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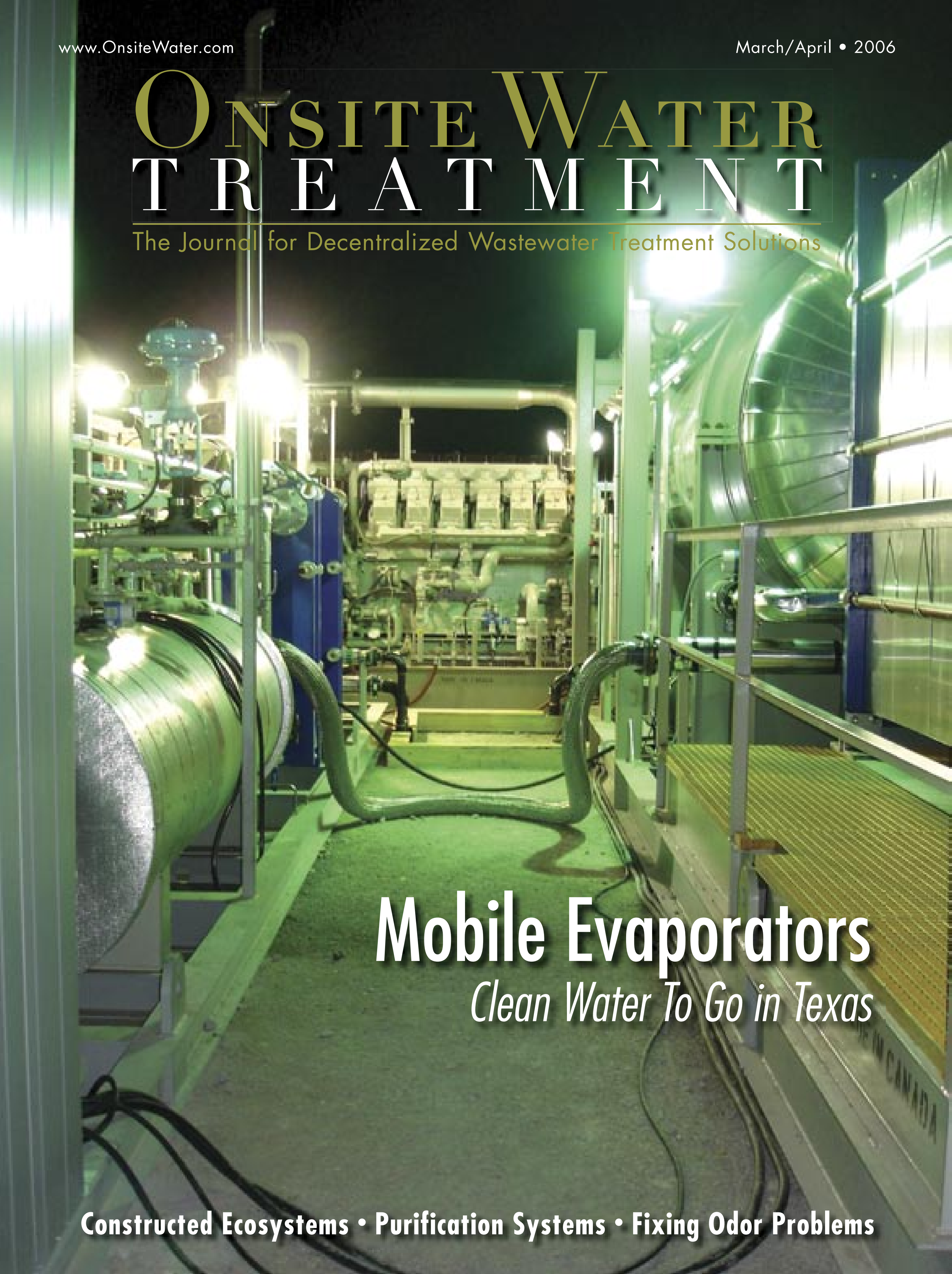

Mobile Evaporators

Clean Water To Go in Texas

Constructed Ecosystems • Purification Systems • Fixing Odor Problems

Clean Water to Go

Mobile evaporator treats water in Texas gas field.

BY GEORGE LEPOSKY

Almost two miles beneath the arid plains northwest of Fort Worth, lies one of North America's largest natural-gas reservoirs, the Barnett Shale formation. To fracture the formation's rock strata and release the gas, producers pump vast quantities of water down the wells—500,000 to one million gallons per "frac job." It returns to the surface so polluted that conventional treatment methods haven't been practical. Currently, most of this wastewater is hauled to a deep-well injection site for disposal.

Last year a new water-treatment technology that turns frac wastewater from a liability into an asset arrived in the Barnett Shale gas fields. It's the NOMAD 2000 Mobile Oilfield Evaporator from Aqua-Pure Ventures Inc. of Calgary, AB, Canada.

Fresh water already is in short supply in the region, and demand from oil producers and from growing cities is rising. The costs of hauling large quantities of fresh water from other areas, followed by the hauling and disposing of the wastewater, represent a major expense for the gas drillers.

The NOMAD cuts these costs 50% to 60% by creating usable byproducts. Employing a mechanical vapor recompression evaporation (MVR) process, it recycles 85% of the wastewater into distilled water suitable for reuse in another frac job, concentrating the impurities into a brine with several potential uses. (With a lower contamination level in the feed water, the system could achieve a 90% to 95% recovery of distilled water.)

Aqua-Pure now has three NOMAD 2000 systems operating in Wise County, TX, the first delivered in February 2005 and the others in September. Each has a daily output of 2,000 barrels of distilled water and 350 barrels of concentrated brine. "This is just the beginning," says Patrick Horner, Aqua-Pure's process engineer. "We're touching a drop in the pond right now. It takes 12 months to build one unit. We can build several at a time, but we're working on doing it faster and faster. We have a pent-up demand that currently exceeds our ability to supply it." Aqua-Pure will deliver six new units to the Barnett Shale in the next 12 months.

Modular and Mobile

Mechanical vapor recompression evaporation is not a new technology. "It has been around for about 100 years, but it has some inherent problems," Horner says. "One problem is size; for a system with any significant capacity, a large stationary facility would be required. The traditional MVR evaporator employs a vertical shell-and-tube heat exchanger 8 to 10 feet in diameter and more than 60 feet tall. Because of its height, it requires a firm foundation."

In the Barnett Shale region, individual wastewater sources typically don't exist for a long enough time to justify the cost of a fixed recycling unit nearby, and transporting wastewater long distances to a fixed facility also would make recycling uneconomical. To overcome these challenges, a recycling unit must have a small footprint and be readily transportable while operating at enough capacity to function efficiently and cost-effectively.

"We've come up with an innovative modification enabling us to make a mobile MVR evaporator that provides higher capacity with a much smaller facility," Horner says. "Its footprint is similar to that of a traditional MVR evaporator—about 2,500 square feet—but it is skid-mounted and designed for highway transport on three low-boy trailers without special permitting."

The system consists of three modules, each 11.5 feet wide and 12.5 feet high:

- A pre-treatment module 40 feet long, weighing 25,000 pounds.
- An evaporator module 37 feet long, weighing 42,000 pounds.
- A compressor module 30 feet long, weighing 96,000 pounds.

The NOMAD 2000 also includes interconnecting pipes and electrical connections, and a Model GGHF 60-Hz, spark-ignited, 50-kW generator set from Cummins Power Generation of Minneapolis, MN.

"The system is totally self-contained," Horner says. "It needs no external source of electric power. We draw natural gas directly from the well to run the compressor and to drive the generator, which produces electricity to power the pumps, instruments, and controls."

When treatment at one site is finished, the operators can drain the system, load it on the trucks with a crane, haul it to a new site, and have it set up there within a couple of days.

"We've built the highest-capacity system that is still easily mobile," Horner says. "If we were to build one much larger, it would be much harder to move. This is the optimal balance between capacity and mobility."

Other problems with traditional MVR evaporators include scaling, and the complexity of scale removal. A vertical shell-and-tube heat exchanger employs a falling-film design that boils liquid as it descends. This creates a dry surface at the point of boiling, which promotes scale deposition. Aqua-Pure uses a very compact welded-cassette heat exchanger with a plate-and-frame construction and a rising-film design, in which boiling occurs on a wet surface, minimizing scale deposition. "Ours is a much smaller heat exchanger for the same amount of heat transfer, and much more resistant to scaling and fouling than a conventional system," Horner says. "When the Aqua-Pure MVR evaporator does require scale removal, a two-man crew can clean it in one or two work shifts—significantly less than with a traditional MVR evaporator."

A Gallon's Journey

A gallon of water involved in fraccing has a harrowing journey. First it receives a mixture of chemical additives: a friction reducer (a polymer to reduce the viscosity of the water and improve its flowability so it's easier to pump down the well), a special grade of light sand, and a cross-linked guar gel that helps to carry the sand down into the well.

This fraccing fluid is injected into a gas hole at a high flow rate and pressure to break up the formation, increasing the permeability of the rock and helping the gas flow toward the surface. As the water cracks the rock formation, it deposits the sand. As the fractures try to close, the sand keeps them propped open. Fraccing typically occurs once when a well is newly drilled, and again after a couple of years when the rate of gas flow begins to decline.

Underground, the fraccing fluid picks up other contaminants present in the rock formation, including barium, calcium bicarbonate, iron, magnesium sulfate, sodium chloride, and strontium.

During the next couple of days, 75% of the injected fraccing fluid returns to the surface, where it collects in holding tanks. Then water-hauling trucks transport it to a deep-well injection site several hundred miles away—or to treatment in an Aqua-Pure mobile evaporator located within a few miles of the gas well.

The evaporator installation receives the wastewater in holding tanks or a surface pit, then pumps it through the pre-treatment module to remove additives and other impurities that could foul and plug the evaporator. These include organic materials (bacteria present in the rock formation, and fraccing chemicals), polymers (the friction reducers and cross-linked gels), residual hydrocarbons (trace oil, and volatile organic compounds such as benzene and toluene), and suspended solids (clay, iron oxides, and silica).

"Aqua-Pure uses a chemical/mechanical separation process for this primary treatment," Horner explains. "We mix chemical additives with the water to alter the charge balance, causing much of the suspended and organic material to break from solution. A mechanical separation process removes this material, leaving behind dissolved solids, primarily from underground, to be removed by secondary treatment with the evaporator."

High-Energy Efficiency

After pre-treatment, the wastewater enters the evaporator, where the feedwater stream divides and flows through heat exchangers that recapture process heat from the exiting distillate and concentrated brine. "Due to the heat exchangers, we recover about 95% of the heat energy in the system," Horner says.

From the exchangers, the feedwater goes into a de-aerator column where dissolved gases are vented. Then the feedwater enters a recirculation loop that moves a large volume of fluid from a separator vessel through a circulation pump to the evaporator exchanger, then back to the separator vessel. The evaporation exchanger receives 1,200 gallons of fluid per minute, and boils 60 gallons per minute to produce steam. Then steam and fluid return to the separator vessel, where a compressor draws the steam off the top and boosts its pressure and temperature. This superheated steam provides the energy that evaporates the fluid in the evaporator exchanger.

"If you boil water on a stove, producing one pound of steam takes 1,000 BTUs," Horner says. "Because of the heat recovery, we can theoretically produce one pound of steam with 25 to 40 BTUs per pound—about 1/40th of the energy required to boil water on the stove."

The evaporator exchanger contains more than 100 cassettes, each consisting of two thin metal plates laser-welded together with a half-inch gap between them. The cassettes are aligned in a series and pressed together like an accordion with its bellows compressed.

Inside the cassettes, the high-pressure steam condenses to distilled water, while transferring its latent heat through the cassettes to boil the brine flowing outside.

Aqua-Pure buys the evaporator exchangers from Alfa Laval AB of Lund, Sweden, a global company founded in 1883 by Gustav de Laval, who invented the centrifugal separator. "The cassettes are made

Water Recycling Will Aid Barnett Shale Production

The Barnett Shale formation northwest of Fort Worth is the largest natural-gas production field in Texas and the third-largest in the nation. More than 3,000 natural-gas wells have been drilled in the Barnett Shale formation since 1982, yet up to 85% of its recoverable gas supply—more than 25 trillion cubic feet—remains untapped.

The formation begins about 8,500 feet below the surface and extends to a depth of about 10,000 feet.

Extraction of natural gas from the Barnett Shale formation has increased greatly in recent years, from 275 million cubic feet per day in 1999 to 900 million cubic feet per day in 2005. More than 60 drilling rigs are active in the area, and the rate at which wells are being drilled is increasing at a vigorous pace.

The original Barnett Shale production area extended from Forth Worth's northern suburbs in Tarrant County into adjoining Denton and Wise counties. Now—due to drilling of horizontal rather than vertical wells, and to the use of new fracture stimulation methods—production is expanding to encompass a total of 10 counties north, west, and south of Fort Worth. Also, drillers originally allowed at least 40 acres between wells, but plans are afoot to reduce that distance to 10 acres.

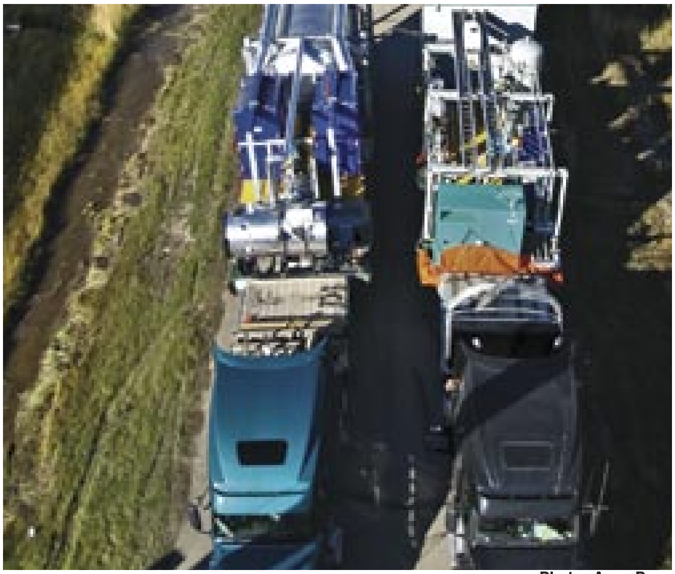

Photo: Aqua-Pure

When treatment at one site is finished, the operators can load the system onto trucks and haul it to a new site within a couple of days.

from Titanium Grade 1 and are welded in Sweden with an automated welding process," Horner says. "Titanium is used because of its high heat-transfer properties and its ability to resist the corrosive effects of boiling brine." Other materials used in the evaporator exchanger include stainless steel and proprietary composites.

For similar reasons, Aqua-Pure uses KF 2000 pumps from ANSIMAG Pumps of Arvada, CO, a Sundyne Corporation subsidiary. These non-metallic, magnetically driven centrifugal pumps have no mechanical seal, preventing leakage of process fluids. "Hot brine is very hard on mechanical seals," Horner notes. Materials used in these pumps, such as sintered silicone carbide and carbon fiber-reinforced fluoroplastics, are inert to almost all chemicals.

Reusing the Residue

From the evaporator exchanger, clean water is pumped into the distillate tank, where non-condensible gases such as carbon dioxide are vented outside. Then it is pumped to the distillate exchanger to transfer its heat to the incoming feed water, and continues on to an outdoor frac pit where gas producers draw water for a frac job.

"The distilled water is very clean compared to what it was," says Horner. "Our target is less than 10 ppm total dissolved solids. Sometimes it contains trace amounts of volatile hydrocarbons. With a carbon filter and hydrogen peroxide treatment, it could be drinking water. We get it well within the purity level that it needs for frac reuse and leave it at that."

As the steam rises to the top of the separator vessel, concentrated brine sinks to the bottom, where it is drawn off and pumped to the blowdown exchanger to transfer its heat to the incoming feed water. Then it continues outside for disposal or some productive use.

"Drilling companies and well-service companies can use the concentrate as a kill fluid," Horner says. "The gas pressure in the Barnett Shale formation is 4,000 psi. When they finish drilling, they need a way to keep that gas from flowing to the surface. Concentrate injected into a gas well acts as a cork. It's denser than water and has properties similar to potassium chloride mixed with water."

Horner says the long-term objective, when Aqua-Pure has enough NOMAD 2000 units in the field to produce more brine than the demand for kill fluid can absorb, is to send the excess to a crystalizer in a central location.

The crystalizer would make still more distilled water, as well as solids that could go to a landfill rather than an injection well for less costly disposal. Perhaps, he suggests, those solids also could be used for something productive.

Aqua-Pure has partnered with a firm experienced in building crystalizers that work in conjunction with evaporators, Swenson Technology, a subsidiary of G.K. Enterprises, Inc., in Monee, IL. "Swenson helped us with a lot of our research and development," Horner says.

A Service Company

The NOMADs are owned and operated by Fountain Quail Water Management LLC, of Jacksboro, TX, an oil-field service company that is a joint-venture partnership with ownership shared equally between Aqua-Pure and a group of local investors, the Elenburg family. Aqua-Pure builds the units and sells them to Fountain Quail for about $2.5 million apiece. "Fountain Quail does all the work," Horner explains. "It transports, operates, and maintains the plant, charges a fee for each barrel of wastewater it treats, and then sells distilled water back to the producers.

"In addition to saving the producers money, this service reduces their fresh-water demand, the trucking of both fresh and contaminated water, and the disposal volume.

"It also provides a broader environmental benefit. Any time you take water from surface sources or wells that tap a fresh-water aquifer, if you inject it deep underground, it's out of the hydrological cycle forever. We're keeping it on the surface and cleaning it so it can be reused and remain part of the hydrological cycle." **OW**

Miami, FL-based science and technology writer **GEORGE LEPOSKY** *is a frequent contributor to Onsite Water Treatment.*

A Clean-Water Niche Company

As its name implies, Aqua-Pure Ventures Inc. (*www.aqua-pure.com*) of Calgary, AB, Canada, focuses on innovative approaches to wastewater treatment.

The firm began in Kelowna, BC, Canada, with an emphasis on municipal wastewater treatment. It remains active in that field today as North American distributor of the Salsnes Filter, which was developed in rural Norway. A machine with an endless mesh screen, the Salsnes Filter provides compact primary sewage treatment for small municipalities.

By removing a large portion of the suspended solids from sewage, the Salsnes Filter decreases the biological oxygen demand and total suspended solids in the output to going secondary treatment. Aqua-Pure Ventures is exploring application of the Salsnes Filter to wineries, pulp mills, offshore platforms, ships, and other facilities.

Aqua-Pure says the evaporator design that is at the heart of its NOMAD 2000 Mobile Oilfield Evaporator can be employed in a variety of other applications. These include seawater desalinization, and processing of landfill leachate, medical wastewater, and pulp and paper wastewater.