

Smart Data Collection: Using Custom Forms on a Handheld Smart Phone to Delineate Wetlands

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ABSTRACT

Wetland delineations require time consuming field work. The goal for this project is to automate the administrative documentation associated with routine wetland determinations. Specifically, the aim is to collect the appropriate data in the field, manipulate the data only once, and create reports and forms directly from field data with no additional transcription. Today, some scientists manually complete a draft of the routine wetland determination form in the field and later finalize it in the office prior to submission to the United States Army Corps of Engineers (USACE). The approach presented here automates this process using custom designed computer forms installed on handheld smart phones. Automated data collection tools allow personnel to quickly collect data in the field using software customized for the specific project. With automated data collection forms, scientists reduce the time spent in the office correcting sometimes hard to read field notes, minimize the time required to quality control field data, and eliminate the time spent retyping final reports from field notes. The custom form software uses streamlined data collection tools, auto-complete fields, lookup tables, and pick lists to populate a standard wetland database with the required information needed to complete the USACE forms. Once synchronized with the scientist's computer, the software is automatically integrated with reporting tools and geographic information systems software to create documentation and maps suitable for USACE review. The automated wetland forms are more accurate, reduce administrative project time by 20% (a conservative estimate), and produce a higher quality submittal through real-time field data validation.

Key words: automation—custom data collection forms—smart phone—technology—wetland delineation

PROBLEM STATEMENT

Wetland delineations require time-consuming field work. Field scientists must collect several pieces of ecological data to satisfy United States Army Corps of Engineers (USACE) wetland determination requirements. As the national approval authority for wetland determinations in the United States, all field work must be documented on USACE-approved forms derived from the 1987 *Wetlands Delineation Manual*. Today, some scientists manually complete a draft of the routine wetland determination form in the field and later retype the form in the office for submission to the USACE. The paperless approach presented here automates the determination process using custom designed forms installed on handheld smart phones.

OBJECTIVE

The goal for this project is to automate the administrative documentation associated with routine wetland determinations. Specifically, the project's aim is to collect the appropriate data in the field, validate the data onsite, manually enter the data only once, and create USACE-required reports and forms directly from field notes stored on a smart phone with no additional transcription or typing.

METHODOLOGY

Creative developers have designed custom applications to collect housing condition surveys (University of Oregon), data collection tools to generate Environmental Impact Statement documentation (Haas 2005), inspecting wastewater discharges (Zuccherro and Sagami 2004) and electric power transmission lines (Southern Company 2004), and Phase I Environmental Site Assessments (Bell 2003). Environmental Systems Research Institute (ESRI) produced Figure 1 below to highlight the many possible applications for mobile data collection solutions. Practically, the number of applications for mobile data collection tools is endless.

Robust, inexpensive mobile data collection tools are not readily available for performing wetland determinations in Iowa. A flexible software application that is easily tailored to the unique soil types, vegetation, and hydrologic characteristics of Iowa is needed to automate the data collection efforts for wetland determinations in Iowa.

The software and hardware tools discussed in this paper are based on off-the-shelf technology, customized to the unique characteristics of Iowa's wetlands. There are two major components to this mobile data collection application: hardware and software.

The platform selected for this application is developed and sold by Hewlett-Packard. The device is the iPaq hw-6495 smart phone. This device is unique because it encapsulates an onboard global positioning system (GPS) receiver, a digital camera, a cellular phone capable of wireless data services, and an operating system compatible with Microsoft Windows.

		Industry			
		Government	Utility and Infrastructure	Environment	Public Safety
Task	Field Mapping	<ul style="list-style-type: none"> Recording Building Footprints Right-of-Way Mapping Based mapping 	<ul style="list-style-type: none"> Centerline Review and Mapping Facility Mapping 	<ul style="list-style-type: none"> Forest Boundary Mapping Trail Mapping Geochemical Mapping Volcanic Deposit Mapping Wetlands Delineation 	<ul style="list-style-type: none"> 911 Address Mapping Minefield Mapping Military Fieldwork and Mapping
	Asset Inventory	<ul style="list-style-type: none"> Street Sign Inventory Municipal Assets Inventory (GASB 34) Tree Survey Census Data Collection Housing Condition Survey Cemetery Inventory 	<ul style="list-style-type: none"> Recording Installations Storm Water Inlet Inventory Storage Tank Mapping 	<ul style="list-style-type: none"> Toxic Inventory Mineral Exploration Vegetation Survey Wetland Survey Archaeological Site Survey 	<ul style="list-style-type: none"> Aerial Survey Fire Perimeter Mapping
	Asset Maintenance	<ul style="list-style-type: none"> Road Condition Survey Streetlight Survey Patient Registration 	<ul style="list-style-type: none"> Power Pole Maintenance New Equipment Installation Pavement Condition Assessment 	<ul style="list-style-type: none"> Crop Management Vacant Land Condition Management Timber Harvest Management Drainage System Management 	<ul style="list-style-type: none"> Locating Buried Infrastructure Recording Avalanche Observations Facility Maintenance Survey
	Inspections	<ul style="list-style-type: none"> Road Pavement Management Code Enforcement Health Inspection Housing Condition Water Rights Enforcement 	<ul style="list-style-type: none"> Meter Reading Septic System Inspection Documentation Compliance Monitoring Dam Safety Inspection 	<ul style="list-style-type: none"> Habitat Studies Weed Abatement Well Sampling Wildfire Sightings 	<ul style="list-style-type: none"> Damage Inspection Tracking Violations Street Sign Inspection Flood Risk Assessment
	Incident Reporting	<ul style="list-style-type: none"> West Nile Virus Incidents Public Nuisance Surveys 	<ul style="list-style-type: none"> Locating Outages Regulatory Compliance 	<ul style="list-style-type: none"> Animal Migration Tracking Oil Spill Assessment Radioactive Contamination Tracking 	<ul style="list-style-type: none"> Property Damage Assessment Accident Reporting

Figure 1. Possible applications for mobile data collection tools

Software installed on this device includes ArcPad 7.1 (ESRI 2007) and Pendragon Forms 5.0. Each software application is customized to reflect the unique soil types, vegetation, and hydrologic characteristics of Iowa.

According to Ishara Kotiah (2004), senior analyst with Spatial Vision, “ESRI’s ArcPad software is an easy-to-use, low-cost mobile mapping tool that can be integrated with a corporate geographic information system (GIS) deployment. ArcPad provides intuitive mapping, basic GIS query tools and GPS functionality for recording locations. ArcPad can make field data collection and verification fast, easy, and accurate. ArcPad can be deployed on a range of handheld PDA devices and tablet PC’s.”

Pendragon describes its Form 5.0 software as “the smart solution for today’s mobile worker. Create custom forms that meet your business data collection needs. Take your forms with you on Pocket PC and collect data where you work. Get more accurate data, and get it faster. Data from handhelds is automatically transferred into Microsoft Access or your enterprise database each time you synchronize and without tedious and error-prone retyping.”

The Pendragon Forms 5.0 software works by creating a Microsoft Access database and associated tables for each custom form. The software provides two development scenarios. In the basic development environment, the user does not need to manually create the database relationships or field mappings. The forms software creates the database tables and automatically creates the links between the required data fields in the form and the underlying database. The database synchronization conduit is installed automatically during the installation process. The user simply synchronizes the handheld computer with the desktop or laptop computer. During the synchronization process, new records on the handheld are sent to the PC, and new or changed records on the PC are sent to the handheld. In the advanced development environment, more experienced users have the flexibility to synchronize a custom designed form to an external Microsoft Access database or other open database connectivity data source. The advanced form integration process is illustrated in Figure 2.

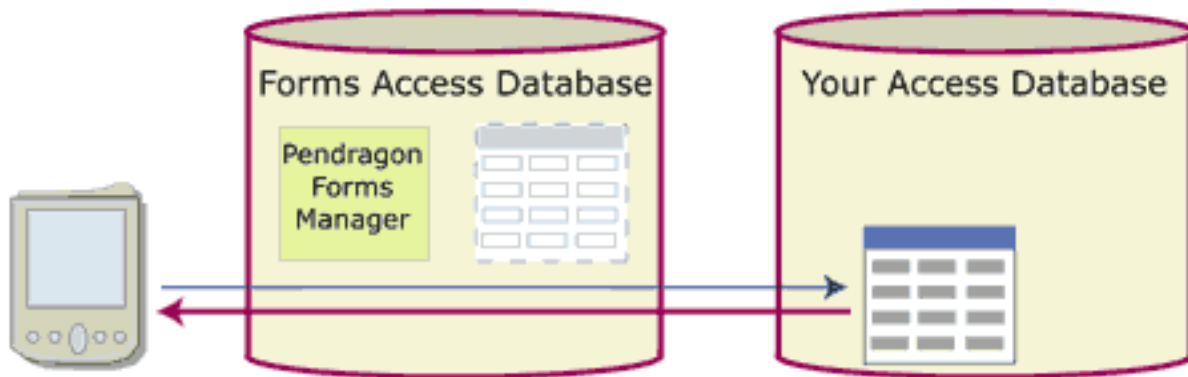


Figure 2. Form software integration with external data sources (<http://www.pendragon-software.com/>)

The process of converting paper forms into electronic ones is relatively simple using Pendragon Forms software. Each paper form is manually converted into a series of database tables and associated fields. The user has the ability to customize the look and feel of the form application to make it user-friendly and intelligent. The software intelligence is created by integrating a list of meaningful attribute domain choices in a pull-down menu to reduce the time needed for entering field data attributes. These standardized pick lists reduce data entry error and eliminate the need for interpreting muddy or sloppy field notes back at the office. Figure 3 illustrates the custom designed, menu-driven format of the wetland form application.



Figure 3. Wetland software screen shot

When the data conversion process is finished, the end result is a database that contains each question or required entry from the paper-based form. This electronic database is the basic building block for more advanced automation tools like custom designed reports or integration with GIS mapping applications that draw their input datasets from the underlying wetland form database. Figure 4 illustrates the final USACE Routine Wetland Determination form as an example of automated reporting. This custom designed reporting tool is built inside the Pendragon Forms database using standard Microsoft Access reporting tools. This reporting tool integrates the data collected on the smart phone's form software (and underlying database) into the appropriate layout and format for USACE submission.

With the appropriate data collected in the field, the user can develop numerous reports to pull information from the form database. The only prerequisite is the form must have a field in the database to store the information. Custom reports could link photos captured in the field of sensitive habitats, unique hydrologic conditions, or rare soil characteristics for later analysis in the office or for inclusion with the USACE wetland form submittal.

**DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)**

SITE DETAILS

Project/Site: <u>Otter Creek North Bank</u>			Date: <u>12/13/2006 3:31:26 PM</u>
Applicant/Owner: <u>City of Ankeny</u>			County: <u>Polk</u>
Investigator: <u>Ted McCaslin</u>			State: <u>IA</u>
Do Normal Circumstances Exist on the site?	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>	Community ID: <u>PEM</u>
Is the site Significantly Disturbed (atypical situation)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Transect ID: <u>1</u>
Is the area a Potential Problem Area? (If needed, explain on reverse.)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Plot ID: <u>1</u>

VEGETATION

Dominant Plant Species (and Indicator Status):	Stratum	Indicator	Notes:
<u>Phalaris arundinacea L.</u>	<u>Herb.</u>	<u>FACW+</u>	
Percent of Dominant Species that are OBL, FACW, or Fac (excluding FAC-): <u>100</u>			
Remarks: <u>No visible vegetation problems noted</u>			

HYDROLOGY

<input checked="" type="checkbox"/> Recorded Data (Describe in Remarks): <input type="checkbox"/> Stream, Lake, Or Tide Gauge <input checked="" type="checkbox"/> Aerial Photos <input type="checkbox"/> Other <input type="checkbox"/> No Recorded Data Available	Wetland Hydrology Indicators: Primary Indicators: <input type="checkbox"/> Inundated <input type="checkbox"/> Saturated in Upper 12 Inches <input type="checkbox"/> Water Marks <input type="checkbox"/> Drift Lines <input checked="" type="checkbox"/> Sediment Deposits <input type="checkbox"/> Drainage Patterns in Wetlands Secondary Indicators: <input type="checkbox"/> Oxidized Root Channels in Upper 12 Inches <input type="checkbox"/> Water-stained Leaves <input checked="" type="checkbox"/> Local Soil Survey Data <input checked="" type="checkbox"/> FAC-Neutral Test <input type="checkbox"/> Other (Explain in Remarks)
Field Observations Depth of Surface Water: _____ (In.) Depth of Free Water in Pit: _____ (In.) Depth of Saturated Soil: _____ (In.)	
Remarks: <u>No hydrology problems noted</u>	

Form Template approved by HQ USACE 3/92
Forms version 1/02

Figure 4. USACE Routine Wetland Determination form

IMPLEMENTATION OBSTACLES

Although many benefits of customized data collection forms exist for routine wetland determinations, developing an automated data collection software solution is not without obstacles. The software development process requires a significant investment in time and in technology. Complex form

development and integration with an existing database design could require between 70 and 100 hours designing, coding, and testing the application prior to deployment. The software and hardware investments could easily cost \$2,000 or more depending on the user's specific database performance and storage requirements.

CONCLUSIONS

The automated wetland forms are more accurate, reduce administrative project time by at least 20% (a conservative estimate), and produce a higher quality submittal through real-time field data validation. Other mobile data collection solutions have created similar results. According to a study completed by the Air Force, automated mobile data collection tools helped create a 90% reduction in the number of man-hours required to monitor solid waste infrastructure on a combat air base (Houston, Sinclair, and Robertson 2005). Similarly, Bell noted other observed strengths of a mobile data collection solution including the following:

- Reduction of time spent in field
- Reduction of time spent performing manual data input
- Reduction of time required to quality control the data
- Field data may be uploaded directly to a PC. This reduces the time necessary to transcribe handwritten field notes and also reduces error in transcription.
- Reduction of time spent to create final reports
- Custom forms may include validation that may allow or disallow data entry.

Mobile data collection using form software deployed to handheld smart phones reduces administrative documentation associated with routine wetland determinations and produces a higher quality submittal through real-time field data validation. With automated data collection forms, scientists reduce the time spent in the office correcting sometimes hard to read field notes, minimize the time required to quality control field data, and eliminate the time spent re-typing final reports from field notes. The flexible software application presented in this paper is easily tailored to local wetland conditions and is needed to automate the data collection efforts for wetland determinations in Iowa.

REFERENCES

- Bell, K. 2003. Developing a Site Assessment Methodology Using ArcPad and GPS Technology. Paper presented at the 2003 ESRI International User Conference.
- Haas, A. 2005. Save Time and Eliminate Errors with a Customized ArcPad Application. Paper presented at the 2005 ESRI International User Conference.
- Houston, R., S. Sinclair, and J. Robertson. July–September 2005. Where's the Trash? *ArcUser Online*.
- Kotiah, I. 2004. Tips for Customising ArcPad for Data Entry. *Spatial Vision*.
<http://www.spatialvision.com.au/html/tips-arcpad.htm>
- Southern Company. 2004. Streamline Inspection Effort. *Energy Currents*, Fall 2004.
<http://www.esri.com/library/reprints/pdfs/enercur-southernco.pdf>
- University of Oregon. *Community Based GIS with ArcPad*.
<http://www.uoregon.edu/%7eschlossb/arcpad/>.
- Zucchero, R. J., and L. J. Sagami. 2004. *Incorporating a NPDES Program into an Established Annual Inspection Program*. <http://gis2.esri.com/library/userconf/proc04/docs/pap2087.pdf>