Leachate Recirculation

While the Kettle Boils

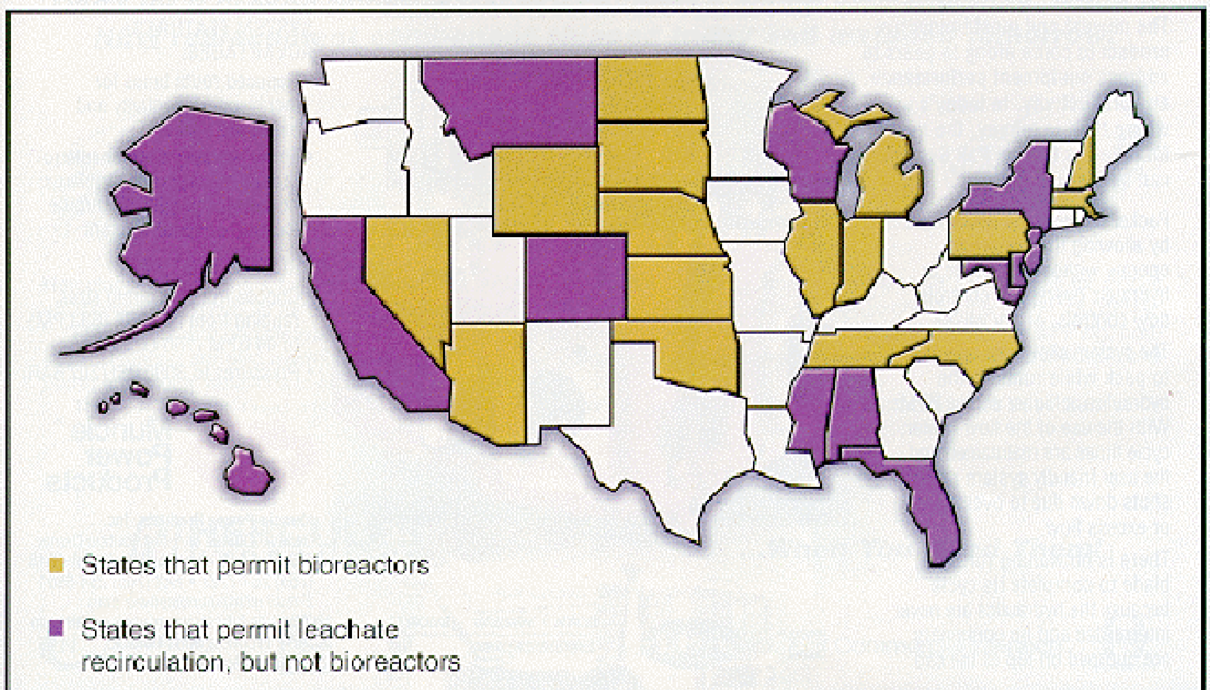
by Anne Magnuson

Questions and contradictions abound: Is leachate recirculation cost effective? Does it really get rid of leachate? Does it remove contaminants? Does it increase landfill life? If we keep the kettle boiling with recirculation, are these corners of the environment protected for future generations? Will dry-tomb landfilling prolong postclosure care?

For now, the practice of leachate recirculation varies from landfill to landfill. Many run pilot projects with the hope of increasing waste stabilization, reducing the volume of leachate to be treated, and enhancing methane generation. A few sites, after much research and study, operate full-scale bioreactors.

A 1977 SWANA survey of all 50 states (with 31 respondents) revealed that at least 130 US sites engage in some leachate recirculation with the operation of bioreactors, although this is allowed in only 12 of those 31 states. (See Figure 1.) On the other hand, J. Walter Spear, principal consultant with J. Spear Associates in Milwaukee, WI hazards the guess that not many more than 30 sites recirculate to any great extent and that of these, most of the operations are pilot studies. Landfill managers clearly test the waters with research before jumping into full-scale operations.

FIGURE 1. Recirculation, State by State



Many questions remain to be answered and misconceptions clarified. A 1998 copyrighted volume by Lewis Publishers in Boca Raton, FL, titled *Landfill Bioreactor Design and Operation,* details the experiences of numerous laboratory, pilot, and full-scale bioreactor tests and amply discusses research and how-to issues. The text was authored by two

Florida specialists: Dr. Debra R. Rheinhart, associate professor of civil and environmental engineering at the University of Central Florida, Orlando, and Dr. Timothy C. Townsend, assistant professor in the Department of Environmental Engineering Sciences at the University of Florida, Gainesville.

Meanwhile, Drs. C. Fred Lee and Anne Jones-Lee, principals of G. Fred Lee & Associates in El Macero, CA, define their view of leachate recycle (as they call it) in many published papers, editorials, and reviews. The SWANA Landfill Bioreactor Advocacy Committee promises a recirculation report to be in draft form soon. Engineer John Styles writes from the University of Melbourne, Australia of numerous research questions to be tested. In addition, Spear, a lecturer for Sanitary Landfill Design Seminars at the University of Wisconsin, Madison, points out what he notes are basic misunderstandings within the leachate recirculation field.

TABLE 1.

Summary of AIB Results at the Columbia County Baker Place Road Landfill

Parameter Results (7/97)	
Biodegradation Rate	Increased >50% (1)
Leachate BOD, Fecal Coliform	Reduced by 65% to 90%
Metals Concentration in Leachate	Reduced by 75%to 99% (2)
Organic Concentration in Leachate	Reduced by 75% to 90%
Methane Generation	Reduced by 50% to 90% (3)

Notes: (I) Biodegradation of organic fraction yet to be determined.
(2) Iron reduced by 75% to 90%; lead eliminated completely.
(3) Methane reduced by 5t1% to 90% for 80% of the points; 70% to 90% for the row of points closest to air injection.

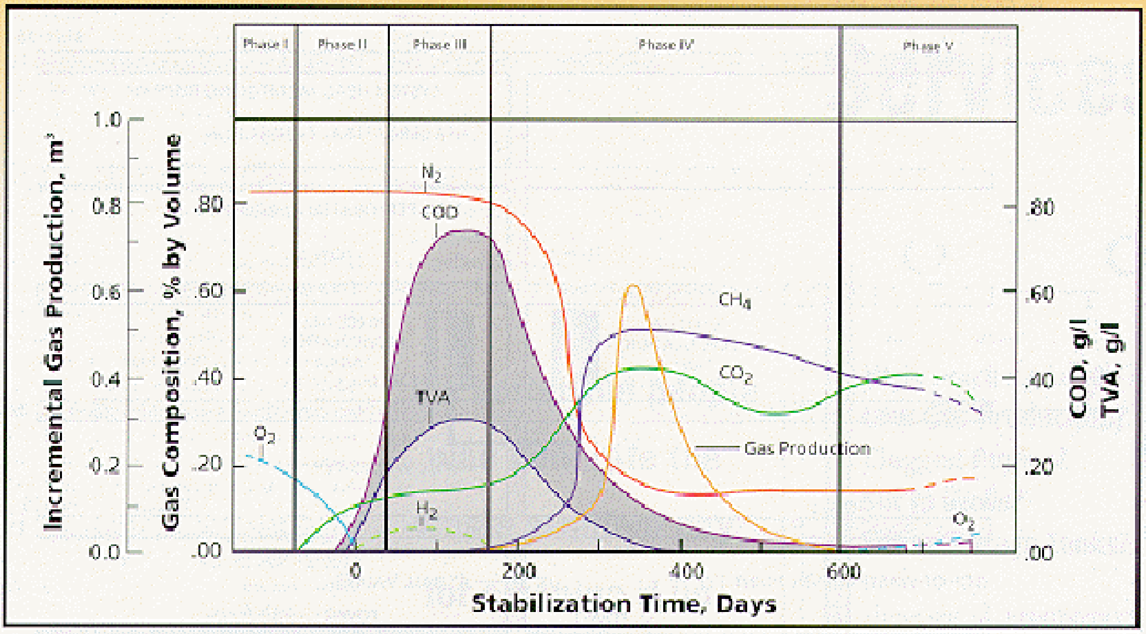
First of all, says Spear, leachate recirculation does not get rid of leachate. "Actually, it does the opposite," he suggests. "Over the life of the site, leachate recirculation increases the amount of leachate that is removed from the site." But there are other, very good reasons for using leachate recirculation, continues Spear. It does reduce the cost of leachate treatment. Without leachate recirculation, the characteristics of leachate change with time in a landfill. In later years with recirculation, Biological Oxygen Demand (BOD) has gone down and both the BOD and the metals contamination become more uniform. Therefore, in the landfills early life, leachate treatment (usually at a municipal wastewater treatment plant) involves biological methods. Physical-chemical treatment procedures are employed to treat leachate produced during later stages. "So you are not going to constantly change treatment methods and additives. [Thus]You have a constant cost and it is a minimal cost," says Spear.

A second benefit, notes Spear, is the settling of the landfill mass by weight and through hydraulic consolidation as the refuse more rapidly decomposes to form carbon dioxide and methane. This extends landfill life. "And another reason for leachate recirculation, probably the most important, [is that] we can effectively force the majority of the biological activity to occur during the life of the landfill and postclosure period. I think the dry cell technology presents an interesting set of problems for our grandchildren. And I think a lot of these problems can be alleviated by aggressive recirculation," be says.

Rheinhart and Townsend agree that recirculation will shorten the postclosure time period by stabilizing the waste and accelerating gas generation, an energy resource. Also, post closure can be modified after stabilization, in their view, through landfill reclamation to recover landfill volume, restore real estate, lower closure costs, and recycle soil and materials.

Lee goes a few steps further by insisting that the degradation of solid waste in a landfill no longer concurs with the curves set forth by Dr. Fred Pohland in the 1970s. (See Figure 2.) Because of the popular new use of plastic bags in garbage disposal, Lee advocates shredding MSW before landfill interment to make degradation more uniform throughout the cell. Otherwise, *"You* wind up with a situation in which leachate recycle, which means getting more moisture back into the system to stimulate bacteria to ferment the waste, doesn't really work for much of the waste. So you really have to wait on the decomposition of the bags," he says. "This is a pretty slow process."

FIGURE 2. Five Phases of Landfill Stabilization



(Pohland and Harper, 1986) "Landfill Bioreactor Design and Operation" by Rhinehart and Townsend

Lee also points out the danger that RCRA liners, as advocated by EPA (which did not have leachate recycle in mind), may not sufficiently protect against groundwater pollution while recirculating leachate. Since the hydraulic loading is increased, he believes a double composite liner is needed. Then the bottom collection system can act as a lysimeter if the first liner is breached. If leachate is found in the secondary collection system, he suggests it is time to dig up the waste for remediation. "Its probably better they pollute earlier rather than later, so the people who generate the waste problem can pay for cleaning it up, rather than pass the situation on to future generations," says Lee.

"The third component of leachate recycle is that leachate recycling by itself will not produce a nonpolluting residue," he says. "You still have the salts, the heavy metals; you've gotten rid of some of the organic, but not all so a number of constituents go 'round in circles every time you recycle it." Basing his conclusions on his own research and independent work by Emcon Chairman Emeritus John Pacey in San Mateo, CA, Lee advocates administering a clear-water wash through the waste after leachate recycle for a period of 10 to 15 years. "After you have fermented all you are going to get through leachate recycle, and you get all the gas out you are going to get out [a period of about five years, Lee says], then put in the clean water."

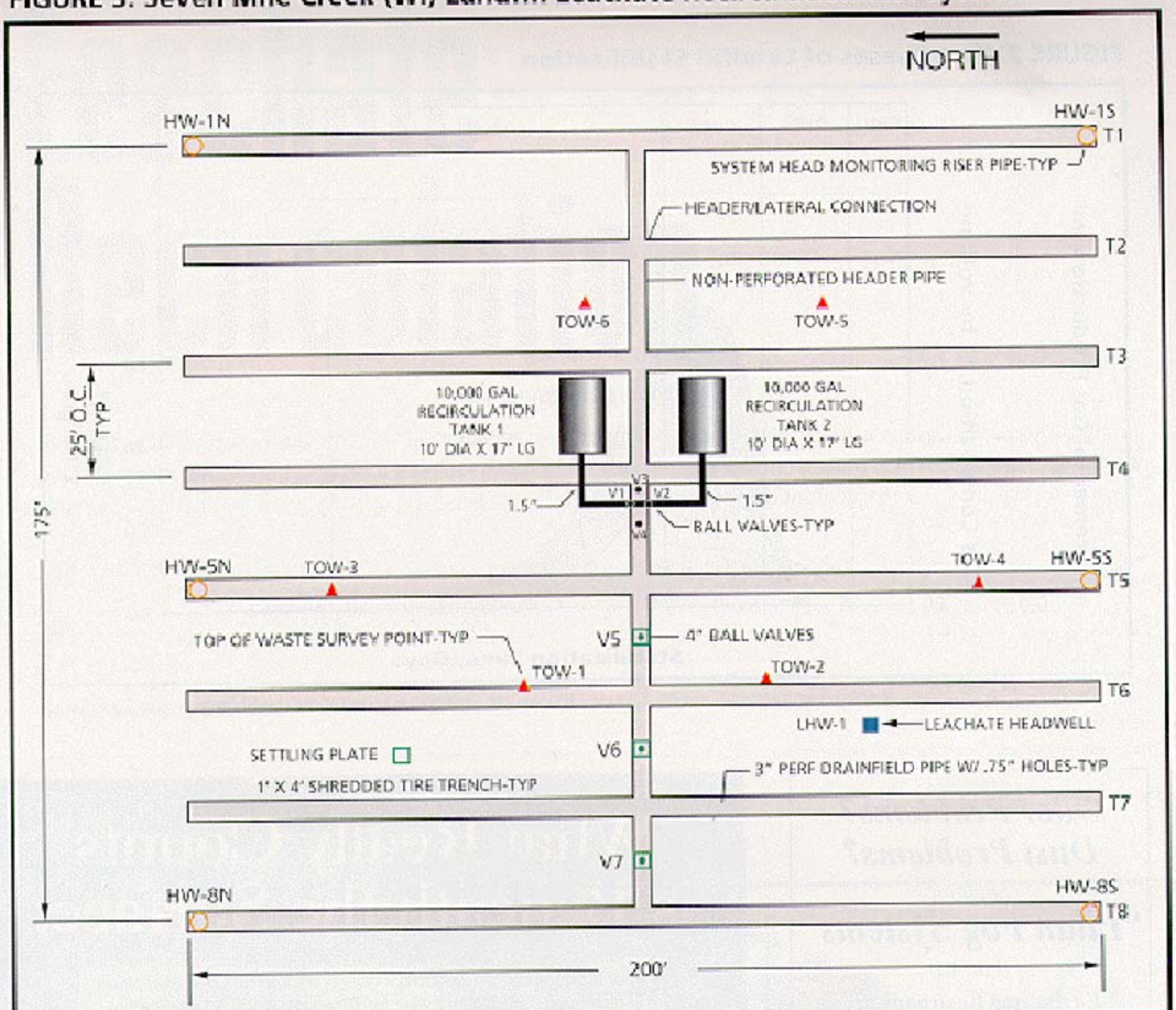
Styles, STA. Yuen, and T.A. Mahon with the Civil and Environmental Engineering Department at the University of Melbourne, suggest in a 1995 paper those areas of research that they feel should soon be addressed. First they summarize parameters already investigated. Citing the literature, Styles et al. conclude: (I) When leachate recirculation is initiated without a natural or added buffer (for example, lime) the acid environment will inhibit methanogenesis bacteria and delay methane production; (2) Recirculation with a sludge additive sometimes promotes methane production formation in the early stages, early stages, but in later stages, the sludge appears to accomplish little; (3) Recirculation with shredding of the waste has nor been reported in research data; (4) Recirculation with the addition of nutrient materials such as phosphate and nitrate does not seem to enhance degradation; (5) Laboratory results of recirculation with temperature control show an optimum range of 34 to 38 C for anaerobic degradation, but these results are not available from full-scale operation; and (6) Recirculation with the addition of an anaerobically digested refuse or a bottom thin layer of compost reduces leachate strength.

Styles et al. say many of the full-scale projects to date have been efforts to examine gas enhancement and/or in situ leachate treatment effects They report that the University of Melbourne is collaborating with Browning Ferris Industries

Inc. of Houston, TX in a full-scale recirculation test at the BFI Lyndhurst Sanitary Landfill just southeast of Melbourne. Goals to be pursued during this study are quantifying waste stabilization, evaluating various recirculation techniques, developing a numerical computer model to simulate recirculation for design purposes, and developing a leachate volume production model, write Styles et al. Indicators to be monitored at Lyndhurst include: quantity and composition of collected and recycled leachate; landfill gas production rate, yield, and composition; waste temperature; landfill settlement; climatic data and surface runoff; moisture distribution profile; and leachate head on the liner. Styles et al. emphasize the importance of operating a control cell of almost identical waste in every full-scale study.

With all of these questions still to be pursued, pilot studies continue in the US and abroad. Ayres Associates in Eau Claire, WI ran a six-month Phase One project at the 800-tpd Seven-Mile Creek Sanitary Landfill to test construction methods and hydraulics for a future Phase Two recirculation system. The Seven-Mile landfill was thought to be an ideal site for leachate recircolation because it primarily takes MSW, it uses a sand daily cover, and it sports a composite liner. The demonstration test cell was 200 ft. x 200 ft. in size and employed a pressurized drainfield concept. Eight trenches, 25 ft. apart and containing corrugated polyethylene pipes embedded in tire chips, were connected to a header pipe fed by two 10,000-gal. underground fuel oil tanks (modified for storing leachate). The leachate flow toward the trenches was controlled by valves on the header system, according to an Ayres report by environmental engineer Steven A. Bischoff. (See Figure 3.)

FIGURE 3. Seven Mile Creek (WI) Landfill Leachate Recirculation Test System



Indicators monitored were: the hydraulic loading rate showing the daily quantity of leachate; leachate buildup in the head wells at the ends of the trenches; head accumulating on the liner; the extent to which microbial growth might clog the pipes and tire chips; visual checking for seepage along the active fill area of the sideslopes near the test area; settlement; and gas production. Some seepage occurred at the west slope of the landfill during the test. Engineers sequentially decreased the volume of leachate applied to the trenches nearest the slope. This also provided an estimate of horizontal migration of the leachate under system operation.

FIGURE 5. Aerobic Landfill Bioreactor System

In September 1996, the county-owned Eau Claire site was sold to Superior Services Inc., which recognized the value of the recirculation test and retained Ayres to continue the project. Continuing Phase One, Superior excavated part of the test area and leachate tanks. It was agreed not to use the corrugated flexible piping in Phase Two because of potential long-term coupling concerns with differential settlement. Phase Two will contain HDPE piping with welded joints, but will not contain valves within the waste itself in order to simplify the system. Tire chips were found to be functional and cost effective. It was decided to increase the space between trenches from 25 ft. to 50 ft.

As for test results, 1.46 million gal. of leachate were recirculated during the six months. Stable head results were achieved by applying approximately 1.8 gpd/ft.^{2} under saturated conditions. The liner head did not exceed 1 ft. Approximately 25% more gas was produced from two gas wells near the recirculation system compared to the other wells in the overall gas collection system. Solids did not build up in the leachate piping and minimal slime was noted on the tire chips. It was not verified why the east-side piping failed to allow a sufficient leachate flow. "It didn't appear to be clogged when we opened it up, yet it never developed a head. It was taking leachate real slow," said Ayres Solid Waste Group Manager John Iverson. He also said that there was insufficient leachate produced at the site to fill the entire system in Phase One.

In December 1997, Superior Services received state permission to install Phase Two for conducting leachate recirculation in a 100-ft. x 300-ft. test area with a 2.5-ac control. Underground tanks will not be included for leachate storage because they take up precious landfill space. The waste depth of the test area in Phase One was about 30 ft. and will get deeper as disposal progresses in both Phase One and Phase Two. Riser pipes will be added at both ends of the Phase Two distribution pipes to provide for leachate entrance into the system and to measure the leachate head to make sure the leachate flows the full 300 ft. The risers will also provide pipe cleaning capability. Parameters to be assayed in Phase Two include leachate BOD and Chemical Oxygen Demand (COD) changes, the number of gallons used, and gas production. Currently, methane is already flared at the Seven-Mile Creek site and Superior may consider resource recovery in the future.

Yolo Country Recirculation Project

The ongoing recirculation project at the 500-tpd Yolo County Central Landfill near Davis, CA aims to escalate gas generation and stabilize waste in under 10 years while recovering 95% or more of the gas. "We are hopeful we can stabilize the waste in five years," says assistant civil engineer Rick Moore with the Division of Integrated Waste Management in the county Department of Public Works.

Two 100-ft. x 100-ft. cells were constructed in 1993 with waste disposal in 5-ft. lifts to a depth of 40 ft. starting in May 1995, according to a county DPW report. Each lift was surrounded by thick, compacted clay levees with 1 ft. of chipped greenwaste as daily refuse cover. After filling with waste, the top of both the control and enhanced cells were overlaid with 18 in. of shredded tires as a gas collection layer. a geotextile, 2 ft. of soil, and a gas-impermeable, linear LDPE by Polyflex Inc. Gas is also collected through two 4-in. PVC pipes made of wire mesh containing gravel or shredded tires. A moderate vacuum hooked up to the WTE gas-collection system for the entire landfill helps draw up the gas, which is then used to generate electricity or flared when the WTE system shuts down for maintenance. (See Figure 4.)

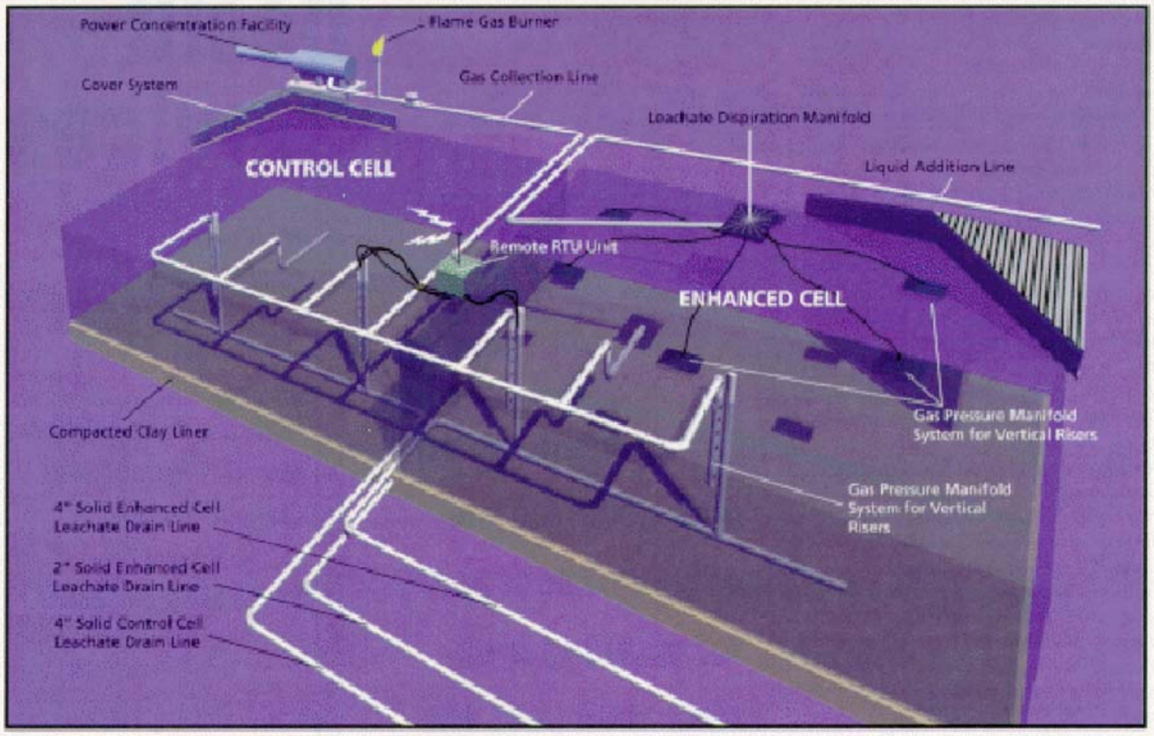


FIGURE 4. Methane Enhancement by Accelerated Anaerobic Composting Demonstration Project

Both clear water and leachate are recirculated in the Yolo enhanced cell--first the water, and then the leachate to bring the cell up to field capacity. A surface method of liquid dispersal is utilized through 3-ft. x 10-ft. x 5-ft-long trenches, 14 of them, dug right into the ADC and waste. The trenches contain shredded tires. The leachate enters the trenches through individual vertical pipes with the flow controlled by a distribution manifold sitting on the top cover. Leachate drains to perforated HDPE manholes for collection or disposal, if required.

Parameters monitored at the Yolo County site include: liquid volumes to show the needed moisture to reach field capacity; hydraulic permeability of the waste; gas volume and composition; waste-mass temperature; leachate headon the liner; leakage of the liner (which would show up in the secondary leachate collection system constructed under the enhanced cell); leachate composition; settlement; and gas pressure.

Among the many expected long-term benefits of the Yolo demonstration will be the nearly complete elimination of methane emissions and the reduced emissions of VOCs. Engineers anticipate that decomposition will be more precisely predicted, which will facilitate sizing WTE equipment. Potentially, landfill life will be increased and the length of time the landfill requires post-closure care will be shortened because of waste stabilization.

Preliminary Yolo results, according to county researchers, reveal that the enhanced test cell generates 30% more gas than the control cell over an 18-month period. The enhanced cell has produced 37% of its expected methane yield overtime, and the control cell 25% of its expected yield. So far, the enhanced cell does not seem to have increased the methanes energy potential. The waste absorptive capacity stands at 45 gal. of liquid/ton, an amount that does not overload the system or endanger groundwater. The control cell has settled an average of 9 in. whereas settlement in the test cell is 29 in. on average, indicating a significant potential for increasing landfill capacity. Shredded tires proved a successful medium for allowing gas flow--as good or better than gravel.

Yolo County employs PVC piping throughout the test site. HDPE pipe was used only within the composite liner. Gypsum blocks manufactured by Electronics Unlimited and perforated PVC pipe filled with pea-gravel and three electrodes act as moisture sensors. Temperature sensors were manufactured by Thermometrics Inc., and buildup of leachate head in the collection trench is measured with a Druck PTX 164 pressure transducer. For leachate flow measurements, Signet and Sparling Tigermag flowmeters are utilized. The meters for gas flow measurements are provided by Dresser Industries Inc., Model SM 175. A Grundfos pump powers the circulation of water and leachate

Aerobic Digestion at The Columbia County Baker Place Road Landfill Near Augusta, GA

A full-scale test of aerobic digestion of MSW, by injecting air into the landfill in conjunction with leachate recirculation, yields noteworthy results at the 260-tpd Columbia County Baker Place Road Landfill, near Augusta, GA. Six-month data of the 8-ac aerobic bioreactor show a dramatic increase in biodegradation and just as startling decreases in leachate BOD, leachate metals and organics contamination, and methane production. (See Table 1.) Further, leachate volume to be treated and disposed of was reduced to zero. All of the leachate collected at this 16-ac Subtitle D landfill, which opened in late 1995, is recirculated within the eight-acre bioreactor even though the region has experienced some heavy rainy spells during the test period. These results have been achieved by maintaining an optimum moisture content and stabilizing the waste temperature at 120^{o} to $150\ ^{o}F$, according to the researchers.

The results of this ongoing experiment offer a new perspective for future landfilling, says Project Manager Mark Hudgins with American Technologies Inc. at his firms regional office in Aiken, SC. Leachate treatment and disposal costs are ended or reduced and aerobic digestion can significantly change the equation on methane production, he explains. This type of system offers an alternative to installing WTE systems to produce electricity. "Sometimes that's not so economical he says. American Technologies also suggests that future landfills might be rapidly biodegraded to increase landfill life, reclaim the land through mining, or even create perpetual landfills while avoiding permanent capping and closure.

The design of the aerobic bioreactor is fairly simple. (See Figure 5.) The entire 8-ac area has been covered with 2 ft. of clay. Air is injected at the bottom of the test area through existing leachate collection pipes. As the leachate flows out of the bioreactor from the bottom surfaces of the PVC leachate pipes, air is blown in through the top of the same perforated pipes by ten S-hp, single-phase Sweetwater electric blowers. Air is also introduced via vertical injection wells. The collected leachate from the landfills 250,000 gal. holding tank is forced into the surface dispersal system with a 1-hp, single-phase Goulds pump. This dispersal system was created by digging into the clay cap and running flexible hoses to the top of the waste. A basic PVC manifold distributes the leachate from the top of the clay cover. "So, basically, the leachate starts at the top of the waste and cascades downward through the waste," Hudgins remarks.

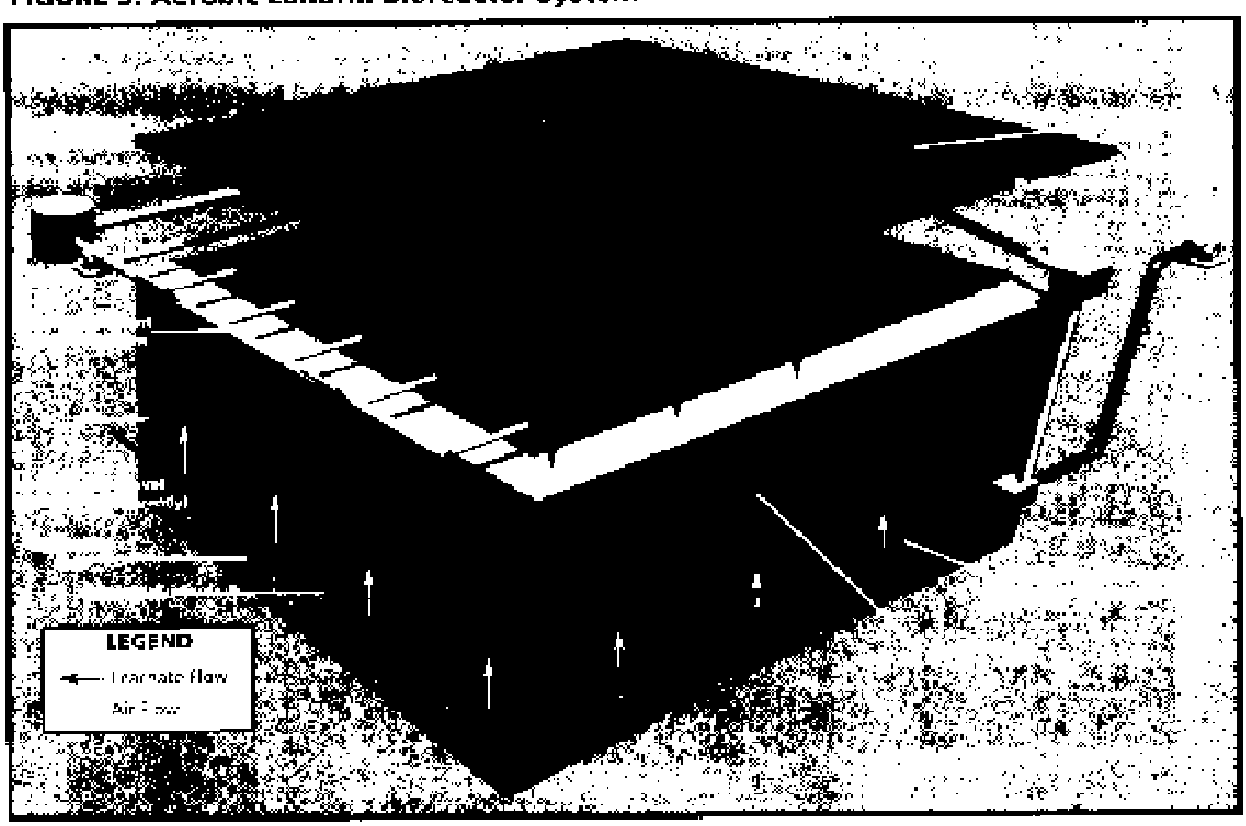


FIGURE 5. Aerobic Landfill Bioreactor System

Phase One at Baker Place Road will progress on the 10-ft-deep waste for a period of 1.5 years to be dovetailed in January 1998 with Phase Two bioreactor efforts on the remaining 8 ac. There, waste is now being placed to a depth of 20 ft. After a time, the aerobic process will be turned back on the Phase One area, which by then will have accepted more waste.

In future designs, operators will move from one portion of an active landfill to another as the waste is accepted and it biodigests. Hudgins says, "Our present strategy is to do what we are doing like a pancake. Combine this with a rotating cell schedule. At one section of the landfill place the waste, and at another its cooking. When that gets through, go back into the section where waste has been placed. Basically, we chase each other, if you will, around the landfill." On returning to a bioreactor cell, workers will drag back the clay cover and stockpile it, add fresh waste to the settled, degraded areas, and compact the trash as usual.

The research effort at Baker Place Road was made possible through a federal Department of Energy technology transfer initiative. American Technologies designed, constructed, and operates the bioreactor, although Columbia County itself continues to operate the landfills waste disposal.

American Technologies cites design and operational issues to consider when implementing aerobic digestion, such as the present waste disposal procedures, waste height and composition, environmental regulations, and individual site conditions. The firm estimates that capital costs for constructing such a bioreactor is roughly $35,000 to $50,000/ac. The firm suggests that operations and maintenance should begin at about $25,000/month but be reduced over time.

Author Anne Magnuson is a frequent contributor to MSW Management. *We would like to extend special thanks to Brian Guzzone of SWA NA for providing much of the data on leachate recirculation and bioreactive landfill activities in the US.* MSW Management *is looking for additional information and invites your comments on similar activities in the US and elsewhere. Contact John Troths e-mail erosion @ ix. netcom.com, or at (805) 681-1300.*

Reference as: "Magnuson, A., 'Leachate Recirculation,' MSW Management, March/April (1998)."