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J.P. Salanitro et al. 1994.

J.P. Salanitro et al. 1998.
Perspectives on MTBE Biodegradation and Potential for In Situ Aquifer Bioremediation, in Proceedings of SW Regional Conf. Of NGWA, Anaheim, CA, June 3-4.

J.P. Salanitro et al. 1999.

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The "National Sediments Dialogue"

By Richard J. Wenning and Greg Planicka

Contaminated sediment problems represent a complex and multifaceted science, economic, and public policy challenge in the United States and abroad. Issues of health and ecological risk; the efficacy, risks and high costs of assessment and treatment technologies; appropriate and efficient use of resources; public concern; intricate and sometimes inconsistent statutory authorities, and, overlapping governmental jurisdiction represent some of the complexities.

These complex and interrelated issues are important elements of any decision-making landscape. And like many other environmental policy challenges, there is no panacea or single remedy for resolving what the United States Environmental Protection Agency (USEPA) has characterized as potentially costing hundreds of millions of dollars in future remediation and management costs in the U.S. over the next decade.

“At present, risk analysis is not applied comprehensively in contaminated sediments management. The expanded application of risk analysis would not only inform decision makers in specific situations but would also provide data that could be used in the selection and evaluation of sediment management techniques and remediation technologies.” National Academy of Sciences, “Contaminated Sediments in Ports, Harbors and Waterways” (1997)

The environmental and economic stakes are high, and the level of public concern is increasing. The presence of contaminated sediments poses a significant barrier to waterway maintenance at many U.S. ports. The USEPA has identified 96 watersheds containing over one billion cubic yards of contaminated surface sediments. In addition, there are at least six different federal statutory regimes that provide authority to address sediments. There are at least as many federal agencies with some responsibility for regulating water resources, including wildlife and sediment. And, there are many more state and local environmental authorities and transportation, marine/coastal, and economic development agencies with sediment management part of their portfolios.

A Need to Coordinate Science and Policy

Several national and regional organizations, and a countless number of companies and academic institutions have initiated projects and research programs to develop testing methods, assessment tools, management technologies and decision-making matrices for addressing contaminated sediments. From these efforts, the concept of risk assessment and risk-based decision-making has often emerged as a potentially unifying principle.

Still, consensus on a risk-based approach for prioritizing water bodies, performing the assessments, and selecting remedies for these sites remains an elusive goal. There is currently no national integrating body for technical and policy experts to debate and reach consensus on appropriate sediment characterization and management techniques. The process is often made difficult by technical uncertainties or competing objectives.

In the midst of the widely divergent efforts currently underway, the National Environmental Policy Institute (NEPI) has stepped forward. NEPI intends to bring as many stakeholders as possible together to establish a national framework that encompasses the issues surrounding the management of sediments in the nation’s ports, harbors and waterways. In particular, NEPI has identified the need for a well-accepted, integrated conceptual risk analysis model (which includes risk assessment, risk management, and risk communication) for managing sediment; as well as a forum for information exchange and education among diverse technical experts and policy makers with sediments decision authority.

The NSD Project

In January 2001, NEPI convened the National Sediments Dialogue (NSD) to address these problems and advance a more integrated, coherent national approach to managing contaminated sediments. The NSD Working Group is composed of federal, state and local government decision-makers, scientists, economists and public policy professionals drawn from academia, government agencies, industry, and NGOs with expertise in sediments.

The NSD Working Group includes representation from...
several U.S. federal agencies, including USEPA, Navy, Army Corps of Engineers, National Oceanic and Atmospheric Administration, Fish & Wildlife Service, and the Agency for Toxic Substances and Disease Registry. At present, participating state agencies include California, Louisiana, Michigan, New Jersey, New York, and Oregon. Other participating organizations with a special focus on sediments include the National Academy of Sciences, the Sediment Management Work Group, the Remediation Technology Development Forum and the Water Coalition.

National Sediment Dialogue

The goal of the NSD is to identify and facilitate the actions needed to create more uniform, science-based policies for addressing contaminated sediments in the United States. To support this goal, the NSD has committed to:

- Facilitate a deeper, more substantive context for sediment management decision-making by integrating and building upon the significant work of the many institutions and technical experts involved in the current policy and technical debates;
- Serve as a forum to share concerns and solutions among diverse stakeholders with regulatory, technical, and policy responsibilities at a variety of contaminated sediments sites and assist in the development of consensus approaches to remediation; and,

- Develop common ground for a national risk analysis framework that addresses contaminated sediments by involving key technical experts and policy makers from a diverse array of public and private stakeholders and engaging elected officials, their staffs and key leadership at both the federal and state levels.

A Risk-Based Framework

Agreement on the construct of a consensus-based risk analysis framework is certainly the first and, perhaps, most daunting challenge facing the NSD. The purpose of this framework is not to supplant the protocols and requirements of specific statutes or regulatory initiatives; but to provide stakeholders with a unified, tiered approach for addressing complex remediation issues. NSD participants acknowledge while sediments sites are complex and defy a one-size-fits-all approach, a unified framework can ensure that the best science and policy information is brought to the attention of decision-makers.

The three main components of the framework envisioned are risk assessment, risk management, and risk communication.

The first component, risk assessment, embodies environmental characterization and the considerable debates over appropriate procedures for conducting screening-level and detailed assessments, and how those efforts might vary depending upon the regulatory context and management purposes. Sediment testing methods, identifying back-ground conditions, selecting endpoints, defining reasonable ecological and human exposure models, and addressing scientific uncertainties are at the core of this debate.

The second component, risk management, poses similar challenges but embodies the remediation and restoration process. Some stakeholders believe dredging may be the preferred remedy for resolving most contaminated sediment problems and represents a sound strategy for reducing environmental impacts in some waterways. Other stakeholders caution that ecosystems are much too complex, distinct and varied to predict whether a single remedy will reduce, exacerbate or have no impact at all on ecology. Still other stakeholders focus on the overall size of the sediments problem, the potential costs involved, and the need to combine a variety of management strategies (e.g., natural attenuation, dredging, in situ capping, and containment).

The third component, risk communication, is a challenge focused squarely on public policy. The initial efforts of the NSD will focus on depoliticizing environmental issues by focusing stakeholders on the underlying ecological and engineering principles, establishing common ground on the state-of-the-science, and defining the important technical areas requiring further improvements. While final decision-making often rests on nonscientific reasons, regulatory and policy decision-making should incorporate a strong science base.

The NSD working group embraces risk communication as a key agenda issue. A large measure of the NSD's success will rest on identifying and building consensus on good decision-making models for assessing potential remedies, best practices for validating and monitoring different options, and evaluating the effectiveness of past and present options. Working towards consensus will demand the involvement of appropriate policy makers and their staffs at the federal and state levels. A closely related second measure of NSD's success will entail public involvement and understanding of the benefits and risks of different remedies.

Progress Thus Far

NSD planning meetings in 2000 and early working group meetings in 2001 indicated that the NSD should cover key issues across the spectrum of sediment decision-making from initial site evaluation and risk assessment to public communication and remediation/management. Over the next year, the NSD Working Group will proceed in a step-wise fashion to tackle each element in the spectrum.

Since its inception last year, the NSD Working Group has identified and discussed a draft set of key issues, in which clarification or greater consensus would substantially advance sediment management decision-making.

Most recently, the NSD Working Group has focused on defining initial screening-level assessments, relevant threshold questions and problem formulation. In tandem,
the working group has begun reviewing existing frameworks and conceptual models, and has begun the daunting task of building a national risk analysis framework for contaminated sediments. These developments will be captured in an NSD white paper. NEPI anticipates release of the first draft of NSD's risk analysis framework as a white paper later this summer, and publication of a final framework document before the end of the year.

In addition to a coherent risk analysis framework, two activities are contemplated as part of the NSD which could provide critical support to risk managers and help meet their future needs. These include critical evaluation of past and on-going remediation and restoration activities using a technical peer-review forum; and, coordinating and encouraging field trials for technically sound, innovative technologies to determine their appropriateness under field conditions and evaluate long-term effectiveness.

About the National Sediments Dialogue Project

The National Environmental Policy Institute (NEPI) is a non-profit organization that seeks to achieve advances in environmental policy through nonpartisan, consensus-based dialogue. NEPI has been at the forefront of developing policy recommendations for expediting the cleanup of contaminated sites through its "How Clean is Clean?" projects, Bioavailability Policy Project, and Democratizing Environmental Policy series of regional and national conferences.

Led by NEPI Chairman and former Congressman Don Ritter, Project Director Marianne Lamont Horinko (Clay Associates, Inc.), and NEPI Director of Projects Greg Planicka, the NSD is intended to draw upon the leadership and experience of a wide array of stakeholders in the sediments cleanup debate to foster consensus, information-sharing, and improved cleanups to enhance our nation's health and environment.

To learn more about the NSD and other NEPI activities, contact Greg Planicka at NEPI or visit their web site at www.nepi.org.

Richard J. Wenning is the Practice Director for Environmental Management & Risk Services at The Weinberg Group in San Francisco. Greg Planicka is Director of Programs at NEPI in Washington D.C. and is responsible for the National Sediment Dialogue project.
The need for a Watershed Information Network was identified in April 1996 at a workshop entitled “Watershed Stewardship in Missouri: Status and Opportunities”. More than 25 Missouri entities with watershed-related management interests were represented by 162 participants. During a facilitated discussion of “opportunities”, the need for a central point of contact for information, data and education materials regarding watersheds gained unanimous acceptance and approval. Post-workshop surveys confirmed this positive expression of interest in a clearinghouse for information and data, and the respondents outlined their expectations. Out of this initiative, the Missouri Watershed Information Network (MoWIN) was developed to assist citizens in locating and accessing information relative to Missouri watersheds and to increase their knowledge about watershed conditions and best management practices. MoWIN, a partnership of 29 state and federal agencies, non-governmental organizations and natural resource interest groups, provides information that may assist citizens in making informed decisions to protect, conserve and enhance their shared natural resources. MoWIN’s challenge is searching through data from the Internet and natural resource interest groups and getting it in a usable form for citizens to promote healthy watersheds. To date, MoWIN has developed a website (http://outreach.missouri.edu/mowin/) with projects to gather, compile and distribute watershed information. In addition to Internet referrals, staff provide information using the phone, fax, mail, e-mail, workshops and conference presentations.

The wealth of watershed data and information is growing rapidly. So is the number of people trying to access them. There is a need to avoid duplication and make it easier for clients to find what they are seeking. The growing public and agency interest in watersheds, and the significant increase in number of watershed-based activities, call for orderly collection and dissemination of information to the public. No central location for watershed information is now available to reduce time and frustration for researching and planning watershed projects.

One of the driving reasons for so much activity and interest in watershed stewardship is that water quality and quantity issues rank near the top of the list for county, state and national environmental priorities. Atrazine detects in surface water supplies have many rural communities in Missouri agonizing over what to do next. Major floods in 1993 and 1995 left many individuals and communities struggling to learn available options. Water quality protection is an issue facing the swine and poultry industries in Missouri. Urban and suburban areas also face water quality and quantity issues. As these and other water issues gained public attention, agencies and organizations are being charged with the responsibility of meeting the emerging related needs. Partnerships and alliances are seen as central players in raising the level of awareness regarding watershed stewardship as a way of improving natural resources management (Ball, R. & Dillard, J, 1998).

Too often, responsible stewardship of our shared natural resources is seen as a function of government alone. However, a high percentage of our land is in private hands. Thus, each of us has a role in conserving and protecting our natural resources; "we all live downstream".

Natural resource stewardship is not an isolated issue, neither is it a government only responsibility. Rather, it is an important "component of complex human-environment system interactions that may together bring the world to the edge of catastrophe or create improvements in welfare and equity for all people" (Niemczynowicz, 2000), and it's everyone’s responsibility.

We should be asking three simple questions:
• Are we watershed wise and friendly?
• Who lives in our watershed, upstream and downstream?
• Have we considered what we send downstream to our watershed friends?

Answers to these questions, and the choices that we make every day can make a difference and impact the watershed.

**About The Missouri Watershed Information Network (MoWIN)**

MoWIN was developed to assist citizens in locating and accessing information relative to Missouri watersheds.
(Figure 1) with the following goals;

- Increasing knowledge about watershed conditions and best management practices.
- Having more landowners and interested citizens becoming aware about the state of their watersheds;
- Impacting actions or non-actions on shared natural resources, and
- Helping citizens find the information they need to make informed decisions regarding natural resources stewardship.

MoWIN is currently a partnership of 29 state and federal agencies, non-governmental organizations and natural resource interest groups (Table 1.). MoWIN encourages effective management of water resources using updated information. By collaborating with governmental agencies and citizen groups, MoWIN has the opportunity to empower citizens and foster a dramatic increase in public awareness regarding the state’s environmental management. Watersheds must be managed with a long-term outlook, and the information technology has created opportunities to provide people with significantly improved information regarding the quality of watersheds. Hence, MoWIN activities are guided by these principles:

- Citizens will always have the need for safe, clean, fresh drinking water,
- Everyone lives in a watershed,
- People will do the right thing given the right information,
- More information is available than has been used to improve water quality.

The health of our watersheds is everyone’s responsibility.

To achieve these principles, MoWIN has become a first point-of-contact for watershed information for Missourians offering a service that is not located elsewhere in the state.

Working together, we can make a difference. Our every-day choices impact our watersheds. For example few of us know that the amount of fertilizer, insecticide or water used on one’s lawn makes a difference, or that used motor oil or other chemicals poured on streets and driveways while washing vehicles causes water pollution. In addition, water runs downhill. Water is a universal solvent; therefore, it takes most dissolved substance particles of any kind
with it as it goes. Therefore, the less pollutants we put on or in the environment, the less that ends up with the fish and our drinking water. It is the intent of MoWIN to inform citizens about watershed events, meetings, current projects, local contacts, human resources, financial assistance, water-related terms, technical assistance, educational resources, watershed-related information by county, source water protection, resource management, planning, restoration and research-based scientific data.

**Information**

According to the Environmental Protection Agency (EPA), "Clear, accurate, and timely information is the foundation of a sound and accountable water quality program. Informed citizens and officials make better decisions about their watersheds." (Clean Water Action Plan, 1998). Keeping citizens informed about watershed conditions by using research-based scientific management practices may contribute toward important natural resources conservation decisions and boost watershed stewardship activities at the grassroots level. Expected outcomes include healthy watersheds with sustainable soil, water, plant, animal, and air resources as indicated by improved water quality. In addition, healthy watersheds provide:

- sustainable natural resources for future generations
- safe, clean drinking water
- a place to recreate, relax, and have fun, and
- long-term productive agriculture and economically healthy communities.

Furthermore, good watershed information and stewardship provide socioeconomic values related to future reduction in restoration costs, and promotes diffusion of non-point source pollution resulting in economically healthy watersheds.

**Objectives**

Specific objectives of the MoWIN project include:

- Develop and maintain an easily-searchable web site for agricultural and natural resources information and data
- Compile an electronic natural resources conservation directory for Missouri which lists all entities involved in watershed stewardship
- Compile a comprehensive bibliography of existing electronically available publications and guide sheets pertaining to the management and use of Missouri's watersheds.

**MoWIN Features and Activities**

MoWIN is a service that is not available anywhere else in the state. It makes accessing watershed information very easy for Missouri citizens. MoWIN offers a web site, toll-free number and e-mail for locating and accessing watershed information. The productivity and working relationships that MoWIN personnel have created are very important to the success of the project. The list of programming efforts below (Table 1.) show the overall effort that MoWIN personnel have put into making MoWIN a useable and successful program. Staff disseminate information through local, regional, national and international workshops, conferences, and meetings. Additional tools include brochures, e-mail, fax, telephone and personal visits, monthly, quarterly and annual reports. Current features include:

- MoWIN Features - Web site tutorial
- About MoWIN - General information about MoWIN
- Acronym City - An alphabetical list of often-used acronyms related to watershed stewardship
- Agricultural and Natural Resources Contacts Directory - Quick, easy, and useful access to agricultural and natural resources conservation agencies, organizations, and other state and federal entities in Missouri
- Announcements - Current information about agricultural and natural resources, water quality regulations, funding sources, and other watershed related information
- Educational Resources - Water-related and environmental education links
- Glossary of Water-Related Terms - A comprehensive list of air, soil and water-related terms and meanings
- Grants and Funding Sources
- Meetings/ Events Calendar - State, national and international calendar of meetings, events, and conferences that enhance knowledge and provide global ideas related to...
watersheds
- Watershed Management, Planning, Restoration and Research Data - Information sources to assist in making decisions related to watershed management, planning and restoration
- Watershed Projects - Comprised of several watershed projects that provide awareness of, and knowledge about, best watershed management practices (includes the Agricultural Nonpoint Source Special Area Land Treatment Projects)
- Watershed-Related Information by County - (Missouri Counties) - compilation of watershed information from various state, federal and non-governmental agencies
- Watershed Resources - Links to other watershed and natural resources
- Comments, Suggestions, Questions - Designed for feedback to/from MoWIN’s users
- MoWIN’s Pantry - Includes MoWIN’s documents, project meetings, Advisory Council Member contacts etc.

In addition, the Missouri Conservation Assistance Guide Project is another major collaborative effort with USDA Farm Service Agency, Missouri Department of Agriculture, Missouri Department of Conservation, Missouri Department of Natural Resources, University of Missouri Outreach & Extension, USDA Natural Resources Conservation Service, and the Missouri Association of Soil and Water Conservation Districts. The effort is to publish a hard and electronic copy of Missouri’s technical, financial, educational and informational assistance.

MoWIN staff respond to telephone and e-mail requests on topics including: environmental regulations, water quality, regulations pertaining to building waste water lagoons, waste disposal into creeks, streams/rivers, information regarding dam facilities, reservoir levels and updates, scholarly research on watershed health, point/nonpoint source pollution, dam and flooding problems. Other requests include drinking water information in specific cities, counties and watersheds, re-channelizing of streams, vacancy announcements, water use permits, water testing, educational materials, watershed projects and research.

**Impact**

Impact is based on web site hits which average 600 - 800 a month, telephone, e-mail and personal consultations. Follow-up impact surveys mailed to the original 162 workshop participants in September 1999 revealed that MoWIN is a good source and tool for watershed planning, water quality initiatives, natural resource agency contacts, services and environmental assistance. Other comments noted that the web site information is diverse, easy to use, saves respondents time and frustration, and has exceeded respondents’ expectations. Links to the other involved agencies and offices are very helpful, the website is easy to use yet contains an incredible amount of information, and that MoWIN has evolved beyond the original expressed interest. Evaluations completed by participants at the end of University of Missouri’s Extension training experiences indicate that MoWIN is a useful and convenient watershed information tool. Examples of comments submitted in sup-
port of the website the last half of 2000 include:
• "I just wanted to let you know that your website glossary on specific hydrological terms is simply FANTASTIC - what a resource." 11/24/00. Lethbridge, Canada.
• "I just wanted to let you know that you did a great job at the Groundwater Foundation Conference. After you left, I received many positive comments about your presentation and the cohesive efforts of MoWIN." Springfield, Mo.
• "Your MoWIN site is very nice, very professional. We will be sending you our completed Ongoing Projects Form as soon as possible, and look forward to being included on the premier information site regarding Missouri's watersheds!" Springfield, Mo.
• "I just took a spin through your web site and have these comments: First, it is well-organized and clean - nicely uncluttered unlike so many. Thanks." Seattle, Wash.
• "I love the website! I just wanted you to know the Soil & Water Conservation District has a website you can link to. We would like to link to you if you don't mind." St. Louis, Mo.

The Partnership
MoWIN's Partners (Table 1.) make significant contributions financially and in-kind. Examples include the invaluable amounts of time spent by staff working on various web site features. Partners' designated representatives spend considerable time reviewing MoWIN's needs, activities, web site information, attending committee meetings, representing MoWIN in various environmental discussions and assisting in the dissemination of information to Missouri's citizens and natural resources agency personnel through various informational forums.

Future Perspectives
MoWIN's long-term goal is prevention and management of nonpoint sources of pollution to ensure future water quality and availability while protecting the environment and restoring impaired watersheds. Using education and information, MoWIN designed this web site to assist citizens in understanding the impact of their actions or inactions on the future of the state's water resources. The project is intended to encourage natural resources stewardship by utilizing available information resources. We are rapidly reaching a point where more data is becoming electronically available. In the long run, we envision a "point and click" map of Missouri's 66 8-Digit Hydrologic Unit Codes (see Figure 1) linked to all available information where clients can bring up their watershed on the screen and pose questions to the MoWIN system and to related linked web sites. The challenge is searching through data and getting it in readily useable form to the client's domain to promote healthy watersheds. For more information see the web site at http://outreach.missouri.edu/mowin

References


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Tabitha Madzura is with the University of Missouri Outreach & Extension, Columbia, Mo.
Soils

Storm Water - Drinking Water

By Alfred R. Conklin

There are two connections between storm water and drinking water. One is water, which runs over the earth’s surface and winds up in streams, ponds, lakes and rivers from which it is withdrawn to use as drinking water. The other is through plants into and through the soil to ground water. From there it is withdrawn from wells to be used as drinking water.

In the first instance water picks up contaminants, both organic and inorganic, and deposits them in bodies of water. Hydrocarbons, in the form of fuel and grease from automobiles, busses and trucks, constitute common organic contaminants. In reality they also include any organic compound used in the home or in industry. They also include organic matter both living and dead. This could be the bodies of dead animals as well as their manure and the microorganisms that go along with both. Inorganic contaminants can range from acids used in cleaning brick to bases used in cleaning houses.

In the second case water takes a tortuous path to the surface and then through the pores of soil. In this process it is acted upon by many physical processes, chemical reactions and biological processes. Larger particles of either inorganic or organic material are trapped and filtered out. Organic and inorganic molecules are adsorbed by soil clay and organic matter. Some is also trapped in small soil pores. The form of inorganic chemicals is changed by chemical reactions and by living organisms. Organic matter is decomposed by soil microorganisms leaving carbon dioxide, water and humus.

Microorganisms added to soil in storm water are introduced into a hostile environment. They must compete with microorganisms adapted to the varying water and air content, nutrient availability and pH of soil. Pathogenic organisms find the constant variation in temperature and pH particularly difficult to survive. Organisms are attracted to the charges on soil particles and are also physically filtered out. These organisms can only survive in soil by entering a resting or hibernation phase, which protects them from this hostile environment.

Not all rainwater enters the soil. No matter how well soil is vegetated some water runs off and some erosion, called geologic erosion, occurs. This amounts to 1000 kg/ha or less of soil per year (1000 lbs. per acre per year). It is important to keep in mind that soil erodes from the surface down. The top most layers are removed first and anything on the soil surface is moved along with them. This eroded soil moves into streams, rivers, ponds and lakes. It may be deposited in streams and rivers or it may be carried by them to a pond, lake or to the ocean and deposited there. It may move directly into ponds and lakes where it is immediately deposited as the water velocity decreases upon entering the body of water.

Accelerated erosion occurs in agriculture. When the best soil conservation practices are used this amounts to 2000 to 3000 Kg per hectare per year. The majority of agricultural chemicals, lime, fertilizer herbicides and insecticides are applied to the soil surface. Even in cases where the chemicals are incorporated into the soil they are most often applied to the surface first and incorporated some time later. Because of the method of application, soil chemicals are subject to erosion along with soil and thus can end up being deposited in bodies of water, which subsequently become sources of drinking water.

Agricultural materials which end up in bodies of water are not limited to agricultural chemicals. Manure and microorganisms associated with animals and animal production are also eroded along with soil and wind up in bodies of water. Both of these components make water unfit for use as drinking water unless it undergoes extensive purification. In addition these components result in a high biological oxygen demand in water. This will also have detrimental effects on the water quality.

One should not believe that agriculture is the only source
of soil and pollutants in drinking water. At all construction sites, housing developments, road construction and others, erosion and pollution of water occurs. This water also finds its way into streams, rivers, ponds and lakes. Whenever the soil surface is bare and left that way for a period of time the soil is subject to erosion. In addition any chemicals spilled on the soil in the construction process will be eroded with soil and wind up in water.

To keep storm water as clean as possible we need to control water running off houses, and roads in the city and prevent soil erosion in all other situations. Roofs and roads are impervious to water and it runs off these surfaces. In the process it washes off organic and inorganic debris,. The water then runs into storm water drains and finally into bodies of water.

If storm water is passed through sand before entering a body of water it will be significantly cleaner. Proper construction of sand filters can increase their percolation rate while maintaining their filtering capacity.

Storm water from open or agricultural land can be completely eliminated very simply. Soil erosion starts by raindrops hitting the bare soil surface and dislodging primary soil particles, sand silt and clay. This is called splash erosion (see diagram). It can be controlled by preventing rain from hitting the soil surface. The simplest way to do this is to have plants growing on it. Leaves adsorb the energy in the raindrops and gently move the water to the soil surface. Plant residues covering the soil surface, straw for instance, will do the same thing over the short term but are less effective.

The second step in soil erosion is the movement of water over the soil surface. Water movement over the soil surface, called sheet erosion, is again controlled by having plants growing on it. The more plants the better. Not only do plants prevent or slow water movement over the soil surface they also encourage infiltration. Water infiltration into vegetated soil is much faster than into unvegetated soil. Water that moves into the soil cannot

erode it. In addition movement through the soil, as mentioned above, results in it being cleaned.

Other more costly practices can also be used to control water movement over the soil surface. Low embankments, sometimes called bunds, can be used to prevent water movement across a slope. Terracing has been in common use for preventing or slowing the movement of water over fields.

Implementation of simple and inexpensive methods of water control and filtration can decrease the amount and improve the quality of storm water. Sand filters and soil erosion control are two such methods.

Alfred R. Conklin, Jr. Ph.D. is professor of agriculture and chemistry at Wilmington College in Ohio.

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Environmental Serv. & Products
Environomics Southwest, LLC
Enviropro Inc.
EPOCH Environmental Group
Fast-Tek
Four Seasons Environmental, Inc.
FPM Group
Gem Star Associates
Geonics Limited
Groundwater & Environ. Services
H2M Group
HRP Associates, Inc.
HydroTerra Environmental Serv.
IMS Environmental Services
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Keramida Environmental, Inc.
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Longhunter Contracting Company
Maxymillian Technologies, Inc.
McTighe Industries
Northern Environmental Tech.
Nova Consultants, Inc.
OES Environmental, Inc.
Quest Environ. & Eng. Services
Resource Control Associates, Inc.
Rindt-McDuff Associates, Inc.
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SITE Environmental Services, Inc.
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Vanasse Hangen Brustlin, Inc.
Veeder-Root Company
Vierbicher Associates, Inc.
Wagner Environ. Consultants, Inc.
Roy F. Weston, Inc.
Williams Environmental
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Vapor Extraction
A2L Technologies, Inc.
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Waste Stream Analysis
Bowser-Morner, Inc.

Wetlands
ARM Group, Inc.
ATC Associates, Inc
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Vanasse Hangen Brustlin, Inc.
Vierbicher Associates, Inc.
Roy F. Weston, Inc.
Woodard and Curran
Woods Environmental, Inc.
X-19 Biological Products, Inc.
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Activated Carbon Adsorbers
Adwest Technologies Inc.
Andersen 2000, Inc. (M)
Barnebey Sutcliffe
Carbon Resources, LLC (D)
Carbonair Environmental Sys. (M)
Carbtrol Corporation
EnviroSupply & Service (D)
EPG Companies, Inc. (M)
Facet International
Mobile Process Technology
New Pig Corp.
TurnKey Solutions, Inc.
Williams Environmental (D)

Activated Carbon Regeneration
Atlantic Screen (D)
Barnebey Sutcliffe
Carbon Resources, LLC (D)
Carbonair Environmental Sys. (D)
EnviroSupply & Service (D)
Geotech Environmental Equip. (D)

Adsorbents
Atlantic Screen (M)
BBC International, Inc. (D)
Bioscience, Inc.
Carbon Resources, LLC (D)
Facet International
W.L. Gore & Associates, Inc. (D)
Monier Lifetile
New Pig Corp.
Parker Systems, Inc. (M)
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Bioscience, Inc.
Remediation Service, Intl. (M)

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Aeromix Systems, Inc. (M)
Apex Environmental, Inc. (D,M)
Bioscience, Inc.
Brown Bear Corp.
Facility & Resource Mkt. Grp. (M)
Remediation Service, Intl. (M)
ReRem Equipment (D)

Air Spargers
Bioscience, Inc.
Carbonair Environmental Sys. (M)
EnviroSupply & Service (M)
EPG Companies, Inc. (M)
Fliteway Technologies, Inc. (M)
Geotech Environmental Equip. (M)
King, Buck Technology
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Williams Environmental (D)

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Andersen 2000, Inc. (M)
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Carbonair Environmental Sys. (M)
Carbtrol Corporation
EnviroSupply & Service (M)
EPG Companies, Inc. (M)
Fliteway Technologies, Inc. (M)
Geotech Environmental Equip. (M)
Remediation Service, Intl. (M)
ReRem Equipment (D)
Williams Environmental (D)

Analyzers, Water
Bioscience, Inc.
Geotech Environmental Equip. (M)
Geotechnical Services Inc.
I.E. Monitoring Instruments (D)
Rite in the Rain
Sentex Systems, Inc. (M)
Skalar, Inc.
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BBC International, Inc. (M)
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Bioscience, Inc.
Bio-Tech 2000, Inc. (D,M)
CL Solutions
The Critter Company (M)
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Facility & Resource Mkt. Grp. (M)
MicroSorb Environ. Products
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Waste Stream Technology (M)

Baffles, Floating
SPCC, Inc. (D)

Baghouses
Andersen 2000, Inc. (M)
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Prosonic Corporation (D)
Remediation Service, Intl. (M)

Landfill Liners
Integra Plastics (D,M)

Low Nox Burners
Adwest Technologies Inc.
Alzeta Corporation (M)
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Membranes
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Campbell Scientific, Inc.
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CEA Instruments, Inc. (M)
Clean Environment Equipment (M)

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W.L. Gore & Associates, Inc. (D)
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Solinst Canada Ltd. (M)
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Veeder-Root Company
Wilks Enterprise, Inc.

Oil Skimmers
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McTighe Industries (D)
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Adwest Technologies Inc.
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Tesco Tank
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Containment Corporation
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EPG Companies, Inc. (M)
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McTighe Industries (M)
New Pig Corp.
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Wilkins Environmental (D)
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SEI Industries, Ltd.
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Pugmill Systems, Inc. (M)
Rock Systems, Inc. (M)

Pumps
Astbury Group (D)
Atlantic Screen (M)
Carbonair Environmental Sys. (D)
Clean Environment Equipment (M)
ConVault, Inc. (D)
Environmental Serv. & Products (D)
Envirosupply & Service (D)
EPG Companies, Inc. (M)
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Facility & Resource Mkt. Grp. (M)
Gast Manufacturing, Inc.
Osprey Biotechnics
U.S. EPA
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ANKA Technology (M)
Buck Scientific Inc.
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Geonics Limited (M)
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Geotechnical Services Inc.
KVA (K-V Associates, Inc.)
Prosionic Corporation (D)
Rite in the Rain
Simco Drilling Equipment, Inc.
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Geotechnical Services Inc.
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KVA (K-V Associates, Inc.)
Rogue Environmental Equip. (M)
Government Institutes Division
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RockWare, Inc.
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Software
Apex Environmental, Inc. (M)
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Government Institutes Division
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Monier Lifetile
Remediation Service, Intl. (M)
RockWare, Inc.
SPCC, Inc. (D)
U.S. EPA
Waterloo Hydrogeologic, Inc. (M)

Soil Handling Equipment
Murphy Products, Inc. (M)
Rite in the Rain
Rock Systems, Inc. (M)
U.S. EPA

Spectrometers
Astbury Group (D)
Bioscience, Inc.
Buck Scientific Inc.
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Containment Corporation
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Rain for Rent (D)
SEI Industries, Ltd.
SPCC, Inc. (D)
Tesco Tank
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BBC International, Inc. (M)
John L. Biesz, Consulting (M)
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The Critter Company (D)
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Facility & Resource Mkt. Grp. (D)
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Fax: 716-856-0583
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Fax: 905-339-0016
www.bennettemv.com

See ad on page 3

John L. Biesz, Consulting
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Fax: 610-398-9317

Bio-Genesis Technology, Inc.
7343 E. Camelback Road
Scottsdale, AZ 85251
Phone: 480-990-0709
Fax: 480-990-7745
www.biogti.com

Bioscience, Inc.
1550 Valley Center Parkway
Suite 140
Bethlehem, PA 18017-2267
Phone: 800-627-3069
Fax: 610-691-2170
www.bioscienceinc.com

Bio-Tech 2000, Inc.
420 Clematis Street
West Palm Beach, FL 33401
Phone: 888-246-8324
Fax: 561-832-6075
www.biotech2000.com

Blue Ridge Environmental, Inc.
PO Box 166
18135 Lincoln Road
Lincoln, VA 20160
Phone: 540-338-8547
Fax: 540-338-8548

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BOSS International, Inc.
6300 University Avenue
Madison, WI 53706
Phone: 800-489-4775
Fax: 608-258-9910
www.bossintl.com

Bowser-Morner, Inc.
4518 Taylorsville Road
Dayton, OH 45424
Phone: 937-236-8805
Fax: 937-233-2016
www.bowser-morner.com

Brown Bear Corp.
PO Box 29
Corning, IA 50841
Phone: 641-322-4220
Fax: 614-322-3527
www.brownbearcorp.com

Brown Environmental Services Corporation
42 Sequoia Drive
Newtown, PA 18940
Phone: 866-77-BROWN
Fax: 215-504-5067
www.brownbio.com

Buck Scientific Inc.
58 Fort Point Street
East Norwalk, CT 06855
Phone: 203-853-9444
Fax: 203-853-0569
www.bucksci.com

Campbell Scientific, Inc.
815 W. 1800 N.
Logan, UT 84321-1784
Phone: 435-753-2342
Fax: 435-750-9540
www.campbellsci.com

Carbon Resources, LLC
5222 Rosewood Drive
Oceanside, CA 92056
Phone: 760-630-5724
Fax: 760-630-9930
www.carbonresources.com

Carbonair Environmental Systems
2731 Nevada Ave. N.
New Hope, MN 55427
Phone: 763-544-2154
Fax: 763-544-2151
www.carbonair.com

Carbtrol Corporation
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Suite 5202
Bridgeport, CT 06607
Phone: 800-242-1150
Fax: 203-337-4353
www.carbtrol.com

Carus Chemical Company
315 Fifth Street
PO Box 599
Peru, IL 61354
Phone: 815-223-1500
Fax: 815-224-6697
www.caruschem.com

CEA Instruments, Inc.
16 Chestnut Street
Emerson, NJ 07630
Phone: 201-967-5660
Fax: 201-967-8450
www.ceainstr.com

CH2M Hill Constructors, Inc.
3 Hutton Centre Drive
#200
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www.ch2m.com

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Chicago Chem Consultants Corp.
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Suite 2C
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Phone: 312-226-2436
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www.chicchem.com

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16623 Bethayres Road
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Fax: 301-963-5293
www.chirlin.com

Civil and Environmental Consultants
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Phone: 412-429-2324
Fax: 412-429-2114
www.cecincl.com

CL Solutions
11231 Cornell Park Drive
Cincinnati, OH 45242
Phone: 513-247-0404
Fax: 513-489-2533
www.cl-solutions.com

Clean Environment Equipment
1133 Seventh Street
Oakland, CA 94607
Phone: 800-537-1767
Fax: 510-444-6789
www.cee.com

Clean Venture/Cycle Chem
201 South First Street
Elizabeth, NJ 07206
Phone: 908-355-5800
Fax: 908-355-3495
www.cyclechem.com

Clearwater Group
520 Third Street
Suite 104
Oakland, CA 94607
Phone: 510-893-5160
Fax: 510-893-5947
www.clearwatergroup.com

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1992 Hunter Avenue
Newton, IA 50208
Phone: 641-792-8285
Fax: 641-791-1361
www.jmcsoil.com

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101 Accord Park Drive
Norwell, MA 02061
Phone: 781-982-5400
Fax: 781-982-5490
www.col-col.com

Columbian TecTank
PO Box 2907
5400 Kansas Avenue
Kansas City, KS 66106
Phone: 913-621-3700
Fax: 913-621-2145
www.columbianetectank.com

CompuChem
501 Madison Avenue
Cary, NC 27513
Phone: 919-379-4000
Fax: 919-379-4050
www.compuchemlabs.com

Containment Corporation
10895 Portal Drive
Los Alamitos, CA 90720-2508
Phone: 800-235-7421
Fax: 714-821-9949
www.containmentcorp.com

Control Instruments Corp.
25 Law Drive, Fairfield, NJ 07004
Phone: 973-575-9114
Fax: 973-575-0013
www.controlinstruments.com

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4109 Zeering Road
Denair, CA 95316
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Fax: 209-632-4711
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Fax: 510-791-3306

Cura Emergency Services
2735 Villa Creek Drive
Suite 275
Dallas, TX 75234
Phone: 972-488-2222
Fax: 972-488-1741
www.spillspolutions.com

Custom Biologicals, Inc.
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Suite 208
Boca Raton, FL 33487
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Fax: 561-998-2699
www.custombio.com

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2300 M-139, P.O. Box 97
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Phone: 616-926-6171
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www.gaudetassociates.com

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Leesburg, VA 20175
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Fax: 703-777-3814
www.geomodel.com

Geonics Limited
1745 Meyerside Drive
Unit 8
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Phone: 905-670-9580
Fax: 905-670-9204
www.geonics.com

Geophysical Applications, Inc.
125 Washington Street
Suite 2
Foxboro, MA 02035
Phone: 508-543-1388
Fax: 508-543-1019
www.gomanrupp.com

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601 N. Broadway
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Phone: 800-436-7762
Fax: 785-825-2097
www.geoprobosystems.com

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8035 E. 40th Avenue
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www.geotechenv.com

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Phone: 714-832-5610
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www.geotechnical.net

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Phone: 617-653-9945
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www.channel1.com/dglassasssoc/

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8855 North 55th Street
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www.globaltechnologiesinc.com

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Elkton, MD 21921
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Fax: 410-506-4780
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Mansfield, OH 44901-1217
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Fax: 419-755-1404
www.gormanrupp.com

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Rockville, MD 20850
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Fax: 301-921-0373
www.govinst.com

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PO Box 1750
Wall, NJ 07719
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www.gesonline.com

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Houston, TX 77098-4044
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Oklahoma City, OK 73123
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Melville, NY 11747
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HydroTechnics, Inc.
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Albuquerque, NM 87199
Phone 505-797-2421
Fax: 505-797-0838
www.hydrotechnics.com/flowsensors

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New Products

Oily Wastewater Treatment Systems
Carbtyp Corporation, Bridgeport, Conn., offers a low maintenance treatment system to remove oil from wastewaters. These systems are applicable for industrial processes, maintenance area floor drains, vehicle washing, bilge treatment, etc.

The treatment system uses a combination of treatment technologies, including oil-water separator, filtration and oil adsorption media. The treatment system is fully automatic and requires no chemical additions. This keeps operation, maintenance and labor costs to a minimum.

Carbtyp Corporation, 800-242-1150.

New Pipeline Fittings for Tanks Eliminate Leak-Prone Bolt Holes and Sealants
ModuTank, Inc., Long Island, N.Y., offers advanced flanged bulkhead fittings enabling only single hole penetrations for piping have been introduced by ModuTank. Wall-piercing bolts are eliminated by this design. Wide, thick, gaskets tightly seal the fittings under adjustable force against tank walls.

Bolt-related leakage is eliminated, and no wall sealants are required. The new fittings are available in PVC and stainless steel in standard sizes for 2” to 24” piping. They are equally suitable for new and existing steel, and for concrete tanks with or without epoxy or glass coatings, or with membrane liners.

ModuTank, Inc., 718-392-1112.
UL Listing for Oil/Water Separators
Highland Tank, Stoystown, Penn., announces that Underwriters Laboratories, Inc. (UL), has authorized a new UL label for its product line of engineered Oil/Water Separators rated at 10ppm under UL Subject 2215, Outline of Investigation for Oil/Water Separators. UL Subject 2215, establishes the design, construction and performance standards for Oil/Water Separators. Highland Tank is the nation's largest producer of above and below ground Oil/Water Separators. Highland Tank, 814-893-1109.

KAPPA-3 Ambient Air Monitoring
Trace Analytical, Menlo Park, Calif., offers the KAPPA-3 air monitor that measures critical environmental compounds from low parts per billion to parts per million levels. The monitor uses the highly selective and extremely sensitive Reduction Gas Detector (RGD). Minimal matrix effects from any saturated hydrocarbons makes the KAPPA-3 unique for selective ambient air monitoring.

The unit is rugged and compact, ideally suited for installation in a mobile laboratory for field surveys or employed as a stationary ambient air monitor system. KAPPA-3 is fully automatic from sampling to reporting.
Trace Analytical, 650-364-6895.

Booster Compressor Now Available to 650 psig
Kaesar Compressors, Fredericksburg, Va., has introduced the new Booster Extra Pressure (EP). These reciprocating units now provide pressures as high as 650 psig. They are a convenient and economical way to boost existing plant pressure while eliminating the need for expensive separate high pressure systems for PET Bottling Systems and other applications.

Booster EP compressors come complete with TEC motor, motor starter, Kaesar Control monitoring system, aftercooler, prefilter, anti-vibration pads, and discharge hose, and they have 100% duty cycle.
Kaesar Compressors, 540-898-5500.

Irrigation Meters
ISTEC Corporation, Roselle, N.J., has announced the introduction of a complete line of irrigation meters. These meters measure and monitor the flow of irrigation, well water, and even extremely polluted water. This meter does not require electrical power and still can be read remotely.

The ISTEC irrigation meter has a self-cleaning turbine, so that you can measure water that has up to 30% suspended matter.

The ISTEC Series 1900 Irrigation Flow Meter has a hermetically sealed flow counter and uses magnets to activate the counter. This unique flow meter can be installed in a vertical, horizontal or inclined pipe. Remote readings can easily be retrofitted onto the flow meter.
ISTEC Corporation, 908-241-8880.

New Literature: How to Select a Continuous Solvent Vapor Monitor to Meet NFPA 86-1995 Requirements
Control Instruments, Fairfield, N.J., offers a new technical note to assist operators in selecting a solvent vapor monitoring system that meets the requirements of NFPA 86, including revisions to the standard made effective in 1995. The note discusses the essential requirements for a reliable solvent vapor monitor including sample delivery systems, speed of response, accurate calibration response, avoidance of condensation, failsafe malfunction logic and maintenance.
Control Instruments, 973-575-9114.
Portable Filtration System Built on a Push Cart
TurnKey Solutions, Mahwah, N.J., offers Free-N-Cleen, designed and manufactured as a portable filtration system built on a push cart. It features a coalescing oil/water separator and bag filter housings which are engineered to remove free oil and suspended solids at a flow rate of 0-2 GPM. Bag filters are available in various micron ratings. The system is highly effective at filtering machine coolant baths and wastewater.
Turnkey Solutions, 201-848-7676.

New Wall Mounted Gas Monitor
CEA Instruments, Inc., Emerson, N.J., has introduced the Guardian, a newly expanded family of wall mounted, continuous gas monitors available for Carbon Monoxide, Hydrogen Sulfide, Oxygen, Chlorine, Sulfur Dioxide, Hydrogen Cyanide, Hydrogen Chloride, Nitrogen Dioxide, Nitric Oxide, Hydrogen, Phosphine and many others. Standard features include digital display, NEMA 4X enclosures, output relays and multi-level audio and visual alarms.
The Guardian controller is available with up to four remote sensors which are fast responding and unaffected by temperature and humidity changes. A system test button, local danger alarm indicator, and fault alarm assures proper operations. The unit is easy to install, operate and maintain.
CEA Instruments, Inc., 201-967-5660.

Newly Equipped Soil Shredder/Aerator
Royer (A Terex Company), Myerstown, Penn., offers the Royer 466 Soil Shredder-Mixer. It is newly equipped with an incline grizzly screen and remote, computer control unit. These features dramatically improve processing efficiency by reducing the workload of the one loader/operator.
This machine utilizes a unique shredding process that allows most organic material to be blended, aerated and “screened” by way of a patented Royer Cleated belt. This includes higher moisture and clay content products.
Royer, 717-866-2357.

Shield Provides Added Diaphragm Protection in Sludge and Slurry Applications
Pressure Systems, Inc. (PSI), Hampton, Va., has introduced a new stainless steel shield option for its KPSI™ Series 750, a non-fouling, anti-clogging level transmitter designed specifically for harsh sludge, slurry, and other water and wastewater applications. The new shield protects the unit’s elastomeric diaphragm in these demanding environments, thus increasing the life of the product.
The KPSI Series 750 level transmitter is manufactured of Type 316 stainless steel in a compact, rugged package. The transmitter has a 3” wide sensing area and a highly flexible, PTFE elastomeric diaphragm that is directly exposed to the sensing medium.
Pressure Systems, Inc., 800-328-3665.

Recently Published Children’s Book: Wally and Deanna’s Groundwater Adventure
Waterloo Hydrogeologic, Waterloo, Ont., has recently published a children’s book called Wally and Dianna’s Groundwater Adventure. The educational book provides a uniquely styled approach tc teaching children about water resources and the environment, and introduces them to some of the basic issues surrounding groundwater resources protection and management for a community.
Waterloo Hydrogeologic, 519-746-1798.
Low Flow Groundwater Sampling System
QED Environmental Systems, Inc., Ann Arbor, Mich., offers the new MicroPurge® basics™ MP10 Controller. The device makes low-flow sampling pump control easy. Simple up and down arrow keys deliver fingertip flow rate control, with micro-processor-based expert optimization and recall of predetermined well settings built-in, plus an Automatic Drawdown Control option. As compact as a lunchbox (10-3/4 x 9-3/4 x 5"), the MP10 is housed in a tough, hardshell case for field portability and protection.
MicroPurge basics equipment is a revolutionary new approach to low-flow sampling. Every component is compact, lighter weight, more affordable, and engineered for simple operation and reliable low-flow performance.
QED Environmental Systems, Inc., 800-303-6041.

Web-Based Library of Pipeline Strainers and Plastic Valves
Hayward Industrial Products, Inc., Elizabeth, N.J., offers the website www.haywardindustrial.com with access to an extensive amount of applications and selection data on pipeline strainers, plastic valves and other flow control products. Because the library is online, it’s available 24 hours a day.
Data are presented in a series of articles in an easy-to-read format with helpful illustrations. Articles can be printed in standard page format by just clicking a button. An additional click of a button allows the reader to send the article to a co-worker.
Unlike many references from manufacturers, Hayward presents a wealth of generic material, not manufacturer specific.
Hayward Industrial Products, Inc., 908-351-5400.

Railcar Spill Containment
UltraTech International, Inc., Jacksonville, Fla., offers the new 9-foot Ultra-TrackPans as practical, economical “spill-pads” for use at industrial rail sidings. Rugged, all-polyethylene construction has excellent chemical resistance and will capture up to 160 gallons of spilled fluid. Patented, modular design allows below-grade piping to be installed to channel large spills to holding ponds, tanks, etc. Covers are available to keep rainwater out, helping facilities comply with new Stormwater Management Regulations. Ultra-TrackPans are available in any desired length.

Chemical Resistant Tubing
Saint-Gobain Performance Plastics, Wayne, N.J., offersTygon® Ultra Chemical Resistant Tubing, Formula 2075, providing a unique combination of chemical resistance, clarity and flexibility. Plasticizer-free, the tubing minimizes the risk of fluid contamination common with other flexible tubings, and features an exceptionally smooth inner surface that inhibits particulate buildup. Its low sorption characteristics also help to maintain fluid integrity.
The tubing meets all USP Class VI criteria and will not evidence premature embrittlement and cracking. It also possesses hydrophobic qualities that reduce absorption of aqueous fluids and minimize outgassing from tubing that protects sensitive environments.
Saint-Gobain Performance Plastics, 973-696-4700.
Swivel Fill Adaptors Bring Fill Sites into CARB Stage I Compliance

S. Bravo Systems, Inc., Commerce, Calif., offers the new swivel fill-site adapters for product and vapor recovery. The new B-70B Swivel Fill Adapter for product, and B-75B Swivel Fill Adapter for vapor recovery, were recently approved by the California Air Resources Board (CARB) and are third-party tested.

Both fill adapters are designed in brass for optimum electrical conductivity, and have stainless steel ball bearings that swivel and rotate with the thrust of the fill and vapor loading elbows while their bases remain secured to the storage tank’s riser pipes. The rotating movement helps prevent spillage of product during tank filling and the release of fugitive vapor emissions, meeting CARB Stage I compliance.

Expanded Line of Submersible Pumps

CH&E Pumps, Milwaukee, Wisc., is now promoting its greatly expanded selection of submersible pumps acquired with their recent acquisition of ABS Pumps, Inc. CH&E, longtime leader in self-priming trash and centrifugal pumps, also offers sludge-handling electric diaphragms and new style submersibles to a variety of markets nationwide. The manufacturer continues to introduce engineering features designed to increase efficiency and reduce maintenance.
CH&E Pumps, 800-236-0666.

Floating Sensor Detects Oil Sheen on Water

Ionics Agar Environmental, Watertown, Mass., offers the Leakwise® Model No. ID-223/2000. The device continuously monitors the surface of water and detects the presence of a hydrocarbon layer as little as 0.3 mm in thickness. The sensor not only detects the presence of minute traces of oil, but can monitor on-line thickness changes in those situations where some oil is always present.

The new sensor uses the technology of measuring electromagnetic absorption rate changes in designing their new instrument. Since water absorbs more electromagnetic energy than hydrocarbons, absorption rate changes are proportional to the hydrocarbon level changes.
Ionics Agar Environmental, 617-926-2510 ext. 425.

One, Two, Three and Five Ton Custom Flatbeds

Winkel Manufacturing, Glen Elder, Kan., offers customized, heavy-duty, larger size trucks with flatbeds. Features include, heavy duty rear hitch, side boards of 14 ga. smooth formed steel with 1-1/2” x 3” rectangular tubing stakes, side stake pockets, retractable steel ball hitch, tail and corner marker lights, tag bracket, back-up lights, header frame options and optional mud flaps. Beds are constructed of 1/8” deck plate floor, 5” channel main frame with optional 6” channel available for hydraulic lift headroom.
Winkel Manufacturing, 800-466-3606.
Innovative Stormwater Treatment Technology

By Rodolfo Manzone

Clean Water Background

The regulatory evolution of Federal clean water legislation, beginning with the 1972 Federal Water Pollution Control Act, and culminating with the 1987 Water Quality Act, has helped improve the nation's water resources dramatically. The Clean Water Act's commitment to water quality has largely paid off in improved sewage treatment, reductions in industrial toxics flowing to rivers and streams, declining fish kills, and a growing number of rivers and lakes returning to healthier status. Billions of dollars committed at the federal, state, and local level of government have been spent in response to this changing legislative and regulatory environment.

Many problems remain, however. Nonpoint source pollution, such as agricultural runoff, sewage overflows during storms, and runoff from city streets, has proven difficult to effectively address, let alone curtail. In addition, street runoff usually washes directly into nearby waters without any treatment. A recent EPA survey found that almost half of America's waterways are still damaged or threatened by water pollution, much of it from this polluted runoff. As former EPA Administrator Carol Browner noted at a February 1998 press briefing -- "the problem of polluted runoff is without a doubt the most important problem we face today in terms of protecting our rivers and lakes."

How bad is the urban stormwater issue? In the Los Angeles area, for example, according to National Resources Defense Council, "on each rainy day, 10 to 15 billion gallons of toxic urban runoff pours directly from the streets, untreated, into storm drains and out into Santa Monica Bay. Even on dry days, about 25 million gallons of urban runoff flows through storm drains and onto beaches."

Further, in a 1995 study, King County, Wash. (Seattle area) concluded that the annual stormwater runoff from one square mile of roads and parking lots contains as much as 20,000 gallons of oil! Urban stormwater problems are unique because of the various toxic cocktails washing off streets, highways, parking lots, and industrial sites.

The Ultra-Urban Filter

AbTech Industries, Scottsdale, Ariz., has developed the Ultra-Urban® Filter (UUF). It works by catching trash, rubbish, sediment and debris, as well as soaking up hydrocarbons out of stormwater sloshing along urban surfaces. The UUF is an innovative low-cost BMP (Best Management Practice) designed to help meet NPDES (federal permitting process) requirements with effective filtration, efficient application, and moderate maintenance. The UUF is ideal for municipal, industrial, and construction applications for reducing nonpoint source pollution.

The UUF is a corrugated plastic device that fits inside a catchbasin, secured at street level just below the inlet opening or inlet grate. As stormwater flows into the catchbasin, trash and sediment is collected in the upper part of the UUF while the polluted stormwater flows into the UUF's sides and bottom and passes through the OARS® Smart Sponge® filtration media lining the UUF - AbTech's proprietary blend of hydrocarbon absorbing polymers.
Product Design

AbTech has two primary configurations of the UUF, displayed below. The "drop-in" model literally drops into a storm drain from the top and is secured in place by being attached to the AbTech mounting collar that sits securely at the top of the catchbasin, beneath the grate.

The second configuration is the "curb-opening" version. The curb-opening model is attached to the side of catchbasins that run along the side of a street, sometimes as much as 25 feet in length, typically beneath a sidewalk, and gathers stormwater as it flows away from a street's centerline toward the curb.

Smart Sponge Technology

AbTech's patented Smart Sponge technology is unique, because it is capable of adsorbing, absorbing and then permanently bonding hydrocarbons, without subsequent leaching. Since the absorbed hydrocarbons bond within the Smart Sponge, they will not leach back into the environment; they are converted to a solid. This allows the absorbed hydrocarbons to be classified in most cases as a non-hazardous waste, thus reducing disposal costs and increasing the product's overall cost-effectiveness. Moreover, heavy metals suspended in the stormwater and adhering to trash, sediment, and debris can be captured and trapped in the UUF.

Product Benefits

- Low cost BMP- non-mechanical device for non-point source pollution control.
- Easy to install, no preparation required- can take only minutes.
- Easy to maintain- can be accomplished from street level.
- Non obstructive- does not require structural changes to stormwater collection system; can also be part of new catchbasin construction
- Environmental stewardship- made of recyclable material.
- Hydrocarbon removal-OARS® Smart Sponge® captures up to 99% of oil.

Contaminant removal- prevents sediment, trash, and organic waste from entering stormdrain.

Field Testing

As an example of field testing, figures 1, 2, and 3 are the results of the evaluation performed during December 1999 in the city of Springfield, Mass. The UUF were installed into the storm drains for 60 days.

Noteworthy Installations

Washington, D.C.

The Washington Metropolitan Area Transit Authority, in the interest of taking a proactive stance towards improving the water quality of streams and rivers near its operations, recently chose to install Ultra-Urnan Filters in several storm drains at its Shady Grove, Md. location. This is one of the 78 train stations the Authority operates in the Washington, D.C. metropolitan area. When it rains, these storm drains capture the surface runoff from an area of the train station where buses drop off and pick up passengers.

<table>
<thead>
<tr>
<th>UUF Oil and grease TPH Oil and grease % reduction in Oil and grease TPH</th>
<th>#2</th>
<th>250</th>
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<td>100</td>
<td>2.3</td>
<td>97.7%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Hydrocarbon removal.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Influent</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>50ppm</td>
<td>Less than 0.10ppm</td>
</tr>
<tr>
<td>Zinc</td>
<td>50ppm</td>
<td>0.12ppm</td>
</tr>
<tr>
<td>Copper</td>
<td>50ppm</td>
<td>Less than 0.05ppm</td>
</tr>
</tbody>
</table>

Figure 2. Metals.

<table>
<thead>
<tr>
<th>UUF Initial Weight</th>
<th>Gross Increase in weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>(lbs.)</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>39.35</td>
</tr>
<tr>
<td>(for 22 boxes)</td>
<td>8.49</td>
</tr>
</tbody>
</table>

Figure 3. Debris removal.

El Monte, Calif.

City Engineering Department directed the installation of Ultra-Urnan Filters in heavily used top-down storm drains throughout the city. Several of the locations are along the heavily traveled Valley Boulevard, while other locations include the Civic Center parking lot. The city chose the UUF because other filtering systems tested by the city were inefficient and the maintenance was overwhelming.

Springfield, Mass.

The city needed to address combined sewer overflows that contaminate the city's waterways flowing into the Connecticut River. As a way of attacking this unbelievably costly problem, the city embarked upon the testing project described above and found, with the Ultra Urban Filters, a simple and economical solution to their problem.

Rodolfo Manzone is Executive Vice President and Chief Technology Officer at AbTech Industries, Inc., Scottsdale, Ariz.
Providing safe drinking water in small communities is made more difficult when the only water source available is surface water laden with organic matter, and when skilled labor required to run what amounts to a miniature chemical plant is neither readily available nor affordable.

Traditional methods of removing humic color from raw water -- including flocculation, clarification and other chemical-based approaches -- can require high staffing levels. The plant size required is generally large and cumbersome, and the transporting of equipment and chemicals to remote sites can sometimes be impossible.

A nanofiltration membrane filtration process, now available in North America from PCI Membrane Systems, Inc., Milford, Ohio, promises effective water treatment without high capital costs or heavy labor requirements. The Fyne Process, as it is called, was first used in Scotland and has become the water treatment technology of choice for rural communities with organics-laden surface water from lakes or rivers as the water source. Today, there are over 30 PCI installations running or on order with the three Scottish Water Authorities. Systems as small as 1.8 gal/min (10 m³/day) and as large as 260 gal/min (1420 m³/day) are currently operating. More recently, the first few North American installations have been very successful.

**Situation Analysis**

All along the rocky Canadian Shield, in Alaska, and in the northeast U.S., it is difficult to drill wells for drinking water, so smaller communities often rely on surface water that tends to be heavy with dissolved organic materials. Heavy chlorination is required and that can lead to high TTHM (trihalomethane) and HAA(5) (haloacetic acid) concentrations in the treated water.

Studies have shown that TTHMs and HAA(5)s may be carcinogenic and their presence also has been linked to miscarriages, so Canadian and U.S. regulations limit the presence of some or all of these byproducts in municipal water systems. Until recently, many small communities that rely on surface water for drinking have been exempt from these limits. However, new, more stringent drinking water rules in North America -- including Stage 1 of the Disinfection By-Products rule in the U.S., and new regulations in the Canadian province of Ontario -- are forcing small, rural communities to seek solutions that effectively remove organic matter prior to chlorination.

**How the Process Works**

The Fyne Process is based on a particular membrane filtration process known as nanofiltration. This type of filtration allows inorganic ions to pass through the membrane with the filtrate. Organic compounds (such as humic and fulvic acids), which cause the high color content and disinfection by-products, are held back, along with oocysts, bacteria viruses, and many undesirable metals, including manganese and iron.

There are two membrane configurations (tubular or spi-
ral) that may be specified, depending on plant capacity, raw water quality and recovery required.

Spiral nanofiltration membranes are usually required in large volume systems, but tubular membranes are preferred whenever possible. That’s because spiral systems require feedwater pre-filtration and frequent chemical cleaning. Tubular membranes, which can be kept clean by periodically passing a foam ball down the length of the tube, need chemical cleaning only 3 to 4 times per year.

In a tubular system, the filtration process starts with raw water, which is drawn into the system through a coarse screen and pumped through modules consisting of proprietary half-inch tubular membranes to remove the undesirable dissolved organic materials. As shown in Figure 1, portion of the input water (the filtrate) crosses the membrane and then is ready for chlorination and delivery to consumers. The concentrate or retentate continues to flow through the membrane tube, carrying much of the retained organic matter with it. Because no chemicals are used in the process (in contrast to chemical flocculation and clarification systems), the discharge water is merely a more concentrated form of raw water, which can be returned to the source. Thus, a tubular membrane system achieves between 70% and 90% recovery, with none of the expense associated with coagulant treatment or the high maintenance costs associated with spiral membranes.

Operation is simple and automated, so the plant can run unattended, with intervention on no more than a weekly basis for routine maintenance. Pressure and flow data are logged continuously and the system can even be monitored remotely when an outside telephone line is available.

**EPA Verification**

A study published as part of the EPA’s Environmental Technology Verification (ETV) Program® has verified the performance of a Fyne Process membrane filtration plant tested in Barrow, Alaska. The study confirmed that the plant could produce water that easily met the Disinfection By-Product standards set by the EPA’s stringent Stage 1 D/DBP Rule.

Barrow’s untreated water had an average total organic carbon (TOC) level of 15mg/l and with moderate turbidity. Over the 57-day test period, the average TTHM concentration was reduced from 535 μg/L in chlorinated raw water to just 31 μg/L in water chlorinated after nanofiltration in the Fyne Process test plant. Average HAA(5) concentrations were reduced from 398.4 μg/L to just 6.2 μg/L.

The membrane system also reduced UV<sub>254</sub> absorbance, total organic carbon, and turbidity -- measures of water color and clarity -- by 97.5%, 95.4%, and 98.3%, respectively.

The ETV program was implemented to assist in the development of innovative, cost-effective environmental technologies, including packaged drinking water treatment systems like the Fyne Process. The testing was performed by the University of Alaska, in cooperation with the University of New Hampshire, which is a qualified Field Testing Organization under this ETV program.

**Other North American Results**

Two Canadian installations also are demonstrating the effectiveness of the Fyne Process.

The first system was installed in Nova Scotia in February 2000, and has been running full-time ever since. A second, smaller system began operating in June 2000 at The Tl’azt’en Nation community of Middle River in British Columbia.

Chapel Island is a small First Nation Community located east of Halifax, Nova Scotia. The plant, shown in Figure 2, was installed with a rated capacity 26.2 gal/min (143 m<sup>3</sup>/day), with a 20-year projected demand of 56 gpm (305m<sup>3</sup>/day). The new installation replaced a small pack-
aged water treatment plant using coagulation and filtration technology that required expansion and significant refurbishment.

Raw water is taken from a shallow lake with typical TOC levels of 8 mg/l and color normally in the 40-100 TCU range. The intake is taken through a 3-mm screen and piped to a sump under the water treatment plant room. There is no additional filtration or treatment prior to the membrane filter.

Reject water, which as noted is merely a more concentrated form of raw water with no chemicals added to it whatsoever, is fed back to the lake. When a chemical clean is necessary, these chemicals are sent by separate drain to a wastewater treatment lagoon where sludge from the conventional flocculation and clarification package plant (now removed) had previously been sent.

The system was competitively bid, and although initial capital costs were higher, the Fyne process was chosen from a variety of different treatment methods because of its lower overall life cycle cost. Running cost saving are realized as the Fyne process uses no chemicals in the production of the water and requires significantly less attention, allowing hard-pressed community maintenance staff to attend to other demands. The system also is designed to allow simple plant expansion. Additional capacity can be added easily as and when required to meet changing needs.

The plant has been run above its design capacity since installation, producing on average 155 m³/day, operating each day for 21.4 hrs on process. It was cleaned only twice in the first 12 months after start up and was to have been cleaned for the third time around its first anniversary. The plant did experience a significant increase in pressure over a short period, when cleaning of the inlet works created an infux of sediment into the raw water sump. Although the sediment remained in the inlet line for a number of days, the membrane plant continued to produce its rated volume of water -- albeit at a higher operating pressure -- until its second partial clean a month after the incident. This experience only served to prove the resilience of the Fyne Process to upsets in raw water quality, for whatever reason.

**Middle River Performance**

The T'azt'en Nation community of Middle River is a small village located on a river northwest of Prince George, British Columbia. An isolated community two hours from the nearest town, the site is a prime candidate for the benefits of the Fyne process. The plant operated initially as a 6-month pilot to test its suitability for operation in a remote community. An engineering firm, CH2M Canada, monitors performance of the system for the Department of Indian and Northern Affairs Canada. At the end of the pilot period it was decided to purchase the unit.

The Fyne plant, which has a design capacity of 5.8 gal/min (22 l/min), operates with six PCI C10 filtration modules. Raw water is drawn from the nearby river. Lift pumps provide water to the plant with a 2.5-mm screen at the intake. The Fyne plant was delivered in and continues to operate...
in a heated and ventilated 40-ft container, complete with membrane wash tank, chlorine dosing and contact tanks, and 1,100-gal storage. Reject from the plant is sent to a sump tank overflowing back to the river. To protect the environment, a separate tank is used to contain washing chemicals that can then be taken away by tanker truck.

Since installation, performance of the system has been very similar to the one at Chapel Island. As shown in Figure 3, corrected pressure rose at a constant rate until the first membrane clean, which was scheduled for four months after first operation of the plant. This clean was not entirely effective and a second clean was performed shortly after to establish if any significant irreversible fouling was occurring. Cleaning concentrations and duration were increased and the plant returned to within 96% of its early normalized flux.

Regular analysis of feed water and filtrate is also made and Table 1 shows measured water quality parameters. TOC reductions improved from 30% to 70% over the first 200 hours of operation and have remained consistently low. Iron and manganese were also significantly reduced. While data on TTHM concentrations are limited, formation-potential tests indicate levels well within current Canadian guidelines.

As evidenced in these North American installations, the Fyne Process offers distinct advantages:

- Cost-effective for small and medium-sized systems requiring removal of disinfection by-products precursors; yields chlorinated water below the limits of the EPA D/DPD Rule Stage 1 for TTHM and HAA(5).
- Low staffing requirement; the Fyne Process can be fully automatic, including the cleaning cycle. The plant can operate effectively unsupervised.
- Tolerant to wide variations in raw water quality; does not need adjustment when the feed water quality changes.
- High recovery rate minimizes waste of feed water.
- No chemical sludges generated. Mechanical cleaning means cleaning chemical usage is minimized.
- Compact design. Fyne plants are mounted on a steel frame or skid, and units as large as 100 m³/d/(18 gpm) can be fitted into a standard 20ft or 40ft. container.
  Transportation to remote areas is possible by truck, or even by helicopter.
- Single-phase supply. Optional single-phase electrical supply for smaller plants to suit the remotest of sites.
- Built and tested off-site. On-site work is kept to the minimum of introducing a power supply and connecting the unit.
- Performance guaranteed for capacity and water quality, from a company with extensive colored water operational experience and 25 years in other industrial applications.

PCI expects that the Fyne Process, with its particular advantages for remote, small communities, will be accepted across North America as the process system of choice, just as it has been in Scotland.

American Chemical Society:
37th Western Regional Meeting
2001 An Earth Odyssey

Dates: October 28-31, 2001

Location: Fess Parker Doubletree Resort
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Abstracts Due: March 1 – June 30, 2001
Electronic submission at www.2001werm.org

Symposia include:
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---Atmospheric/NOx Chemistry
---Groundwater/MTBE Contamination
---History of Oil Production
---Green Chemistry

Contact Information via Website:
General/Program Chair: Richard W. Hurst
Exhibition Chairs: A.J. Skarnulis; I. Rabinowitz

David Pearson is General Manager with PCI Membrane Systems, Inc., Milford, Ohio.
The Problem
In 1999 and, 2000 Missouri State police raided and seized over 1,200 meth labs. The actual number of raids and closures in Missouri during this period is known to be larger than the 1,200 noted due to the multiple jurisdictions (e.g. local police units or federal agencies) involved and different reporting requirements from these jurisdictions. Suffice it to say there is a problem. Related problems of the illegal labs include chemical thefts and the diversion of legitimate chemicals into illegal uses. When a lab is found and closed by authorities, law enforcement officials seize the production chemicals and they are taken and held by the authorities for various reasons: as evidence, for disposal or just to keep them off the street. Whatever the reason, once these chemicals are under the control of state officials, there are legal, safety and regulatory obligations that reside with their storage. Chemicals should be separated by hazard class for example. In those situations where a clandestine lab has operated and not been discovered, there are also residual wastes that are left behind and these wastes provide risks that also require addressing. Residuals are also dumped on the side of roads and into non-hazardous dumping locations. Some sites have been discovered where residual chemicals were burned in open pits. While the illegal dumping issues are important, they are not particularly controllable. What can be controlled is the case where legal authorities seize these chemicals and the agency then has the responsibility to handle and store these chemicals according to the law.

Are law enforcement officials as informed about hazardous waste considerations as environmental professionals? Without an explicit training program for state law enforcement professionals, the probability that a line officer will be aware of the environmental nuances of hazardous waste treatment and handling is slim. Because of this basic reality, training is an important part of the Missouri approach to handling this problem. Ecology & Environment provides much of the training to the state on this issue. The basis of concern is the proper identification, handling and storage of the precursor chemicals. Before proper training, captured chemicals have been thrown together without separation or have "disappeared" into dumpsters, down drains or into burn pits. By implement-
ing a rigorous training program, this is no longer the case.

Prior to 1998, MoDNR had had sporadic requests for help from law enforcement. The initial approach was to require the Missouri Environmental Emergency Response (EER) group to respond to every meth lab raid. This proved to be expensive and very time consuming because the response contractor would dispose of each set of chemicals seized when it was seized. In short, every raid was a separate problem and all services were utilized each time. Support was also provided by the US Drug Enforcement Administration (DEA). DEA had contractors assigned to remove and dispose of these chemicals; however, service was sporadic and not always timely.

To coordinate state and federal responses, the governor established a Missouri Interagency Clandestine Lab Task Force. Multiple state and federal agencies were invited to participate. Missouri Departments of Natural Resources, Public Safety, Health and State Highway Patrol, State Fire Marshal's Office, Attorney General and the Missouri Army National Guard. Other agencies included U.S. EPA, and U.S. DEA. Safe chemical handling and storage awareness were established through many hours of debate and discussion. U.S. EPA and the Missouri Department of Health (MoDH) worked with the Task Force to help clarify some of the problems. EPA collected over 150 discrete samples from abandoned meth lab locations and together with the MoDH established health based cleanup information for the public. The MoDH wrote and distributed pamphlets that discussed health effects and guidelines to help one determine whether a site had been used to manufacture meth. One primary target was landlords who might have rented, unknowingly, property to drug manufacturers. The decontamination process for furniture, rugs, plumbing and HVAC areas are covered by the brochure.

One of the top priorities established by the Task Force was to create a Clandestine Drug Lab Collection Station. The collection stations were designed to provide the following: safe and lawful temporary storage; reduced hazards to the public and the environment, reduced down time for law enforcement officials; provided health and safety training, equipment and supplies to law enforcement; and provided for cost effective management of drug lab chemicals and debris. MoDNR has authority under Missouri statutes to authorize exceptions to certain hazardous waste rules (such as manifesting) under certain conditions.

Agencies, such as Fire Marshal, State Highway Patrol, and other state and local Missouri agencies can gain authorization from MoDNR to have drug lab collection stations. These individual stations provide easy to use hazardous waste class separation sections and test kits to determine classification of wastes. Shelves have 1" spill containment lips, and the shelves are locked in place. The base of the structure has secondary containment and skidproof flooring. There are passive air vents and an explosion panel to direct any blast away from people. A dry chemical fire suppressant system and bulk hazardous waste containment drums are also included in the structure. There are manufactured storage sheds just for this purpose and they are 12' L x 9' H x 6'W. These collection stations are small enough that they are prefabricated and large enough to store most collected chemicals for a reasonable period of time (less than 90 days). Station contents can be consolidated for disposal and cost saving thereby accrued.

There are many subtle issues associated with the establishment of these collection locations. As you know, a manifest is required before one can transport a known hazardous waste from its site of generation. Storage facilities require a detailed permit and the list goes on and on. Missouri has been able to comply with these requirements in a responsible manner. One of the things that helped the MoDNR was the ability, under state law, to make exceptions to hazardous waste regulations under certain circumstances. This is one of those circumstances.

There are specific paperwork requirements and detailed training required for participating agencies. Specifics can be obtained from the MoDNR. The resultant cost for this program is orders of magnitude less than the EER process originally utilized. (Traditional DEA or federal cleanup costs average over $2000 per event.) An extra added value of this program is the awareness of things environmental that are transmitted to other government officials. This type of activity trains, educates and increases awareness of basic environmental issues like few other activities. If your state would like to get more information about this program, or where you might obtain training for your personnel, please send an email to wkucharski@ene.com, or contact Missouri DNR directly, Mr. Brad Harris, at nrharrb@mail.dnr.state.mo.us.

Bill Kucharski, former Secretary of the Louisiana Department of Environmental Quality, is now with Ecology and Environment, Inc. (E&E), San Antonio, Texas.
Environmental forensics investigations focus on developing a detailed understanding of the nature of site contamination, identifying the source or sources of that contamination, and developing allocation models for computing proportional ownership and cost-sharing of any remedial action (Stout et al., 1998). By their very nature, environmental forensics investigations develop large amounts of varied technical information about a site. One of the challenges for the environmental forensic investigator is capturing this varied and often complex data, and presenting it in an understandable and defensible manner to non-technical or non-specialist decision makers.

In this article, we discuss the use of 3-dimensional (3-D) data analysis and presentation to vividly and accurately depict site conditions. In addition to rendering graphic depictions of complex subsurface conditions, the quantitative algorithms embedded in modern 3-D geo-technical data analysis tools allow calculations such as contaminant mass estimates and contaminated soil/sediment and water volumes at a site, both of which are useful for technical cost allocation models.

**Varied Sources of Data**

In most every environmental forensics investigation, technical data are collected to describe the nature of the site. The fundamental geologic and hydrologic conditions of a site, characterized from soil boring/sediment coring investigations and observation well measurements establish this physical setting. Typical observations and measurements can include descriptive lithology/stratigraphy, soil texture or sediment grain size, porosity, organic carbon or water content measurements, groundwater elevations, and, if present, the thickness of nonaqueous phase liquids [NAPL]. At well studied sites, regular monitoring of groundwater elevations and NAPL thickness can provide a detailed picture of seasonal influences on these parameters. Together, these depth-discrete geo-technical measurements can be used to describe the physical conditions of a site in 3-dimensional space.

At the heart of virtually every environmental forensics investigation are the results of advanced chemical measurements of various site media. Such analyses are used not only to measure concentrations of individual chemicals or chemical products of concern at the site, but to identify and differentiate the chemical assemblages, and often the sources, of in-place contamination (e.g., McCarthy et al., 1998a, 1998b; Uhler et al. 1998; Stout et al., 1998).

Advanced chemical measurements are typically performed on depth-discrete soil/sediment, water, and NAPL samples. Akin to the geo-technical data described above, the advanced chemical measurement data describe the spatial distribution of contaminant concentrations and the contaminant identity.

Records research of current and past operations at a site provide important information about the type or types of chemicals stored, distributed, and handled over a sites’ history. Carefully compiled site history—ranging from engineering blueprints to aerial photographs—help create a picture of historic site operations that can be used to reconcile findings of contamination both geographically (e.g., was a particular product or chemical handled in or near a building where contamination was discovered?) as well as compositionally (e.g., was the particular product discovered at the site handled by the current or past owner?).

The combination of this type of historical data (e.g., tank
or pipeline locations, etc.) with soil/sediment contaminant data often reveals important spatial relationships between suspected sources and the contamination.

**Assembling 3-D Data**

In our practice, three-dimensional diagrams of site conditions are projected in 3-D Cartesian space using EarthVision® software (Dynamic Graphics, Inc.). Discrete hydrogeologic or chemical data points, each having a unique X, Y, and Z coordinate combination in 3-D space, are assembled, plotted, and ultimately plotted as smooth surfaces using a minimum tension gridding algorithm to closely fit the input data values using bicubic spline techniques.

Contaminant concentrations are contoured at discrete concentration intervals in order to depict regions of varying concentrations. In 3-D space, these contours enclose a volume that is termed an isoshell. An isoshell is a 3-dimensional region that is contained between two concentration limits, which are smooth surfaces, forming a shell of soil, sediment or groundwater that contains similar contaminant concentration levels, e.g., isoshell number one contains all data with concentrations between 100 and 500 μg/kg. Each isoshell can be "peeled back" to reveal a layer of higher concentration, e.g., isoshell number two contains all data with concentrations between 500 and 1,000 μg/kg. By "peeling back" successive layers, regions of increasing concentration ("hot spots") can be revealed.

The spatial position and concentrations of particular chemical products found in mixtures at a site (e.g., middle distillate and automotive gasoline that comprise a TPH plume) are determined by first computing the proportional amount of each product in a given sample using an appropriate allocation technique, and then posting the concentration of that particular product in 3-D space. Using this data, concentration isoshells can be constructed for each product or mixture and depicted in 3-D space.

EarthVision provides powerful numerical integration algorithms that allow the investigator to compute volumes of contaminated soils bounded by concentration isoshells, and hence, estimate contaminant mass within each shell after assuming an average concentration throughout the shell. Combining the geophysical data from the site (e.g., soil/sediment density, porosity) with contaminant concentration data allows the investigator to answer questions such as "what is the volume of soil/sediment and TPH mass within an isoshell that contains TPH greater than 1,000 ppm?", or "what is the proportional volume of soil that contains diesel fuel versus gasoline?".

Figure 1. The lithology of an industrial site (top) helps explain the localized distribution of a diesel fuel plume (bottom). North is toward upper left.
The output from an EarthVision model can be displayed statically ('snapshots', such as shown in this article) or as live, 3-D presentations where the site can be rotated, manipulated, and displayed in real-time.

Below we present two examples that demonstrate the effectiveness that 3-D visualization offers. These examples are composites of the geotechnical and chemical data from numerous sites and, therefore do not represent any specific site that we have investigated.

Example 1--Visualizing Diesel Fuel Contamination

Consider a hypothetical industrial site where a pipeline was suspected of leaking in the subsurface. In this investigation over 50 soil borings were taken and logged, with depth discrete soil samples analyzed for total petroleum hydrocarbons as diesel fuel ($\text{TPH}_d$).

The top graphic in Figure 1 presents a 3-D chair-cut depiction of the stratigraphy at the site. The continuity and distribution of the site lithology is evident, characterized by sand both overlying and underlying a continuous finer-grained sand:silt layer. The bottom graphic in Figure 1 shows the contoured $\text{TPH}_d$ data for the site with the sand:silt layer color-fill removed for visual clarity. $\text{TPH}_d$ isoshells reveal the concentration and distribution of the diesel range contamination was highest in the finer-grained layer. The hot-spots are easily recognized and suggest a potential source area exists/existed in the southwestern corner of the site.

From this one synoptic diagram—rather than a series of tedious 2-dimensional, plane view contour diagrams—an investigator can understand the distribution of contamination and the likely location of its sources, while recognizing the important role that the site’s lithology plays in trapping a highly localized plume of subsurface diesel fuel at the site.

Figure 2. Extensive TPH contamination found across a site (top) as compared to smaller volume of soils containing total PAH above cleanup goal of 5,000 ppb (bottom). North is toward ‘y’.

Example 2--Contaminant Allocation

Consider the due diligence investigation of a refined petroleum pipeline pumping station (owned by potentially responsible party 1: PRP-1) sited on land where a former coal tar processing plant had once existed (owned by potentially responsible party 2: PRP-2). A preliminary investigation suggested widespread TPH contamination at the site.
Nearly 100 soil borings were collected, logged, and analyzed for TPH and diagnostic polycyclic aromatic hydrocarbons (PAH) using advanced chemical measurement techniques for this investigation. The results of this investigation revealed an extensive plume of commingled coal tar processing wastes and diesel fuel.

The spatial distribution of TPH at the site is shown in the top graphic of Figure 2. Note that this rendering identifies a hot spot area in the southeastern corner of the site, with C_{40} total petroleum hydrocarbons measured in excess of 100,000 mg/kg. This hot spot is found to coincide with the location of the historic tar processing facilities. Using EarthVision's quantitative 3-D volume calculation algorithms, the volume of soil at the site containing TPH greater than 100 mg/kg is computed to be 175,000 yd^3.

A technical cost allocation model for cleanup at this site can rely upon advanced chemical measurements and soil volumes calculated using EarthVision. At this site, a total PAH cleanup level of 5,000 µg/kg is assumed. The lower graphic in Figure 2 depicts the concentration isoshell for soils that contain PAH_{total} greater than 5,000 µg/kg. Using EarthVision's quantitative 3-D volume calculation algorithms, the volume of soil containing more than 5,000 µg/kg total PAH is computed to be 93,000 yd^3.

The advanced chemical fingerprinting component of this investigation documents that (on average) approximately 85% of the total PAH in the site soils is derived from coal tar processing wastes, and hence are the responsibility of PRP-2. Multiplying the volume of contaminated soil requiring cleanup action computed above (93,000 yd^3) by a factor of 0.85 indicates that PRP-2 would be responsible for cleanup of 79,000 yd^3 of soil, while PRP-1 would pay for the cost of cleanup of the remaining 14,000 yd^3. This form of volumetric allocation can provide a solid technical basis for establishing (or at least negotiating) liability between the PRP’s.

Conclusions

Three-dimensional interactive surface modeling and interactive volume modeling techniques allow for full three-dimensional imaging of site surface and subsurface features. Quantitative mass calculations of in-place contamination--above regulatory or arbitration thresholds--can be computed for supporting cost allocation models.

Using these state-of-the-art data visualization techniques the hydrogeologic framework, contaminant plume configuration, and fate-and-transport modeling scenarios can be imaged even in highly complex areas. Underground and aboveground storage tanks, piping systems and utility lines, stormwater outfalls, etc. are examples of man-made features that can be added to a site subsurface visualization. The presentation of combined surface and subsurface features and contaminant data into one three-dimensional image can clarify complex scientific relationships. In doing so a powerful communications and potential allocation tool is created for those conducting subsurface studies for non-technical or non-specialist decisions-makers.

References


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- diesel fuel contamination
- contamination at military installations
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DENISE LEONARD
Northeast Regional Environmental Health Center
N344 Morrill, University of Massachusetts, Amherst, MA 01003
Tel: (413) 545-1239 • FAX: (413) 545-4692
Email: dleonard@schoolph.umass.edu

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**EDITOR** Terry Combs editor@aehsmag.com  
**GRAPHICS** Shannon McLennan shanjohn@earthlink.net  
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We invite you to submit an abstract for consideration for presentation at the 12th Annual West Coast Conference on Contaminated Soils, Sediments, and Water, March 2002. Please submit a one-page abstract containing title, 300 word narrative; and for each author: name, degree, affiliation, complete address, telephone, fax and email (see Abstract Submission Guidelines). Indicate whether you wish your abstract to be considered for platform presentation, poster presentation or both. Email submissions are welcome and encouraged (send to marc@aehs.com). Abstracts sent via mail must be provided on both paper and a 3.5" IBM formatted floppy disk. All mail submissions must be postmarked no later than July 13, 2001. Abstracts received that are not in an electronic format will not be considered.

Publication of manuscripts from both platform and poster presentations will be considered for either Contaminated Soils, Sediments, & Groundwater Cleanup Magazine or in one of the following peer-reviewed journals:

- Soil and Sediment Contamination: An International Journal
- Environmental Forensics
- The International Journal of Phytoremediation
- Human and Ecological Risk Assessment

Accepted abstracts will be posted on Conference Website: www.aehs.com. Exhibition space is available for this conference.

Deadline for Submission is July 13, 2001

Sessions: Contributed Papers and Posters are invited for presentation in the general sessions in the following areas:

- Beneficial re-use
- Bioavailability
- Bioremediation
- Brownfields
- Chemical analysis
- Chlorinated compounds (pesticides, solvents, etc.)
- Cleanup standard setting
- Contamination at military installations
- Ecological risk assessments
- Environmental acceptable endpoints
- Environmental fate and modeling
- Environmental forensics
- GIS/Data Visualization
- Hazard, exposure and risk assessment
- Heavy metals (arsenic, lead, chromium and mercury)
- Hydrocarbon identification
- Innovative remediation technologies/corrective actions
- Legal issues in Environmental Health/Toxic Tort Litigation
- Method Detection Limit (MDL)/Practical Quantitation Limit (PQL)
- Mining impacts
- MTBE/oxygenates (regulatory issues, plume characterization, etc.)
- Natural attenuation
- Oil and gas production (issues and trends)
- Perchlorate and TCE
- Phytoremediation
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- Site assessment/field sampling
- Soil chemistry
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