Vol. 14 | Fall 2010

The AquAeTerian

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Hot Topics

Mike Corn was recently selected and certified by the American Academy of Environmental Engineers as a Board Certified Environmental Engineer. Mr. Corn is now one of only 2,500 Board Certified Environmental Engineers in the world.

Mr. Chris Sliger has joined AquAeTer's Brentwood , TN office. Mr. Sliger graduated from University of Tennessee with a B.S. in Nuclear Engineering and is now assisting with data analysis, water quality modeling and regulatory compliance projects.

The President's Corner

"physica prout arti formae"
Science as an Art Form

Thanks to our dedicated employees and clients, who we consider part of the **AquAeTer** family, for allowing us to have 18 successful years in business. The variety of challenging projects we have worked on through the years has enabled us to grow and thrive as a company. Our diverse professional staff now operate from Colorado, Tennessee, Montana, Kentucky and Georgia. We have worked alongside our clients in all parts of the country: knee-deep in creeks and streams from Georgia to Texas conducting water-quality studies; drilling investigation boreholes in the mountains of Colorado and Utah; overseeing construction of landfill cells in the Nevada desert; sampling water from the Aleutians to the Virgin Islands; successfully cleaning up groundwaters and vadose zone contamination using biostimulation and other non-invasive techniques from Nevada to Pennsylvania; collecting environmental due diligence information from Hawaii to South Africa; and racking up frequent flyer miles performing site assessments across the U.S. and the world. We've chased alligators out of ponds in order to treat wastewater effluent; spent late nights and weekends with attorneys preparing expert testimony; and participated in more conference calls and meetings with State and Federal regulatory agencies than we can remember, helping to prepare final revisions to permit applications.

We truly appreciate our clients and the opportunity to work as part of your team. We celebrate the victories you achieve with property transactions, approved permits, environmental compliance, successful mitigations, and modifications to facility designs and processes that improve the bottom line of your businesses.


Mike Corn collecting data in the field during **AquAeTer's** first year - 1992

This issue of the **AquAeTerian** features a historical overview of wasteload allocation studies and modeling, which is described more as "**scientific art**" by the pioneers of stream assimilative capacity. Also included is an article from our Colorado office describing the many factors of environmental landfill monitoring.

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energy • engineering • environmental • sustainability • risk analyses

THE "ART" OF WASTELOAD ALLOCATION STUDIES AND MODELING

BY JOHN MICHAEL CORN, P.E. AND MICHAEL R. CORN, P.E., BCEE

AquAeTer routinely conducts assimilative capacity studies for determining pollutant loads from discharge points that will not degrade stream water quality. Our studies are based on the fundamentals of stream assimilative capacity as developed by several pioneers in the industry. These pioneers describe it more as "**unique engineering** and **scientific art**." One of the issues facing modern stream assimilative capacity analysts is the temptation to rely solely on sophisticated computer models; laboratory data to establish rates; and minimum real data from the field to project waste loadings to streams. We believe that when it comes to conducting these studies, time is critical, rivers are unique, and data must be collected in the field to accurately predict stream assimilative capacity. Anything less than this presents an analysis that through curve-fitting may predict for a single set of conditions, but cannot be used to predict or verify the range of conditions that can occur in a river system.

The following paragraphs describe the "**Art**" of stream assimilative capacity as developed by numerous pioneers in the field.

STREETER-PHELPS

$$DO_t = \frac{k_d * CBOD_u * (e^{-k_d t} - e^{-k_r t})}{k_r - k_d} + DO_0 * e^{-k_r t}$$

The original concept of the dissolved oxygen balance in streams was developed by Streeter and Phelps in 1925. At that time, two parameters were used to predict the stream assimilative capacity for oxygen demanding materials, as follows:

DO_t = Dissolved oxygen at time, t, in mg/L

k_d = $CBOD_u$ deoxygenation rate, day^{-1}

$CBOD_u$ = Ultimate carbonaceous biochemical oxygen demand, mg/L

k_r = reaeration rate, day^{-1}

DO_0 = DO concentration at time 0, mg/L

It is important to note that even though the dissolved oxygen balance was based on minimal oxygen demands in the stream, the fundamental theory of the oxygen balance was that oxygen was uptaken and added back to the stream as a function of "**time.**"

VELZ

The fundamentals of stream assimilative capacity analysis were outlined by Professor Earle B. Phelps, published in Stream Sanitation (1944). Later Professor Clarence J. Velz of the University of Michigan expanded the work of Phelps in his book, Applied Stream Sanitation (1970, 1984). Velz had been a student of Phelps and is widely regarded as the father of our modern understanding of stream assimilation.

Velz described Phelps in the following manner:

"Persistent interest in the stream as a living thing extended beyond scientific observation and description to a canny insight and capacity to synthesize its complex behavior into quantitative formulations."

Velz characterized these foundations as the field of potomology. Velz defined potomology as,

"Potomology applies knowledge from many areas of the physical and biological sciences and mathematics; the potomologist need not qualify as a specialist in each of these areas, but he must be able to integrate knowledge from all of them as he pursues his own specialty, the science of river."

Velz went on to describe the most important aspects of understanding stream assimilation,

*"Furthermore, in application, potomology becomes as much an **art as a science**, tempered by experience and professional judgment."*

Velz suggested the collection of data for a specific river was more relevant and more important in determining the specific water quality problems of a particular river. He commented on the use of theoretical mathematical models versus the application of data by stating,

*"Theoretical-mathematical modeling attempts to develop universal models generally applicable to any and all rivers. The concept of a universal model, at the outset, fails to recognize the inherent **uniqueness** of each river. Such models depend primarily on theory with little or no field data, and are proposed without calibration and verification as to applicability to a specific river. In attempting to cover anything and everything that might occur in rivers, these theoretical models inevitably become excessively elaborate and mathematically complex. These complex general-models are not only inappropriate and unreliable in evaluation of practical alternatives of pollution control problems in a specific river, but have caused preoccupation with mathematical configuration, analytical solution techniques, and computer programming. Rather, the focus and emphasis should be on field investigation and measurement of the **individual river**."*

Velz is not saying that mathematical models are not useful. However, he is saying that mathematical models developed without data relevant to that specific stream or water body should not be relied upon. Velz understood that nature cannot be neatly categorized by a simple mathematical model. This is because the conceptual model that the mathematical model is based on ignores the subtle, varied, and complex nature of the environment. "*Theory and laboratory reaction rates are only guides as to what to look for and measure in the river environment,*" Velz stated.

Velz's statement is as true today as it was in 1970, although much greater reliance on the black-box models is placed today by many pseudo "modelers" who do not understand the art of stream assimilative capacity.

Velz theorized that in order to predict water quality, data needed to be collected during steady-state conditions. This included river hydraulics, temperature, and source loadings. He detailed the requirements for collecting data for predicting the dissolved oxygen sag in streams,

"With so many factors inducing variation in water quality of a natural stream (or estuary), it is obvious that random sampling or sampling over an extended period of time is almost certain to reflect a series of distorted values of heterogeneous condition. It should be equally obvious that sampling must be intensive over a short period to ensure stability and thus permit relating the observed water quality profile to the set of stable conditions that produced it."

Velz recognized that there were abnormalities that must be accounted for when utilizing the Streeter-Phelps deoxygenation rate. He lists five examples of abnormalities as: abnormal specific BOD reaction rate, immediate demand, nitrification, sludge deposits, and biological extraction and accumulation. He theorized that there were two general methods for identifying abnormalities and determining the specific BOD reaction rate. The laboratory investigation allows one to control the time and temperature, but cannot simulate accurately the dynamics of the river environment. The stream survey measures the actual environment, but is highly variable from segment to segment. Dr. Velz's ideas were based on steady-state conditions, but he realized that few rivers can be considered steady-state.

OTHER PIONEERS

Other investigators expanded on Velz's hypothesis but they held to his conviction that in-stream data collected with "**time**" of travel was critical. These investigators included Eckenfelder and O'Connor (Biological Wastewater, 1961); Tsivoglou and Wallace (Characterization of Stream Reaeration,1972); Krenkel and Novotny (Water Quality Management, 1980); and Thomann and Muller (Principles of Surface Water Quality Modeling and Control,1987).

SUMMARY

Deoxygenation and reaeration rates used in predictive models are a function of time. In order to determine these rates, one must follow a slug of water downstream or have fixed points and absolute steady-state conditions.

In conclusion, **AquAeTer** remains true to the "**Art**" of determining stream assimilative capacity which includes three vital components:

1. **Time is critical** (data must be collected with time of travel);
2. **Rivers are unique** (data must be collected independently on each river where a wasteload must be set); and
3. **Real-time data must be collected in the field** to accurately predict stream assimilative capacity.

AquAeTer's Pioneers

AquAeTer's engineers and scientists have been hard at work this season in rivers and streams in Alabama, Georgia, Mississippi, North Carolina and Ohio, collecting water quality samples. They have weathered storms, tides, snakes and alligators, and midnight sampling marathons. Back in the office, they analyze the results of the studies and input them into models to accurately predict wasteload capacity. Included below are a few photos from recent field studies.

For more information on **AquAeTer's** wasteload allocation studies and water quality modeling you can contact John Michael Corn at jmcorn@aquaeter.com or Mike Corn by e-mail at mcorn@aquaeter.com.

Mike and the AAT "River Rats" at the end of a one-week study in L.A.

Mandy taking discharge measurements

AAT field crew releasing dye for time-of-travel

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Terra A. Plute, EI, is a project engineer at **AquAeTer's** Centennial office. Ms. Plute graduated from Colorado School of Mines in 2006 with a B.S. in Engineering with an Environmental Specialty and in 2008 with a M.S. in Environmental Science and Engineering with a focus on Risk Analysis and Site Characterization. Since joining **AquAeTer** in 2008, Ms. Plute has assisted with a variety of projects including environmental compliance monitoring projects, landfill gas monitoring, data evaluation, and environmental assessments. She has also worked on projects related to assessing the life-cycle of manufactured products. Ms. Plute is a licensed Water Well Monitoring Technician in the state of Nebraska and is planning to take the PE exam in 2012.

Environmental Monitoring – Landfills and More!

AquAeTer provides environmental monitoring services to clients who operate Municipal Solid Waste, Hazerdous Waste, and Industrial Waste landfills across the US. From our Denver location, our monitoring team is focused in 2010 on landfills and industrial facilities in Colorado, Nebraska, Nevada, New Mexico, and Utah. Our environmental monitoring services cover the full spectrum from characterizing clients' operations and locations to determining what environmental indicators should be monitored and what media should be sampled, to final reporting of monitoring results to regulatory agencies – and all the steps in between.

When **AquAeTer** performs environmental monitoring at a landfill, we know that we may be working with groundwater, leachate, gas, and surface water. Our sampling teams are well-versed in sampling methods that range from labor-intensive manual bailing of deep monitoring wells to the use of dedicated equipment and truly passive sampling methods. Regardless of the sampling method, adherence to proper procedures and thorough/accurate documentation is critical throughout the monitoring process. Effective environmental monitoring requires organized planning, diligent and safe operation, and concise reporting.

Successful groundwater monitoring starts with good organization. Equipment and sample bottles must be ordered and checked to make sure they arrive in good condition and exactly as ordered. Forethought must be given to how many wells will be sampled, what equipment will be needed, potential health and safety concerns, and personnel availability. In the field, monitoring equipment must be calibrated, groundwater levels checked, and each well inspected and purged before it can be sampled. Each groundwater monitoring plan is slightly different and the differences must be followed. Wells typically are purged with a low-flow technique of 100 milliliter per minute or less until water quality parameters such as pH, conductivity, temperature, DO, turbidity, and ORP stabilize. Samples are collected directly from the purging equipment into a variety of sample bottles requiring different filtration, preservation, and headspace. Samples are placed directly into a cooler with ice for storage and transported to the analytical laboratory.

All samples are tracked on a chain-of-custody that identifies the samples and includes instructions for the lab on analytical methods to be used. The parameters for which samples are analyzed are site-specific, but typically include volatile organic compounds (VOCs), metals and other inorganic compounds, and general water chemistry. Each parameter has a maximum hold time, some as short as 24 hours, during which the sample must be preserved, extracted, and analyzed. Samples must arrive at the lab with enough time remaining to complete the analysis. Estimating field time and travel time to the lab, maximizing available daylight, and arranging for sample delivery during business hours are significant aspects of organized field preparation and execution.

At many landfills, leachate monitoring and sampling are crucial requirements. Leachate must be regularly measured and closely monitored to make sure levels don't exceed regulatory specifications. Samples of leachate typically are analyzed for the same parameters as groundwater depending on regulations and leachate management methods. Leachate samples, like groundwater samples, are collected using automated or manual methods, placed in a variety of bottles with a variety of preservatives, placed directly into an iced cooler, and transported to the lab for analysis. Additional equipment is required for leachate monitoring and sampling because of worker proximity to confined spaces and potentially hazardous conditions, such as gaseous hydrogen sulfide or VOCs.

Landfill gas (LFG) monitoring is a critical requirement at certain landfills. While there are many gases that make up the composition of LFG, the primary LFG constituents that we monitor for are methane, carbon dioxide, and oxygen. Methane content measured in the field is expressed as percent methane by volume in air, and is combustible and ignitable in concentrations ranging between approximately five and 15 percent. A field-calibrated monitoring instrument is used to pump LFG through the instrument until stable readings are obtained. When methane concentrations exceed the lower explosive limit (5%), quick action might be necessary to determine the significance of the situation with regards to persons working or living nearby.

As field team leader, I have enjoyed the challenge of planning the logistics, staging all the needed equipment for a successful landfill sampling event, coordinating with the landfill personnel prior to arriving and while on-site, and working as safely and efficiently as possible to collect and record pertinent data. Back in the office, the teamwork continues with client communication, building data tables, drafting figures, report writing, technical review, and producing the final reports.

For more information on **AquAeTer's** environmental monitoring services, you can contact our Colorado office at 303-771-9150 or our Tennessee office at 615-373-8532.