stationed at remote offices for consultation and collaboration. It also allows data transfer for instant analysis and collaborative feedback.

TESTING AT ENVIRONMENTAL SITES

As mobile technology is becoming more affordable, PDA and wireless mobile devices are gaining acceptance and use at environmental investigation sites. Testing of the BecLogger software on a PDA at environmental sites has yielded positive results. Users respond positively to the built-in tools like the USCS and the respective pull-down menus, and have commented that they can see how fieldwork is aided with devices that include look up lists, digital cameras, GPS technology as well as email, spreadsheets, and Internet access.

Concerns remain, however, that need to be addressed. These concerns include instituting a back-up process for field borehole logging capture. One suggestion is to include printers with the PDAs to keep hard-copy printouts in the event that data is lost. Frequent backup on readily available USB devices is also highly recommended.

Another concern involves the durability of such devices as the PDA. Accidental dropping of these devices on the ground has not damaged the data on the device. However, the devices have not been tested while logging in harsh weather or other severe environmental conditions.

Ruggedized versions of the PDAs offer greater hardware durability and suggest they are worth the additional investment.

CONCLUSION

Results indicate that Phase I was successful and that the accuracy, consistency, quality, and completeness of soil boring data collected is significantly improved through use of the BecLogger mobile application. The increased quality and reduction in no value added review steps will result in increased efficiency and significant cost savings.

Phase II focuses on improved software functionality and tool capability (e.g., integration of wireless connectivity, live client-server computing, GPS based location capture, verbal and script annotation, and capture of digital photographs). The added features will provide field crews, working at remote locations, with immediate, real-time access to technical experts stationed in the office for consultation, collaboration and quick resolution of problems encountered in the field.

BecLogger, the borehole logging software, will be tested in its first pilot environmental field project in March 2004.