The development of a GIS based interface to an ORACLE water quality database at the WVDEP Division of Mining and Reclamtion[1]

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Abstract. For the past several years the WVDEP, Division of Mining and Reclamation has been entering all the state's SMCRA based water quality monitoring onto an ORACLE database. This water quality and quantity data includes all modern data and permit legacy data back to 1994. EarthSoft's EQUIS software was used to help migrate both modern and legacy mining SMCRA water data to a digital uniform format, searchable by various unique identifications. In addition to this, the states in-stream monitoring done for the Clean Water Act is also being placed in this database. This database now contains over one million water samples. Eventually all of the states quality information will be placed in this database. To develop an interface to this data, an ArcGIS toolbar was developed. This GIS toolbar is part of a series water quality modeling tools that can be used in ArcGIS.

This paper will examine this GIS interface to examine the states water quality data. This geographic examination of the states SMCRA water quality data quickly shows the strength and weakness the states water quality database. This GIS functionality allows a quality control, accessibility and a search capability far beyond a paper file system. This paper will also examine the ability of such data to be potentially used in large scales surface and groundwater modeling.

Additional Key Words: ArcGIS, SMCRA, WVDEP, EQUIS, ORACLE

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Introduction

The West Virginia Department of Environmental Protection (WVDEP) has begun the process of converting all of its water quality data to a single digital database format. As of calendar year 2008 this process is already well under way with over 2,000,000 water quality samples stored in various water digital water quality databases. All of this water quality data includes some form location information.

Collecting over 2,000,000 water quality and quantity samples on various ORACLE and ACCESS water quality databases was the easy part. Now the WVDEP and many other states must come to grips with how to geographically retrieve this data in an efficient manner and how integrate all this data from many varied sources. The objective of this paper is to show others the four steps in the GIS integration of its water quality databases used at the WVDEP.

Water Quality Databases at the WVDEP

The Division of Mining and Reclamation of the WVDEP has several different digital water quality databases. Each of these databases is required by a different regulatory requirement and at this time, each is stored in different manner. The primary WVDEP digital water quality databases at this time are:

– National Pollution Discharge Elimination System (NPDES) data
–Surface Mine Control Reclamation Act (SMCRA) permit data
–Watershed Data
–Abandoned Mine Land (AML) Program Data
–Other NPDES sampling (i.e. Total Maximum Daily Load, Anti-Degradation)

The largest water quality database overseen by the Divisions of Mining and Reclamation is the states NPDES data. NPDES water data is a requirement of the federal Clean Water Act. NPDES discharge points are the primary compliance points for all surface mine activity. NPDES data is averaged data as opposed to instantaneous. NPDES data is also collected only when flow occurs at outfalls. Because of this, NPDES point source and in-stream data may be irregular.

Also all NPDES collected data and site locations are company supplied and may have some associated quality issues. At this time all NPDES data is placed on an ORACLE database and checked by using a third party software for compliance. Over 75% of NPDES data is submitted electronically at this time.

Another large database used by WVDEP is surface and groundwater sampling required by SMCRA. Like NPDES data this data is also company supplied. At this time no electronic entry of SMCRA permit data is occurring. The WVDEP has entered all of the legacy data back to 1993 by hand over the last few years. This large water quality database was migrated into an Oracle database using EQuIS. Oracle is an enterprise database system developed by Peoplesoft and now owned by Oracle. EquIS is environmental data management software developed by EarthSoft. SMCRA water quality data is all in stream or groundwater and is taken instantaneously.

The WVDEP also collects instantaneous water quality at over 200 in stream locations through out the coalfields of West Virginia. The state's "Trend Station" analysis is collected by a third party lab contracted by the state and all data is submitted electronically through EQUIS to the states primary ORACLE database.

All water quality collected by the state AML program and the state Special Reclamation program are presently entered by hand into a Microsoft Access database. Almost all water quality data collected by AML is of a point source nature.

The state mining section is also working with states non-mining water resources section to get all Clean Water act in stream sampling in the master EQUIS ORACLE database. This includes all state TMDL and Anti-degradation sampling conducted by the state.

GIS Access of the States Water Quality Data

Because each of the digital water quality datasets discussed above also include location information creating a GIS point file for each sample point is quite easy. A point location shapefile has been created for each of these water quality data sets. However creating one single combined shapefile is problematic, because the location accuracy of the different source is extremely variable. Simply creating location file for various water quality samples is the first and simplest part of creating a geographically based water quality database. The much more

complex and problematic step is to find a way to seamlessly map to either Access or Oracle data to an ArcGIS interface.

In order to develop such an interface tool the WVDEP contracted with West Virginia University (WVU), Natural Resource Analysis Center (NRAC). The NRAC has been working with the WVDEP developing various hydrologic modeling tools using ArcGIS for over a dozen years. This ever-evolving set of GIS tools is called the Watershed Characterization and Modeling System (WCMS). The original WCMS ArcGIS toolbar was developed using Visual Basic and later modified to a .NET environment.

The WCMS developers, at WVU, worked with the WVDEP to develop a real–time GIS interface to the states EQuIS/Oracle database. This database includes all SMCRA and Trend Station data and will soon include the states non-coal Clean Water Act data. The location information for all of these sample points is stored in a single Shapefile under the name "equis_locations". The toolbar that retrieves water quality to this shape file is called the "Equis" WCMS toolbar. As shown in Figure 1, any point location or locations can be graphically picked using the "WCMS" toolbar.

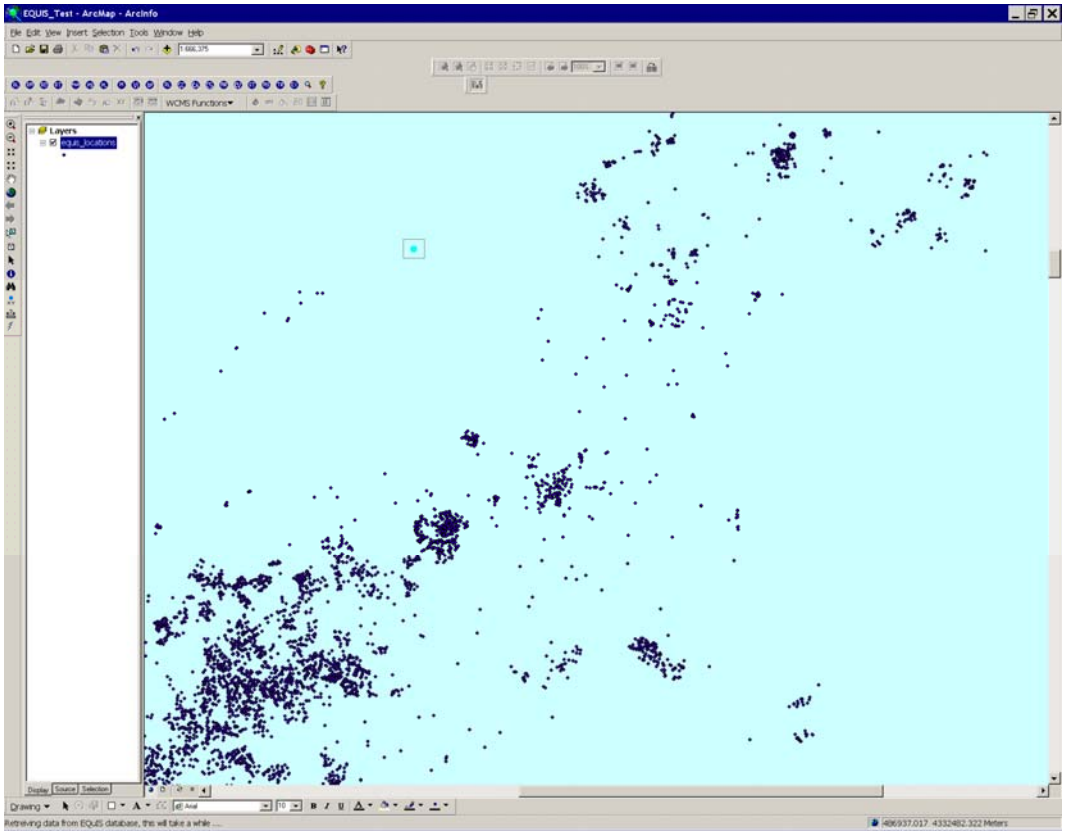

Figure 1. A Shapefile point is chosen using the "Equis" ArcGIS toolbar.

At this point the “EQUIS” toolbar will open Crystal Reports and extract water quality from the EQuIS/Oracle database and display a list of all points within the extraction area polygon. Any given sample point within the extraction polygon can be chosen. Once a point is picked for analysis, all water quality sampling for that unique geographic location is displayed as shown in Figure 2. This report shows a table of all sampling dates in Crystal Graphics. Each sampling date is associated with at least one sampling event. In Southern West Virginia where dozens of mining operations may lie within small watersheds, water samples may by reused many times.

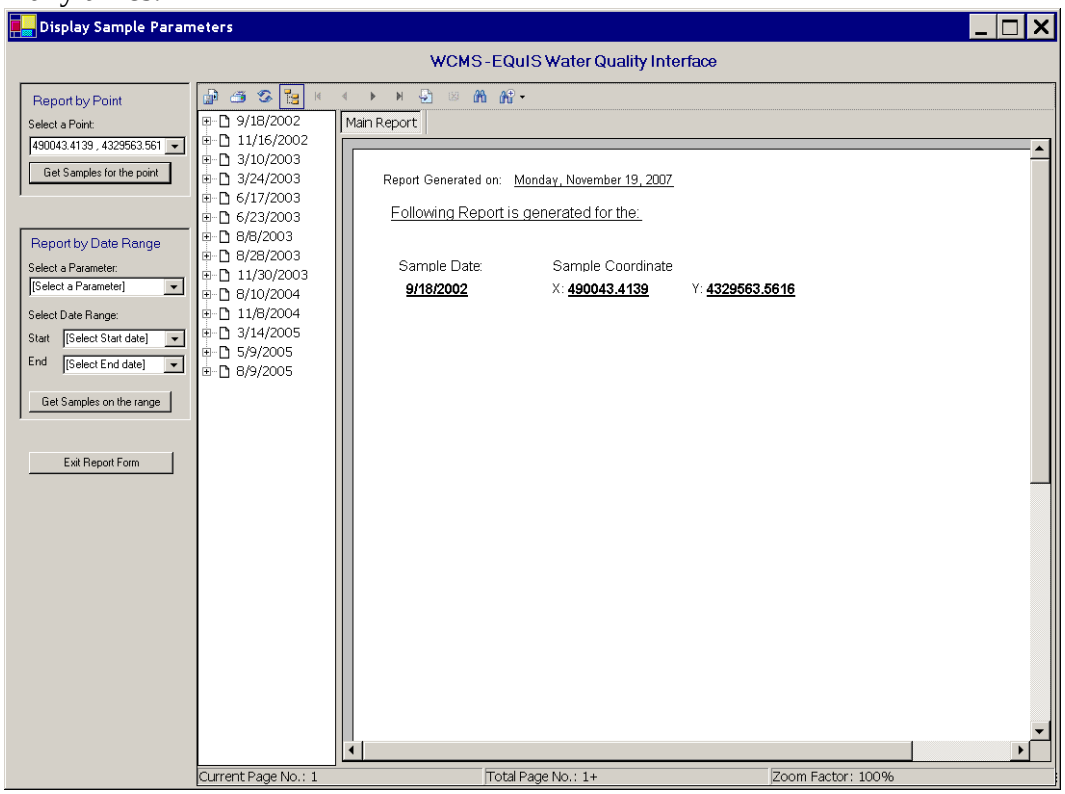

Figure 2. Choosing a point in WCMS-EQUIS water quality interface.

For example picking a specific date such as “9/18/2002” as shown in Figure 3 can bring many sample ID’s. This single sample for a groundwater seep in southern West Virginia has been re-named 7 times. Once a point is chosen all of the water quality sampling events associated with that location can be viewed in graphical manner as shown in Figure 4.

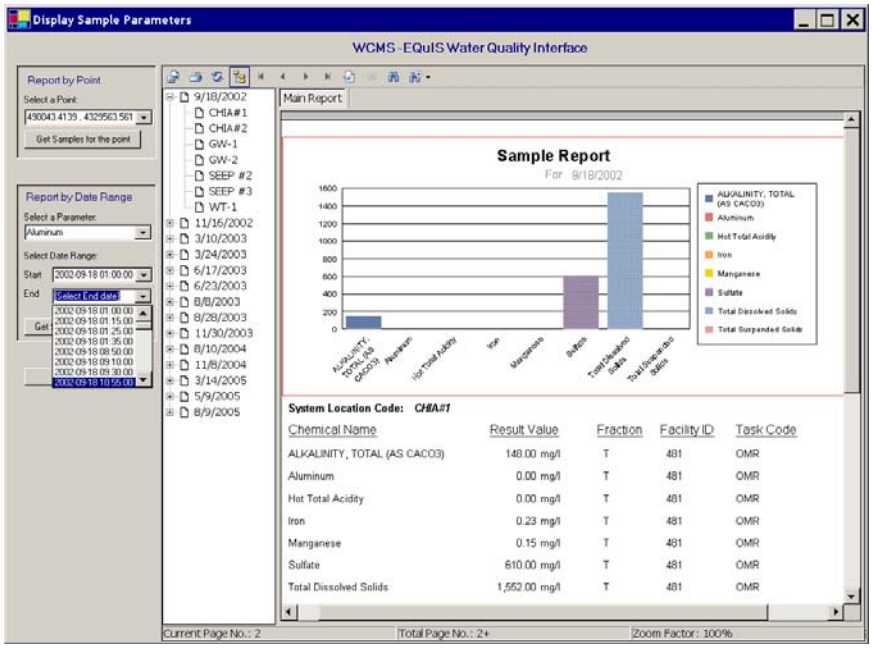

Figure 3. Choosing a specific date for analysis using Crystal Reports.

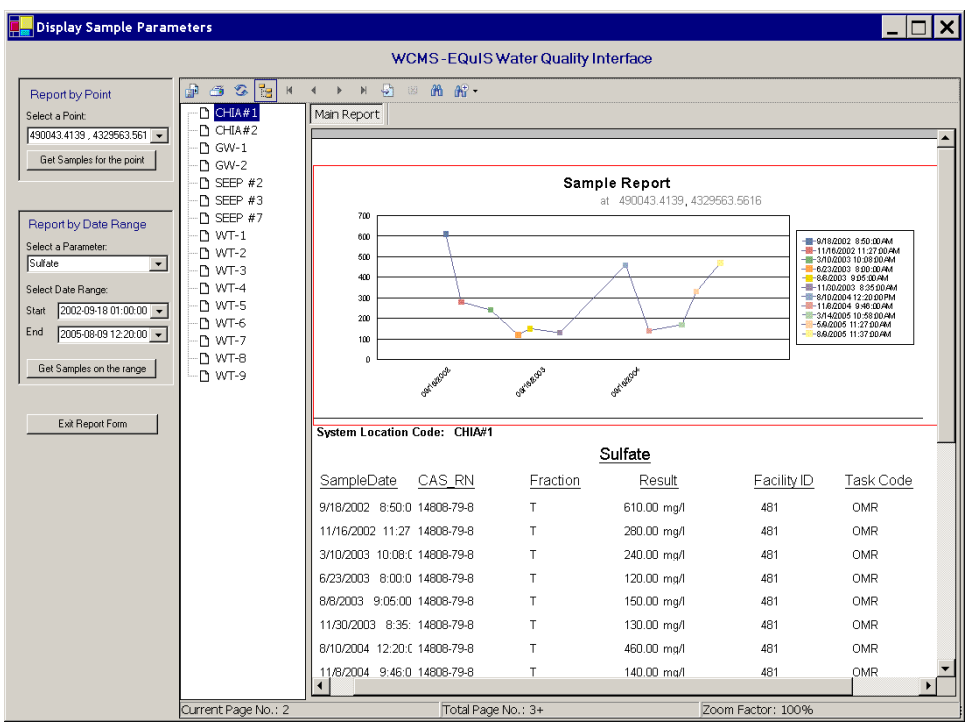

Figure 4. Choosing a report for a data range.

After analyzing all water quality data for a given location, one can simply exit from the report form and you will be automatically returned to ArcGIS. The EQUIS toolbar automatically creates a new shapefile called “EquisResults”. As shown in Figure 5, this new point shapefile has all of the site-specific water quality information from the ORACLE database now available as an associated .dbf file. This can be easily imported into Microsoft Excel for further statistical analysis.

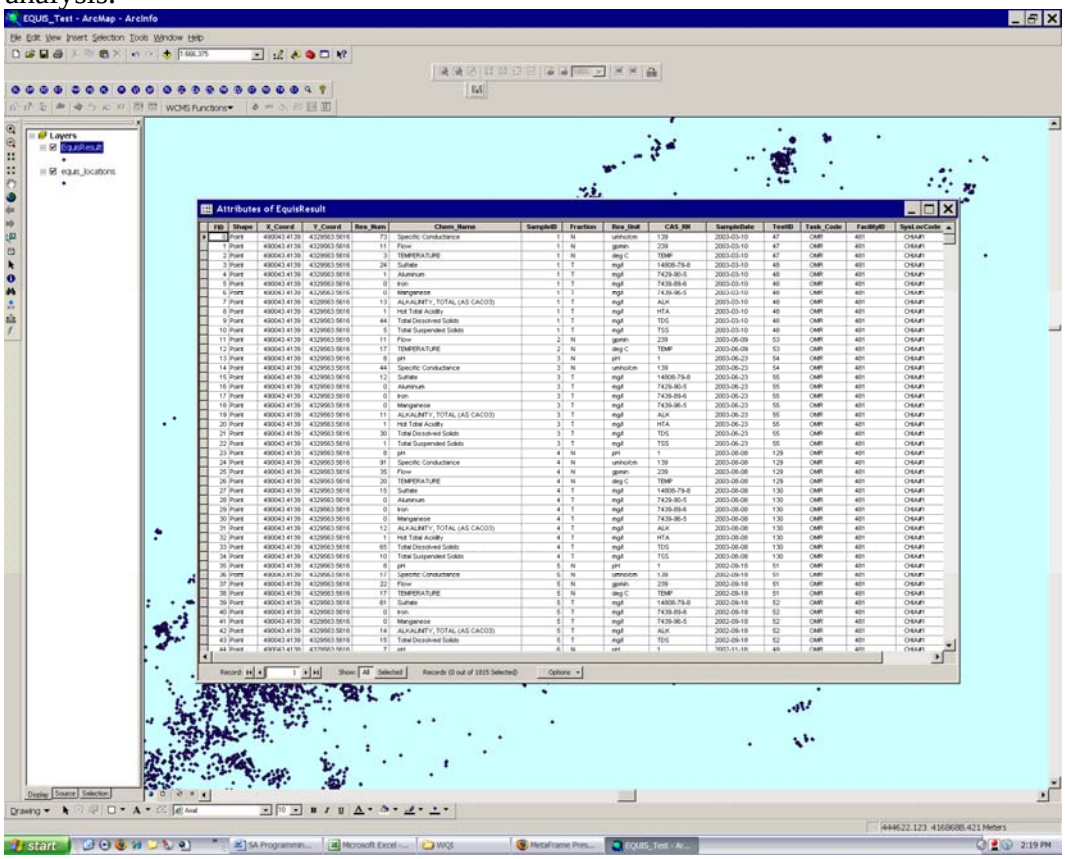

Figure 5. The .dbf file containing all historic water quality data for the points picked with the toolbar.

Mixing Data for Different Sources

Migrating data into a single Oracle database from many different sources has proved problematic but not impossible. Perhaps the most complex issue, is dealing with different regulatory requirements for water quality data coming from different programs. Using EQuIS as the primary interface into an Oracle database is a perfect example of this. EQuIS was developed for use as a Clean Water Act database tool. By default it asks for many aspects of sampling

information that are not required in mining regulations. Because this, the WVDEP had to over-ride these default settings to get over 1,000,000 mining legacy water quality samples entered. Also primary NPDES data cannot be mixed in at this time because of the need to regularly check it for compliance. Maintaining two NPDES datasets or creating a marked and sub-file for all NPDES samples could solve this problem. Also many statistical comparisons of NPDES data with mining data will be challenging because one is mixing averaged and instantaneous data.

At this time several large WVDEP datasets are being maintained on Access based systems. This includes the state AML and non-coal data. Getting these legacy datasets into Oracle will require some work but should be possible. A larger issue is how data that may have location issue problems or data may be used at the same location more then once can be used to analyze Clean Water Act based stream classification. As previously detailed, companies often reuse and rename sample data, this can make a stream appear more degraded or pristine then it actually is. Also data points in the wrong location could have much of the same impact. Both of these issues could be overcome by greater quality control and/or more demanding standards for water quality data in SMCRA.

Though each of these issues represents roadblocks in developing a complete integration of all the WVDEP water quality data sets, even an incomplete geographic database is of extreme value to regulators, business and the public. Also it is only through geographic analysis of all of the states water quality data that problems can be often found so that they can then be corrected.

Surface and Groundwater Modeling

Having the majority of the states water quality saved in a uniform digital format and geographically referenced allows one to develop and refine large-scale water quality models as never before.

For the past six years the WVDEP and WVU have been working to develop a Hydrological Simulation Program - FORTRAN (HSPF) based water quality modeling tool to use in the development of Cumulative Hydrologic Impact Assessments (Lamont et al., 2008). An integrated water quality database allows the use of real water quality data to populate any given model and real data quality control.

More details on the development of this model will be provided in another paper presented at this conference (Eli et al, 2008). Issues involving water quality data such repetition of points and location problems can become even more important when data is being entered into a complex model. Until these problems can be solved in the WVDEP database, this data must be carefully examined before it is used as part of a model or as a check.

Within the last year, the WVDEP and WVU have begun to develop a FORTRAN ModFlow based ground water modeling system to examine mining related hydrologic impacts (Eli et al., 2008). This project is even more complex then large-scale surface water modeling. Major issues that must be overcome include reconciling ModFlow laminar flow with karst-like mine void flow and other mine pool dynamics issues.

Conclusions

Despite many issues in developing the present WVDEP water quality database and an associated geographic interface the WVU/NRAC has produced a very useful tool for mining related permit review. Future work will help expand and refine this database and make it even more useful. The utility of this data and ability to check its quality have only become possible through a GIS based geographic interface. The full utility of this tool is only beginning to be used.

Literature Cited

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