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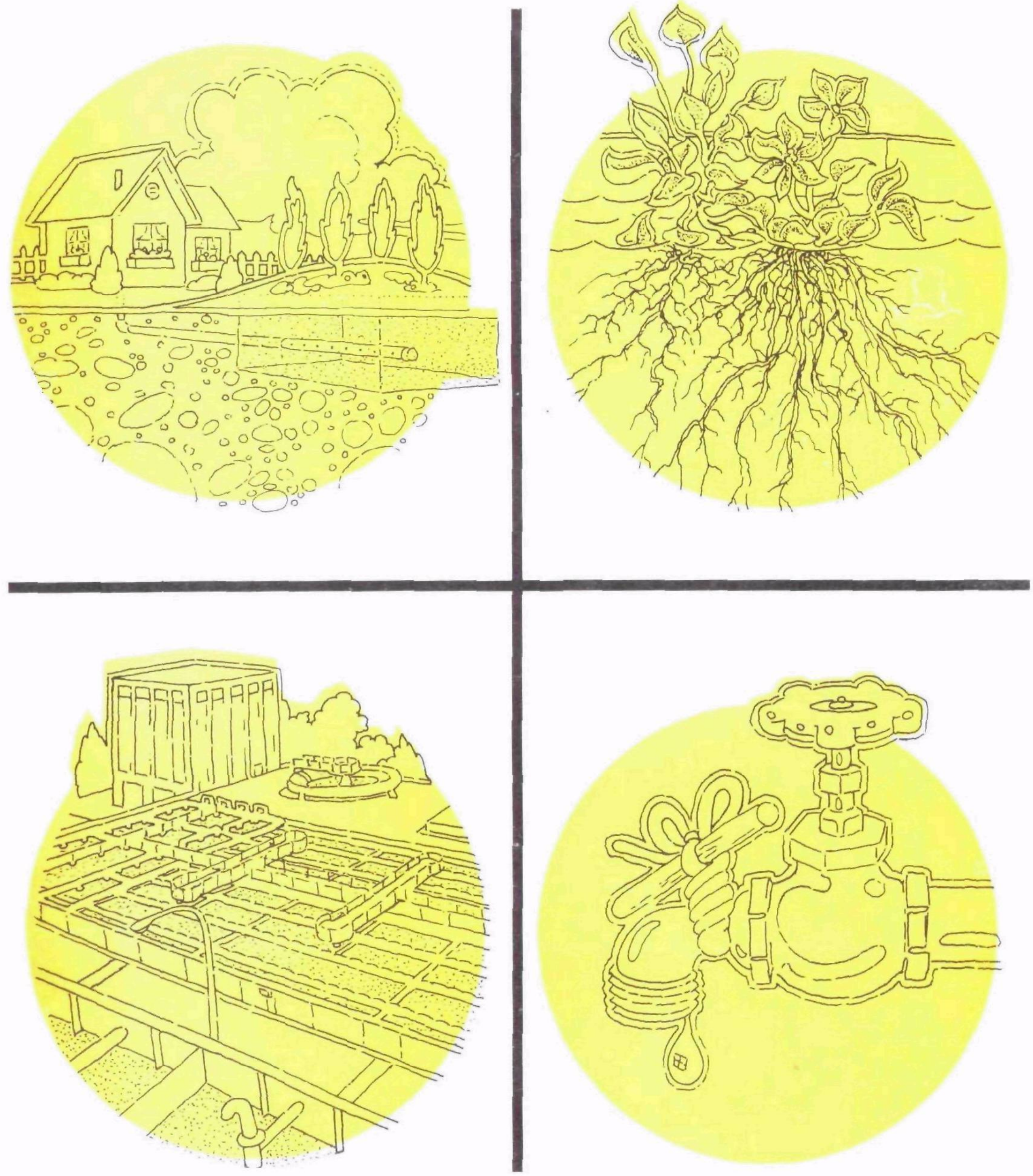
Affluent Effluent

New Choices in Wastewater Treatment



AFFLUENT EFFLUENT: NEW CHOICES IN WASTEWATER TREATMENT

This publication is a collection of case histories illustrating the successful use of innovative and alternative wastewater treatment systems.

It is a Companion Guide to the film Affluent Effluent.

It was prepared for the Office of Water Program Operations, U. S. Environmental Protection Agency,

by

Urban Scientific and Environmental Research, Inc.
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Phoenix, MD 21131.

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INTRODUCTION

This companion guide to the film *Affluent Effluent* provides detailed information on each of the case studies presented in the film. Contacts for further information are cited following each case history. Several additional cases are included in this publication that did not appear in the film. These additional examples present an even broader spectrum of technologies and management techniques.

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THE FILM

Affluent Effluent is a 40 minute color film available in 16mm and 3/4" video cassette for televised broadcast.

The film was produced for use by community decision makers. Affluent Effluent introduces new choices for wastewater treatment including small systems for individual homes (onsite systems); innovative additions to conventional wastewater treatment systems; non-conventional systems; and non-structural alternatives to wastewater management including water conservation measures that result in reduced wastewater flows. Use of this film will increase understanding of non-conventional wastewater treatment technologies and promote sound investment decisions.

Selecting a wastewater management system is one of the most important and costly investment decisions that a community makes. The success of this investment decision can affect the community's ability to grow, its credit rating, the taxes its citizens must pay, the effectiveness of wastewater treatment, and the quality of its water resources.

WHAT ARE THE ISSUES?

The people who work, live with, and pay for these non-conventional wastewater treatment systems discuss the questions you would like to hear answered:

- How does it work?
- How much does it cost?
- How and why they chose the system?
- What about public acceptance?
- What costs and what benefits?
- What was the political process that allowed this option?

Affluent Effluent demonstrates that a community can develop sound wastewater treatment systems by applying local ingenuity, good engineering, and a determination to solve their problems at lower costs to the taxpayer.

HOW CAN THE FILM BE USED?

If you are a community decision maker:

This film can save your community money and make your job easier. Obtaining the first hand information you get from viewing this 40 minute film would be costly if obtained from private research and travel. You could spend hours of your own time reading technical documents and traveling to gain similar information. One good idea from this film could save your community thousands of construction, maintenance and operation dollars.

You will want to show this film to a citizen advisory group, finance committee, consulting engineers, overseeing government agencies, and taxpayers.

If you are a consulting engineer:

Affluent Effluent can be used to educate local decision makers on a range of creative solutions to wastewater treatment problems. It can be used for:

- general information and education
- workshops on wastewater treatment
- promoting constructive discussion among conflicting groups
- generating public interest

If you are a Regional, State, or Federal regulator:

You can use Affluent Effluent to introduce a sense of financial realism into the planning process. The costs of operating and maintaining conventional wastewater treatment plants can soar with increased energy and chemical costs. These unexpected expenses can cut into operating and maintenance budgets, and can result in reduced operating efficiency. Reduced operating efficiency is a prime reason for failing to meet discharge permit requirements. By definition, an alternative or innovative system saves energy or operating dollars. Choosing an appropriate alternative treatment option can reduce the burden of excessive operation and maintenance costs while improving water quality.

Copies of Affluent Effluent for field personnel will enable them to better discuss wastewater treatment alternatives with communities.

The film can be borrowed from the Innovative/Alternative (I/A) Coordinator in your EPA Regional Office:

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Water Division
US EPA Region I
John F. Kennedy Federal Building
Boston, Massachusetts 02203

Jerry Ciotolla
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New York, New York 10278

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The film is also available for rental or purchase. For further information about buying your own copy or renting a print, please write to:

WATER FILMS, 1509 Phoenix Road, Phoenix, MD 21131

ONSITE AND SMALL SYSTEMS

ONSITE WASTEWATER MANAGEMENT PROGRAM

STINSON BEACH, CA What began as a renovation program is now a model preventive maintenance program for small towns that prefer to control the use of septic systems rather than investing in costly, complex, and often unnecessary, central sewage and treatment systems.

One of the simplest, least expensive methods of wastewater treatment is the septic tank/ leachfield. It is the most common onsite system, used by about one-quarter of the nation's housing units. The septic system, however, is all too often viewed as a makeshift, temporary solution for new communities that have not yet developed a sophisticated sewage infrastructure.

From 1950 to 1970 approximately 10 million homes converted from onsite systems to sewers and centralized treatment. Millions of dollars have been needlessly spent because communities have converted septic systems to sewers and central treatment facilities without adequately considering potentially more cost-effective alternatives.

Failing septic systems are often cited as justification to obtain government grants to construct sewers and central treatment facilities. Because of the high costs of sewers, however, problems attributed to failures are only corrected in one area at a time--usually that area of the community with failing systems and large population. As other areas of the community become more densely populated, it becomes desirable to extend sewer service. The sewer service expansion is again justified by failing systems and government funds are again sought to correct the problem.

Some towns, however, are avoiding falling into this costly pattern of development. They simply attempt to renovate existing septic systems and manage these systems so they won't fail. Stinson Beach, a town of some 1,200 persons in Marin County, California, is one of those towns. In the early 1960's, rapid population growth was anticipated in the area and developers began to push for a centralized system. This movement gained momentum when state and county health departments documented high coliform counts in nearby Bolinas Lagoon. Since coliform is a bacteria commonly found in human waste, officials blamed failing septic systems for the pollution.

During the sixties, the Marin County Board of Supervisors authorized a countywide sewerage master plan which grouped Stinson Beach with its neighboring community across the Bay. Several projects were proposed, all based on centralized treatment plants with ultimate land and/or ocean disposal. One of the proposed plans called for pumping all of Stinson Beach's wastewater to Bolinas and then piping it out to sea. During its journey, not only would the waste cross a pristine reef on the California coast, but it would also cross the San Andreas fault a total of twelve times. The estimated cost was $9 million. The town voted down the project.

Several months later, the Regional Water Quality Control Board imposed a building moratorium and gave Stinson Beach permission to pursue land disposal solutions.

Andrea di Marco, past President of the Stinson Beach County Water District, summed up the path Stinson Beach took toward finding a solution to their wastewater treatment problem: "We spent three years scaling down, getting to partial sewering, getting to spray irrigation disposal. Had we not bought the water company from one of the big property owners, we would never have discovered that spray irrigation at the proposed site would have destroyed the community's water supply. Right after that the community said, 'You'd better think of something else.'"

What they thought of, was asking state Senator Peter Behr for help in developing special legislation enabling the water district to manage, or regulate, the existing onsite systems. At the heart of the legislation is the right of the Stinson Beach County Water District to inspect privately owned septic systems. The District can enforce the repair or replacement of any system that fails to meet state, regional, or local codes. The penalties for violation are strict: fines up to $500 and/or imprisonment up to 60 days, with each day constituting a separate offense. A lien may be placed on the property to insure payment. The District also has the option of shutting off the water supply to households with failing systems--a fairly simple, but very effective procedure. In a few cases the shut-off has been imposed.

To understand the regulations, it is necessary to know a bit about septic systems. Wastewater flows from the home to a double chamber tank approximately five feet deep, four and a half feet wide and nine feet long. The tank is set so that its top is at least one foot below the ground surface. The liquid enters the larger of the two chambers first. Here solid waste (sludge) settles to the bottom and lighter wastes and grease (scum) float to the top. A mat of bacteria within the tank helps to break down (decompose) the solid wastes into water and simpler organic compounds. The system may have to be pumped to remove sludge as frequently as once every three years, or less depending on home owner maintenance and water use.

The liquid in the primary chamber then flows through a baffle near the top of the tank into a secondary chamber which is smaller in size. Lighter solids still contained within the liquid settle out in this compartment. From the secondary chamber the liquid flows through an outlet near the top of this secondary tank to a diversion valve which leads to the leach fields. The diversion valve is simply a mechanical means of alternating the use of two leach fields so that they go through a load-rest cycle on a yearly basis.

Once in the leachfields the liquid is cleansed by percolation through gravel that surrounds the pipes and then flows into the soil. For the most part, all of the flow, from tank to fields, is accomplished by gravity. In cases where this is not possible, and the leachfields must be above the elevation of the septic tank, a pump basin and pump are used to elevate the liquid to the leach fields.

A septic system which lasts 25 to 40 years may cost between $2,000 and $15,000 to install. This cost will vary greatly according to household size. Land may need to be purchased for an offsite septic system.

The Stinson Beach Onsite Wastewater Management Program's Rules and Regulations spell out, in very specific terms, the materials to be used for construction of a septic system. The size of the leachfield varies according to soil type and the theoretical water consumption of a household. Setback requirements from buildings, property lines, surface bodies of water and groundwater are also defined. Variances are permitted to some of these factors with approval from the Regional Water Quality Control Board. For example, if a homeowner can prove that through conservation methods they use less water than the standard, they may be given permission to construct a modified leachfield.

Residents are required to put access boxes above their septic tank manholes so that the inspector can examine the functioning of the system periodically. Since nearly all of the septic systems predated the maintenance program, many of them were not advantageously placed for installing the access boxes. Some systems were located under sidewalks or patios. The residents were ingenious about building attractive and inconspicious access boxes.

Each system was inspected at the outset of the program and then reinspected every other year. Less-than-perfect systems are inspected more frequently. If a system appears to be sluggish, eroded, giving off odors, or overflowing, a "Failed System Investigation" is carried out to determine the cause of the malfunction. Where a malfunction is verified a failed system citation is issued. When a system does not pass inspection it must be repaired or replaced.

After a failed system citation is issued the major responsibilty for repairs or replacement lies with the homeowner. The owner does have a right to appeal the citation at a public hearing, but if the appeal is denied the owner has about 135 days to submit a design, find funding, and have the work completed. There are a few options. For example, if the property owner is unable to pay, or unwilling to carry out the repairs, the district may carry out the design and contracting. The district will then contract for the work and insure its reimbursement by attaching a lien. Should the leachfields be exhausted and the homeowner not have enough property for a new field, the district may purchase land and, again, put a lien on the user's property or require installation of an alternative system.

All the costs of maintaining onsite systems are paid by the users. To cover the costs of the district's management expenses, annual permit fees are budgeted on a sliding scale. Nevertheless, the costs are about one-quarter to one-third that of installing even a partial centralized sewerage system. (In 1982 monthly fees were approximately $10.00.)

Stinson Beach had to fight for the right to prove that septic systems, when properly designed and maintained, are an environmentally sound, economical alternative approach to wastewater treatment and disposal. In addition to upgrading existing septic systems, Stinson Beach has installed seven composting toilets with grey water systems. These systems require special monitoring by the district. While Stinson Beach is still a demonstration project, all indicators point to success.

Ms. di Marco stresses a few points for other communities which are considering this approach.

> "When community representatives who are interested in onsite wastewater management come to me, I always ask them a series of questions: How strong is your zoning, your land use management and your community plan? Do you have a recent soils geology analysis and an accurate assessment of surface and groundwater quality, drainage and domestic or agricultural water use patterns? Is a local or county public agency available to assume full legal and management responsibility for the program?"
>
> "If you don't have any of these, you won't be ready to write your program and ordinances for two to three years. A community already has to have some sense of orderly growth and land use control."

Ms. di Marco notes that county, regional, and state administrations must be cooperative, and their codes for septic system design and installation strict enough or they may undermine the local effort. With fully developed management policies and ordinances in place, a strong Board of Directors, manager and staff, and a public education program for system care and water conservation, Stinson Beach has proven that small communities can successfully administer onsite systems.

<u>For more information contact:</u>

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DIAGNOSING FAILING SEPTIC TANKS

MASHPEE, MA Mashpee, a small town on Massachussets' Cape Cod, has opted for onsite wastewater treatment because its population is spread over a large land area. As Charles Buckingham, Town Public Health Official states:

> "Towns the size of Mashpee and with the resources of Mashpee just can't generate the amount of money that's necessary in order to put in a sewage plant. The solution for small towns has got to be greater care and greater restriction of use of the soil and the land, and maintenance of individual septic systems. If we do run into a bad situation with soil conditions where septic systems are in trouble, there are means that you can take to correct that on the site or adjacent to the site for a lot cheaper than going in and putting in a sewer plant for $10 million which will only serve a small area of town."

There was evidence, however, that septic systems near John's Pond were not operating properly. During the summer months fishermen and homeowners noticed a greyish green mass of algae moving through the water. The algae was removed, but the question remained, which septic systems were polluting the water with enough nitrogen to encourage the algae growth? Because nutrient rich septic system effluent is diluted by pond water it might take years before enough vegetation develops in one spot to pinpoint the source. But the town of Mashpee did not want to wait for the problem to become that extreme. "You don't have too much success asking homeowners how their septic tanks work, because each of them believes that his system is perfect," noted Mr. Buckingham. "It's always the neighbor down the line whose system is causing the trouble."

With that in mind the people of Mashpee decided to try some new equipment developed by Dr. William B. Kerfoot: a septic leachate detector called the "Septic Snooper." With this tool it is possible to track down a failing system before it causes extensive environmental damage.

Mashpee's inspection team rowed out into John's Pond trailing the "Snooper" in the water. The detector scans for specific pollutants typical to septic systems. Whenever the needle jumped on the chart recorder, indicating a high level of pollutants, samples were taken of the surface water. On shore, a wellpoint probe was inserted into the ground and another sample was taken. Testing these two samples would tell if pollutants were coming from surface run-off or were leaching from a septic tank into the groundwater and into the pond. If the snooper recorded a stream of contaminants, but an isolated groundwater plume could not be found with a wellpoint probe, it was a clue to check the pond's incoming streams for surface run-off of pollutants.

When test results indicated that pollutants were flowing with the groundwater the team went ashore to track its source. A new instrument recently developed by Dr. Kerfoot, the groundwater flow meter, allows even greater accuracy in determining the source of pollutants. When inserted into a hole dug to groundwater level, the groundwater flow meter uses a heat pulse to measure both the speed and direction of groundwater flow. Prior to its invention, this kind of measurement required painstaking injections of dyes which had to be tracked through wells. The old method was slow and often inconclusive.

With clear evidence in hand, the town of Mashpee found that residents were quite willing to correct failing systems. Dr. Kerfoot is enthusiastic about the new equipment. "For the first time, you actually can detect and treat individual failures on a one-to-one basis before they become so large on a shoreline that they lead to substantial degradation of the individual lake."

Charles Buckingham, Town Health Officer agreed, "I think we saved the pond. This way we've anticipated trouble before it got too big. There's no way to replace John's Pond. You can't pump it dry and start all over again."

For additional information contact:

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281 Main Street
Falmouth, MA 02540

OTTERTAIL COUNTY, MN

Rothsay Camp faced a problem typical of Minnesota's lakes region. A dozen homes, mainly vacation homes, were nested tightly between an access road and Lake Lida's shoreline. Most were equipped with old, rather primitive onsite waste disposal systems. Even those with good septic tanks were experiencing difficulty as their leach fields, set too close to the waterfront, became saturated and caused the septic tanks to back up. The residents also noticed a build-up of plant growth in the lake and realized their septic tank effluent had become a pollutant. With too little room on the individual plots to create new leach fields, residents resorted to carrying their wastewater out of their homes in buckets.

At about the same time, the state and county placed controls on shoreline wastewater management. Rothsay Camp residents approached the County Department of Land and Resource management for assistance in solving their problem and complying with the new ordinances. Rothsay Camp wanted an economical solution which they found with help from County Shoreland Manager Malcolm Lee.

Since the Rothsay Camp Home Owners Association owned 23 acres of land which was used as open space and a buffer zone, Lee suggested that part of that property could be used as a communal leaching field. Each homeowner was required to install adequate size septic tanks. These tanks were hooked into a collection line which carried the effluent to a pump, through a distribution box, and into one of the several trenches which made up the leaching field.

Rothsay Camp is the first example of a cluster system in the county and perhaps in the country. Mr. Lee reports that when the system was designed, they found contractors unwilling to bid because nobody had experience with such a project. Lee approached a local hardware and plumbing business, acted as general contractor and oversaw the construction himself.

The effluent from the septic tanks feeds, by gravity, into a four-inch trunk line which is conveniently set into an old road bed. One home with a basement required a pump to tie into the trunk line. Two main pumps then pushed the effluent up to the leaching field. Originally the design included separate metering for the electricity used by the pumps. Since the amount of electricity used was so small, they decided to run the pumps on electricity furnished by the last home in the row. Every summer at the association's annual picnic, each household pays that homeowner four dollars to cover the annual operating expenses.

The residents of Rothsay Camp check the system themselves. When a tank needs cleaning, the individual owner pays for it. When a main pump needs replacement, the hardware store which built the system installs a new pump and the residents share the expense equally.

All residents signed a Deed of Easement to permit construction, operation and maintenance of a system that crosses their individual properties. This deed also obligates any future owners to comply with the arrangement.

The cooperative system has proven to be an extremely economical, environmentally sound approach. Construction costs, including land, pipes, and pumps, came to $481.17 per household. The costs of additional septic tanks were paid by the individual homeowners. Both the common and individual operating costs for pumps, electricity, and cleaning the septic tanks are minimal.

The county now requires that every waterfront property be certified to indicate compliance with the Shoreland Management Ordinance. This certification can increase the value of a property by as much as $10,000 when the property is sold. Rothsay Camp's willingness to innovate meant that they were able to comply with the regulations at a minimal cost. Naturally, that cost has increased a bit over the past several years, but even at $800 per household this approach is more economical than other methods considered to solve similar problems.

"The techniques that Ottertail County developed at Rothsay Camp proved very valuable to a large project elsewhere in the County. At Ottertail Lake residents were planning to run a sewer line all the way around the Lake, at a cost of about $10 million.

A USEPA Region V Environmental Impact Statement (EIS), developed because of the high costs and social impacts of the proposal, discovered that only 4% of the deterioration in the surrounding water was from human waste. The rest was due to fertilizer runoff from surrounding farms. Building an expensive sewer and treatment plant might not improve water quality significantly. According to the EIS, localized public health problems and nutrient "hot spots" could be resolved for barely one third the cost of the original proposal. This could be done by repair and upgrading of existing on-site systems and selective use of the same kinds of cluster systems built at Rothsay's camp. In September 1981, Ottertail County received a federal and State grant for actual design work for this alternative.

Meanwhile, there are already dozens of houses throughout Ottertail County using cluster systems. Visitors from as far away as Nova Scotia have come to examine this cost-effective wastewater treatment system.

For more information contact:

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Land and Resource Management
Ottertail County Court House
Fergus Falls, MN 56537

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230 South Dearborn Street
Chicago, IL 60604

(Copies of the Environmental Impact Statement developed by EPA Region V for the Ottertail project titled "Alternative Waste Treatment Systems for Rural Lake Projects" are available on request from the I&A coordinator, USEPA Region V.)

MOUND SYSTEMS

ORONO, MN In the late 1970's Orono, Minnesota faced the question of whether to extend their central sewage system into the town's surrounding rural areas. As one of their brochures indicates, they realized the decision could affect the quality of life in Orono:

> "To extend sewers into rural Orono, estimates are that each homeowner would pay $10,000 or more per acre. This cost, as in other cities, may then force subdivision of the land into smaller lot sizes in order to reduce the individual homeowner costs. The rural lifestyle would disappear to be replaced by higher housing density, increased traffic, increased needs for roads, schools and other city services, and in the end increased taxes. Although not so apparent, the increased housing density would adversely affect the environment by reducing ground water reserves, eliminating wildlife habitats, and decreasing storm water runoff quality. Lake Minnetonka would never again be the same."

Although specific septic system design and construction standards had been adopted as far back as 1961, the discharge of inadequately treated sewage from some of these systems to the ground surface was not completely remedied. In April 1978, the Orono City Council adopted additional regulations to ensure that onsite sewage treatment systems would be properly installed and properly maintained. Orono established specific design and maintenance regulations, including an inspection program, licensing for construction and pumping contractors, and centralized records on the maintenance of each onsite system.

The Orono regulation included a provision for alternative and innovative sewage treatment systems where the soil was not suited to the typical leaching field. Much of the soil in Orono contains too much clay to allow septic tank effluent to percolate into the soil from deep trenches. The clay soil also tends to have high seasonally saturated conditions, which also will not allow the installation of typical leaching fields. A leaching field system installed in a clayey soil with high seasonally saturated conditions would cause inadequately treated effluent to surface and cause a health hazard. To solve the soil problem, Orono made use of an alternative system described in the Minnesota State Guidelines for Sewage Systems. The specifications for the sewage treatment mound were adapted from research at the University of Wisconsin Small Scale Waste Management Project. They utilized the naturally more permeable surface soil layers by building the rock bed of the leach field above the natural soil surface.

To build the mound, an area of land, (about 35' X 65' for a typical 3-bedroom home), is plowed or disked to loosen the upper foot of top soil. The selected area can follow the shape of the property, but should not slope more than 12% (3% for heavy clay soil) or be located in depressions or drainage ways. A level layer of sand at least 12" thick is laid down and followed by 9" of clean, igneous rock 3/4" to 2 1/2" diameter. Distribution pipes, connected to the pump station, are placed over this rock. The 1 1/2" to 2" pipe from the pump station connects to a system of parallel 1 1/2" pipes perforated with 1/4" holes every 3' and capped at the ends. Another 2" of rock is placed over the top of the perforated laterals and the rock is covered with 3" or 4" of marsh hay or straw. A sandy loam fill is placed over the rock bed, tapering from 1' deep in the center to 6" at the edges of the rock bed. The entire mound is covered with 6" of top soil and planted with grass. The site for the mound can usually be selected to fit into the landscaping plan.

To insure distribution of effluent over the entire rock bed, a dosing pump is used. The loading rate through the pressurized distribution system is designed to provide unsaturated flow through the sand bed, resulting in an aerobic environment which aids in sewage treatment. The pumping station receives the septic tank effluent and discharges it at a rate of at least 30 gallons per minute for a typical 3-bedroom home. An alarm is installed to warn of pump failure, and the station is capable of storing 1 day's sewage in case such a failure should happen.

Breakdown of pump control switches, a problem experienced in some of the first mound systems, is no longer a major problem. Significant advances have been made in the design and dependability of these switches. They are typically no longer contained in the pump case, but rather function as an auxilliary unit. Either the pump or the switch can be replaced independently in case of failure. Equipping the pumping station control, providing an alarm, storage space, and a manhole access for servicing, has made this unit a dependable part of the sewage system.

Orono's initiative in using the mound sewage system is one more example to show that onsite sewage treatment systems are a cost effective and environmentally sound alternative to centralized sewage systems.

<u>Addendum</u>:

While mound sytems are more expensive than conventional drainfields, they are usually much less expensive than sewers.

A generic cost comparison per dwelling is:

Septic tank with drainfield	$1500 to $4500
Septic Tank with Mound	$3500 to $6000
Conventional Sewers and Treatment	$6000 to $12,000

Overall project savings may often be realized because with onsite upgrading every house may not need a totally new septic tank and drainfield or mound.

For further information contact:

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Extension Agricultural Engineer
University of Minnesota
St. Paul, MN 55108

Michael P. Gaffron
Septic System Inspector
City of Orono
P.O. Box 66
Crystal, Bay, MN 55323

Perry Beaton, Chief
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Minnesota Pollution Control Agency
1935 West County Road, B-2
Roseville, MN 55113

I&A Coordinator
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230 South Dearborn Street
Chicago, IL 60604

MANILA, CA Manila is a small northern California community situated on an isolated peninsula adjacent to Humboldt Bay. Manila was facing severe health and environmental hazards created by a combination of failing septic tanks, a dense population, and high groundwater. Virgil McNutt, Manager of Manila Community Services District, described just how serious the problem was:

> "We were polluting, there's no doubt about it. I've seen 50 to 70 septic tanks buried under water for weeks at a time and then the runoff--the whole area would be polluted with the effluent from these tanks. Then it runs off down the ditches. Very foul odor for weeks afterwards. Actually, it boiled down to, if you saw a nice, big patch of blackberries growing, you could bet that there was a failed septic tank there."

The search for a solution began in 1972. A conventional sewage collection and treatment system was considered, but even with Federal grants, the estimated $30 per month user charge would be too high for many low income households. The system's high cost was largely due to Manila's geological location. High groundwater and sandy soils require pumping the ground dry and shoring trenches to install sewer pipes. In addition the undulating terrain makes it necessary to sink these pipes some twenty feet to insure gravity flow.

In spite of the severity of Manila's water quality problem, an earnest search for an alternative to the failing septic systems did not begin until 1977. Even then regional authorities were pressuring Manila to wait for the construction of a planned regional wastewater treatment facility. Meanwhile, Mr. McNutt learned of promising alternatives being used experimentally in New York State. When he first presented the concept of a low-pressure sewage system, many people unfamiliar with these systems questioned their effectiveness.

A study of Manila sewer problems and the feasibility of possible alternative solutions revealed the potential advantages of a pressure sewer system. The California State Water Resources Control Board was eager to conduct a demonstration project on a promising alternative: a low-pressure sewer system. The State Board was willing to cover all costs of the experiment, and one of their reports succinctly explains why:

> "Presently (1980) $550 million of local, State and Federal funds is committed for the construction of collection systems and treatment facilities in 304 California communities. Approximately three-fourths ($400 million) of this money will be spent for construction of collection systems. In 25 percent of the communities it is conservatively estimated that a low pressure sewer system would be significantly more (i.e., greater than 50 percent) cost-effective than a gravity collection system. This represents a savings of $50 million..."

Manila qualified for this program for several reasons:

- There was a well defined health, environmental, and economic need in the community;

- With 350 residences, the community was small enough to fit within the project's budget, yet large enough to allow for experimental variations in design, and to provide adequate data for analyzing the approach;

- More importantly, the geological features of Manila rendered a conventional gravity sewer prohibitively expensive.

After consideration of several other alternatives, the community and the State chose the low-pressure sewage system for demonstration. The first component of Manila's system is an onsite septic tank. Concrete and fiberglass tanks of varying sizes have been installed on individual lots. In some cases, two to four homes feed into the same tank. In order to ease installation, plot plans of each property were drawn so that residents could take part in deciding on tank location. This approach helped prevent tensions which might have arisen between the utility and the residents. Sludge removal is considered part of the standard system maintenance and is managed by the Community Services District.

A pump inside each tank forces the partially treated effluent into the collector system. Three different brands of pumps ranging from 1/3 to 1 horsepower were tested. The pumps represent the major maintenance task for the district's staff. One problem encountered was that earwigs (small insects) were attracted to the switch breakers. When the breaker tried to close, the earwig got caught, blocking the contact. Pumps are now equipped with failure alarms and each tank is large enough to accommodate storage of one day's sewage in case of pump failure.

Because the effluent pumped from the septic tanks does not contain solids, the pipes in this system are small: 1-1/4 to 1-1/2 inches for connector lines; 3 to 6 inches for mains. These small pipes are the great attraction of low pressure systems. Not only are they less expensive than gravity mains, but they are installed only 2-1/2 to 5 feet below the surface -- a substantially less costly installation process than digging down 20 feet for gravity mains. The system design also allows for regular cleaning and inspection of main pipes. As a safety measure, a stronger-than-necessary pipe was used and an extra encasement covers pipes which cross or parallel water mains.

The terminal for the system is a pump station, a wet well, and a leaching field located on a high sand dune. The wet well essentially acts as a holding tank, smoothing the peaks in daily flow so that effluent is applied to the field at an even rate. To help control odors air is drawn out of the wet well, pushed through an activated carbon filter, and discharged through a roof stack. As this is a demonstration project, the station also includes substantial instrumentation to gather research data. The three acre leaching field is divided into four quadrants to allow alternate rest periods. The leaching lines (1 inch perforated PVC pipe) are set in a one foot deep bed of gravel and covered with a layer of plastic and three feet of sand.

Below the pipes, approximately 30 feet of sand filter and polish the effluent before it enters the ground water table.

Capital investment for the Manila project was $5,080 per connection; this includes on-lot facility costs of about $3,851 per connection, but does not include special testing equipment to gather research data. If a gravity system had been installed, pumping stations alone would have cost one-third of the total capital costs of the low pressure system.

Households are charged a base rate of $7.50 monthly for the first 500 cubic feet of water used and $0.40 for each additional 100 cubic feet of water used. The average monthly cost per connection is approximately $8.00.

David Tollefson of Winzler & Kelly Consulting Engineers sums up pressure sewers' applicability for other communities:

> "Pressure sewers are not going to replace gravity sewers because where you have conditions that accommodate a gravity sewer, there's nothing cheaper. Where you have unique problems though, like bedrock; high ground water; undulating terrain where a large number of lift stations; or rural communities that are spread out; gravity sewers just wouldn't be practical. I think pressure sewers are certainly going to be applied in the future. They're also going to be used in housing development communities where development is going to occur over some long periods of time and they're not going to want to spend the up-front money of putting in a huge gravity sewer line right off the bat. They will develop community pressure sewers."

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CONVENTIONAL TREATMENT WITH ALTERNATIVE OR INNOVATIVE ADD-ONS

GOOD OPERATION AND MAINTENANCE

PORTLAND, OR. Government studies have shown that many treatment plants are not meeting their discharge permit requirements. These requirements are established in a plant's discharge permit by the National Pollutant Discharge Elimination System (NPDES). There are three problem areas which dramatically affect a plant's ability to treat wastewater efficiently and for the least cost.

Substances in the influent that are incompatible with the treatment system or which can destroy the working bacteria of the treatment plant, are common causes of discharge permit violations. This can result when an industry discharges toxic wastes into the sewer system. Operation and maintenance deficiencies resulting from undertrained operators, insufficient staffing, or poorly maintained equipment, are other prevalent reasons for treatment plant problems.

In contrast to many plants in the U.S., Portland, Oregon's wastewater treatment plants are considered among the most effective in the country. Not surprisingly, Portland officials have given special attention to the three problem areas.

Portland strictly monitors sewage treatment plant influent. Industries that discharge wastes that place an undue burden on the treatment plant (ie., high biochemical oxygen demand (BOD) and suspended solids) pay a surcharge for the additional load placed on the plants. Industries that dump incompatible industrial wastes like heavy metals acids or other unacceptable substances, are required to pretreat their wastewater before discharge to the sewage system.

About three-quarters of a million dollars annually is collected from the Portland industrial program. This pays for monitoring, additional treatment costs and also acts as an incentive for industry to initiate recovery or pre-treatment of toxic materials in the wastewater.

To improve the design of treatment facilities, plant personnel work with engineers during the planning stages. This policy has several positive effects on the system. First, plant staff can often identify design problems which the engineer may have overlooked or may not be aware of. For example, plant personnel suggested an innovative design for digester floors to improve the consistency in concentration of sludge solids being drawn from a digester. Another suggestion was made to allow easier access to the digester interior for maintenance personnel.

These, and other suggestions were incorporated into the design of additional digesters at Portland. Second, a cooperative effort enables the engineer to design plant characteristics responsive to the user's needs. Finally, Portland has found that involving plant staff in the planning stages improves their understanding of the system and the engineer's intent. This in turn helps improve staff morale and motivation.

Portland has also placed a very strong emphasis on all aspect's of operation and maintenance. They exercise particular care in hiring and training well qualified operators. The minimum requirement for hiring an operator is either completion of a formal training program, or one year of on-the-job experience in a treatment plant. The supervisory staff has, in the past, conducted year-long training programs for employees. Another policy which improves performance is the rotation of operators to different stations. An employee who understands the system as a whole seems to work more efficiently and enthusiastically. Portland's top management emphasizes high morale both in selecting their staff and working with them.

Portland's wastewater system, serving a population equivalent to over 600,000 is comprised of two activated sludge plants, (one 100 MGD plant, and one 8.3 MGD plant) and 52 pumping stations treating 31.5 billion gallons of wastewater per year. The annual operating budget is about $6 million. The City Council has guaranteed the plants' performance by supplying adequate necessary resources to operate and maintain them well.

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ST. PETERSBURG, FL. St. Petersburg is a large city built on a peninsula, jutting into the Gulf of Mexico and framing Tampa Bay. While much of Florida is blessed with enough potable water, St. Petersburg's wells brought up sea water or water smelling of sulfur which could only be used for limited irrigation purposes. By 1928 the city was water-scarce and still rapidly growing. Forced to purchase land/ water rights in neighboring counties, the city was soon involved in a tri-county water war. A regional water authority was establishled to settle the disputes and provide planning, but St. Petersburg recognized that fresh water would always be a precious commodity.

Because of this chronic shortage, the city limited the use of potable water for irrigation. Regulation posed serious landscaping problems for office buildings, residential complexes, and recreational areas such as golf courses and parks during times of drought.

Meanwhile in 1971, the State imposed strict requirements on the treatment of sewage effluent discharged into Tampa Bay and its tributaries. Although St. Petersburg already had extensive, sophisticated secondary treatment plants in place, they began research and planning for an advanced wastewater treatment (AT) plant. Investigators found that the most difficult pollutant element to remove was the nutrient level in the effluent. Removing nutrients like nitrogen and phosphorus would exponentially increase treatment costs. To build a plant that would meet the State's new discharge requirements, an additional $40 million capital investment would be needed.

If St. Petersburg was going to spend so much money to produce high quality effluent, why throw it away? Why not put it to good use? Since there was a high demand for irrigation water, the effluent could be used in this manner. The benefits of recycling were very attractive. It would: (1) lower the cost of wastewater treatment by eliminating the need for nutrient removal; (2) provide water for irrigation; (3) eliminate all effluent discharge into the bay; and, (4) renew the groundwater supply. The city could charge users for the recycled water to cover some of their treatment expenses. In St. Petersburg the effluent goes through a fairly standard process of grit removal, aeration, clarification and chlorination.

In the mid 1970's the city made a decision to recycle the treated wastewater rather than continue discharging into Tampa Bay. Instead of paying for construction and operation of costly nutrient removal facilities, the nutrients remain in the effluent and now fertilize the irrigated vegetation.

Major modifications made to the plant were the addition of multimedia filters and alum. A retention basin was built and additional chlorination added when quality control demands it.

Once the wastewater is treated, the water is distributed through a system of pipes to irrigation sites. To prevent the mixing of potable and recycled water, the separate distribution pipes and hydrants are color coded. In spite of the fact that the water is constantly tested, and is actually cleaner than some fresh water, users are advised not to drink it. When the supply exceeds both demand and storage capacity, the excess is injected into underground wells.

The cost for the recycling system was $19 million -- a big bill, but less than half the cost of the AT alternative. St. Petersburg is particularly proud of the recognition its recycling system has won. St. Petersburg's system was selected by the National Society of Professional Engineer's as one of the "Ten Outstanding Engineering Achievements of 1976" along with the Viking Mars Landing Spacecraft.

The city is now irrigating 2,000 acres of public and private green space with water that once was discharged directly into Tampa Bay. Assuming that half the water is sold to commercial customers at the going rate of $0.03 per cubic meter, the program generates about $40,000 in revenue per year. The problem St. Petersburg now faces is extending the system to meet demand.

One golf course landscaper's story indicates how successfully the program has solved the local irrigation problems. Before the golf course received recycled water three years ago, the landscaper had to rely on lake water (which accumulated from street drainage) for irrigation. The ponds tended to mix weed seeds into the water supply, fouling both the irrigation system and the greens. After installation of the water recycle system the landscaper has a regular adequate supply of water which has allowed him to cut fertilization in half and has fewer maintenance problems. There are no odor problems.

St. Petersburg's program is an experiment on a large scale. Recognizing the city's success, the State is trying to establish a set of standards for the use of recycled water in urban settings, for crop irrigation, and for industrial use. Visitors from all over the world come to investigate the possibility of recycling as a solution to their water shortage and wastewater management problems. The experts in St. Petersburg advise that in highly industrialized areas the system may require additional precautions, more testing, and more pretreatment, but otherwise they urge any water-scarce city to consider recycling.

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SPRAY IRRIGATION OF CROPS

PAYNESVILLE, MN. Paynesville is a town of 1,200 persons, situated amidst the lakes, corn fields, and dairy farms of rural Minnesota. The people of Paynesville are proud to have created an economical, environmentally sound system for treating their community's wastewater. Their system is both esthetic and inexpensive, and provides benefits to farmers and townspeople alike.

The center of Paynesville has a sewer system which feeds into a series of four ponds, often called lagoons. The four foot deep ponds can treat 425,000 gallons of wastewater per day. The only mechanical part of the system is a pump which brings the water from the town to the ponds. Nature does the rest: sun, wind and bacteria break down the waste. The flat Minnesota terrain, as well as the wind direction and constancy, are particularly conducive to this biological process.

To keep the edges of the ponds clear of excessive growth, sheep are allowed to graze the area. This saves the town the trouble of mowing. The ponds also play host to ducks, herons, swans, and other water fowl. The lagoons look more like a recreational area than a wastewater plant. There is no sludge problem and there are no odors, except for a few days in the spring. The system requires only one man working part-time to maintain. The only repairs necessary have been patches for a few muskrat holes made in the retaining walls. The typical user's sewage treatment bill comes to $3.50 a month.

Up until a few years ago, the town's treated effluent was allowed to flow from the ponds to a nearby river and to continue on its way through the region's extensive waterways. Even though the effluent met all of the State's standards for purity, it was rich in nitrates and particularly high in phosphates. This combination promoted a nutrient overload in the lakes and a build-up of unwanted plant growth, a form of pollution.

Meanwhile, the hot, dry winds of summer were ruining the local dairy farmers' feed crops. By August cornfields were parched and nearly useless. At a cost of $80 per acre (half of which was required to pump groundwater to the surface) farmers could not afford irrigation. One farmer, Art Voss, whose land was near the treatment ponds, looked at the thousands of gallons pouring from the ponds into the river with envy, and a touch of skepticism.

Fortunately at the same time Paynesville's mayor was looking to the farmers for a lesson in resource management. "The manure from 100 dairy cows amounts to a staggering amount of waste. Farmers have an excellent method waste disposal; they haul it out into the field, plow it down, and grow crops. It's a continuous cycle. I felt that if the farmer can do it, why can't we?"

Paynesville has no heavy industry. There are few, if any, heavy metals or harmful chemicals in the effluent, and therefore, it would not be harmful to crops or the livestock to which the crops are fed. Also no chemicals are used in treating the town's wastewater. The water from the treatment ponds (when tested by the State's Department of Public Health) has been declared virtually free of pathogens. With these facts in mind, the town decided to try using its effluent for feed crop irrigation.

The mayor and irrigation specialists developed a plan to recycle the wastewater and called for bids. A technical difficulty over the bidding nearly aborted the project until Art Voss, a local farmer who lived near the pond, volunteered to use his own equipment to apply the effluent to his crops. When, after a few days of application the plants showed no indication of brown spots or other damage, Art Voss began irrigating his own fields.

The experiment proved tremendously successful. Art Voss' crop yield, which averaged 70 to 80 bushels of corn per acre and dropped to near nothing in dry years, jumped to 150 bushels per acre following irrigation with the treated wastewater. Of course any irrigation would have improved the yield, but Voss felt there were particular benefits to using the treated effluent from the ponds. First, the ponds were already at surface level which saved deep well pumping costs. Second, effluent containing phosphorus and nitrogen contributed to fertilization of the crops. Finally, the pond water was warm and did not shock the plants.

Paynesville realizes several additional benefits from this system besides protecting their lakes. Use of the pond water for irrigation helps to preserve the groundwater supply. In addition, farmers irrigating with wastewater effluent increase their production of feed and silage.

Recognizing Art Voss' benefits from use of the effluent, other farmers were quick to demand access to the wastewater ponds. They were willing to do most anything to get the water, offering use of their own equipment to pipe the water to their own property. Four years later, 800 to 1000 acres of land producing animal feed crops are being irrigated with effluent water.

Having proven the program sound, Paynesville was granted EPA funds to extend the system. The town will install pipes to carry the water from the ponds to outlying farms. Irrigation equipment will be purchased by the town and leased to the farmers. They intend to charge $25 per acre irrigated per year. This includes costs for water, power and equipment usage. It is anticipated that this fee will more than cover the systems' operating expenses. At the $80 per acre price for irrigation with groundwater, the farmers consider the effluent a bargain; and the charges offset the cost of wastewater treatment for the town.

Since the water is used only for irrigation during the growing season, Paynesville continues to discharge effluent from the ponds into a river during the winter months. The EPA funds will enable additional ponds to be built, increasing the holding capacity and, therefore, the irrigation water supply.

The people of Paynesville are proud of this system. They created it themselves from a few good ideas, a willingness to take risks, and enthusiasm. It is not only aesthetic and inexpensive, but has an economic advantage for the farmers and the community as a whole. There are relatively few conditions that would keep other communities from considering a similar system. The basic requirements are inexpensive open land near the town for ponds, a controllable level of industrial waste predominantly flat terrain, and adequate feed-crop farming requiring irrigation within a convenient distance from the ponds.

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LAND RECLAMATION/WILDLIFE ENHANCEMENT

MARTINEZ, CA — Amidst the factories, smoke stacks, and highways of an industrial park in Martinez, California, it is remarkable to find a marshland hosting herons, shorebirds, wild ducks, and a wide range of wildlife. It is even more remarkable to learn that this marsh was created by the Mt. View Sanitary District in an industrial area and is fed by effluent from their wastewater treatment plant.

The Martinez high-rate trickling filter plant serves a population of about 12,000. Average daily flow is approximately 800,000 gallons. In 1974 the sanitary district was advised by the State that they could no longer discharge effluent into a tributary to the San Francisco Bay. There were two conventional solutions open to them: invest approximately 6.5 million dollars to hook into a regional treatment plant, or spend 2.5 million dollars on pipes and pumps to carry the effluent one and a half miles away for deepwater discharge directly into the bay. But Mt. View's administration saw another option.

Next to the plant was an area of brackish marsh which had been drained many years before for development purposes. Mt. View officials thought it possible to foster a mutually beneficial relationship with nature. If they could create a new wetlands area using their treatment plant's effluent, perhaps the quality of the effluent would be improved by the natural biological cycles which occur in a healthy marsh. While the district could not guarantee a higher quality effluent, the State's administration was receptive to the idea for several reasons. Since the turn of the century, approximately 70% of California's wetlands have been lost to draining and filling. Habitat for literally hundreds of types of flora and fauna was diminishing. A major link in the ecological chain was slowly disappearing from the west coast. California, experiencing chronic water shortages, also wished to encourage secondary use of water supplies. So, the State allowed Mt. View to proceed with their experiment.

The basic idea, explained Roy Brown, District Superintendent, was wildlife enhancement of an urban/industrial area. They wanted to get away from the concrete, asphalt and steel approach to wastewater treatment, and return to using the natural ecological chain. In addition to providing wildlife habitat, the project had a strong education potential. It provided an opportunity to study birds, mammals, amphibians, insects and smaller organisms in a natural setting.

About twenty acres of wetlands were created and divided into several shallow and deeper water areas so that various conditions could be studied. The combination of elements was found to be most effective in promoting wildlife habitat and, to a lesser extent, improving the quality of the water. First, there must be a large enough span of open water that birds in flight could be attracted to it. Within the pond area, several small islands were built to give the birds safe nesting areas. About a third of the wetland surface is covered with emergent vegetation (tall grasses which grow out of the water). Some 72 species of plants grow of their own accord, providing food, shelter, and nesting for birds and animals. The vegetation also helps prevent erosion. The biologist investigated methods to increase the food supply. With the cooperation of the California State Fish and Game Department, an additional 2.5 acres of seed producing vegetation were planted.

In addition to the open water and plants, an artificial third element was introduced. Ecofloats provide breeding grounds for the small aquatic organisms that help purify the water. The ecofloats consist of little sacks, made from nylon mesh containing redwood bark, which are suspended from the float into the top 6 to 10 inches of water. These provide a surface for the aquatic micro-organisms. Some of the floats have little windmills that mix the pond water from top to bottom and circulate nutrients.

The primary food chain begins with micro-organisms in the water. Small aquatic animals feed on these organisms and on the organic matter suspended in the water. Thirty-four different species of invertebrates living in the wetlands comprise part of the secondary food chain. Different types of fish, including mosquito fish, were introduced to reduce the mosquito population. There are also ninety species of birds, some of them quite rare, that either live in or stop at the wetlands during migration. Finally, another nineteen species of mammals, amphibians, and reptiles have found their way into the man-made wetlands.

There is little question that Mt. View has been very successful in creating a wildlife habitat. In fact, the local Audubon Society gave the district an award for its work, declaring the wetlands one of the best birding areas in the county. The site is popular with all sorts of educational groups.

On the journey through the marsh, organic constituents in the plant effluent are reduced by harmless aquatic organisms. Algae give the water a greenish tinge which, although unattractive, is environmentally safe. There is some reduction in nitrates and phosphates but since nutrient use by plants is tied to the natural growing seasons, it is not as consistent a reduction as that achieved by chemical or mechanical treatment.

Additional experiments are underway using treated effluent from the treatment plant to irrigate trees. This process aids in purifying the effluent by reducing the nutrients and algae. There are initial indications that the rich water encourages the trees to grow very quickly. On a large scale, it may be possible to reap a profitable cash crop of redwoods.

It is almost impossible to place a dollar value on the wildlife habitat created at Mt. View. The capital cost was $300,000 and the operation and maintenance run about $1,200 per year, plus salaries for about 10 hours of maintenance and 15 hours of monitoring and management weekly.

Mr. Brown advises that an artificial marsh of this type is best suited for sites with marginal quality land and a water course that will carry the effluent off for final discharge. Since there could be some problems with mosquitos, it is best located away from a residential area or else institute effective mosquito control procedures.

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SLUDGE COMPOSTING

DURHAM, NH When the selectmen of Durham, New Hampshire began planning a secondary wastewater treatment plant, they approached the problem with unusual foresight. At the time, the existing primary plant was producing 15 cubic yards of wet sludge per week. It was being dumped into a make-shift landfill and causing handling problems and offensive odors. Since the dump was near a river, they were also concerned about polluting the water. In addition, since the town was considering the construction of a new secondary treatment plant that would produce twice as much sludge as the primary plant, they were in need of a solution for sludge disposal.

Incineration of the sludge was considered, but New England's high fuel costs made that approach impractical. Landfill was another possibility, but purchasing land outside the town was too expensive.

The town decided to experiment with composting. In the small town of 6,000 permanent and 12,000 college residents, there was a strong feeling that it made sense to complete the cycle of wastewater treatment by returning a viable product to the land rather than wasting it through incineration or landfill.

Composting is a very natural process. The bacteria, which are abundant in sludge, digest the sludge and produce a humus-like material. They need food, water, and air to break down the sludge. The first two elements are amply supplied by the sludge, but the air must be introduced artificially.

Even before the start of the project, Durham recognized that to be successful, composting must be mechanized, economically feasible, and operational year-round. New England's harsh weather conditions heightened the importance of this last factor. The town carried out a pilot project to determine if composting could meet these criteria. This experiment was not only a success, but provided several valuable lessons in designing a permanent composting system.

The Durham pilot project began on a one-acre lot several miles from the treatment plant. It was quickly realized that transporting the sludge was a messy job that used fuel, tied up trucks and labor. They decided that the permanent site should be adjacent to the new plant for operational efficiency and in the interest of cost-effectiveness. The next lesson concerned the work surface. Initially, a layer of gravel was used for a composting pad, but the gravel caused problems. It was a difficult surface to work on and the stones tended to mix into the compost. A 250'x 152' concrete pad has since been installed. This pad is large enough to build compost piles for a two-month period and still allow work room for handling. It has a built-in drain so that any liquid runoff from the compost piles can be removed and piped back into the treatment plant. A four-foot retaining wall has also been added to one side to make it easier to scoop up the composted material.

Aeration can be the most difficult aspect of composting. This can be accomplished by windrowing (piling the sludge into long narrow rows), but given New England's weather, it was decided that forced aeration would be more practical and efficient. Small fans and pipes are used to move air through the compost piles. Because sludge is so wet and heavy, a bulking agent is mixed with sludge to aid air circulation. Wood chips are used as the bulking agent in the Durham project.

Several methods were used to mix the compost and wood chips during the pilot program. A front-end loader, sometimes in combination with a grader, was initially used at Durham. The problem was that this tied up equipment and labor for a full day for each pile. The sludge itself can also create problems; in cold weather it tends to freeze, and sludge waiting to be mixed tends to smell after a week because without aeration it becomes septic. The new facility is now experimenting with an indoor pugmill that mixes the sludge and bulking components in the proper ratio. The mix can then be added to the compost pile each day year round. The town anticipates that labor requirements will be substantially reduced. Also, the problem of noxious odors should be eliminated.

A typical Durham compost pile handles about 60 cubic yards of wet sludge and 180 cubic yards of wood chips, and measures 60' x 15', and is ten feet high. A layer of composted material one foot thick over the pile acts as an effective insulator. Over the course of about three weeks the temperature within the pile will rise, peaking at about 73°C, and then fall off again. The heat kills most harmful bacteria, but benefits the bacteria that do the actual composting.

Air is circulated through the piles with a one-half horsepower blower connected to perforated pipes placed under the compost piles. During the pilot project, the piles were regularly monitored for both heat and oxygen. Since the heat produced by the bacteria composting the sludge is dependent on the oxygen level, only the temperature of the piles needs checking to assure the composting process is working properly. It is important that the piles attain the necessary temperature to kill most of the harmful bacteria in sludge.

Composting is completed in about 21 days. However, the compost isn't fully stabilized until after another 30-60 days. The final step in the composting process involves screening of the mixture to separate the wood chips from the compost material. Since the compost remains wet and in larger clumps in the winter, a 3/4 inch mesh screen is used to retrieve about 50% of the wood chips in the compost process. In warm or dry weather, a finer 1/4 inch mesh screen is used for up to 80% retrieval of wood chips. The remaining wood chips not recovered help stabilize the compost and add to its value as a bedding material for horticultural uses.

Because it is most convenient to screen the compost right on the composting pad, the town is building storage bins directly adjacent to the pad. A conveyer belt will be installed to catch the wood chips and carry them to a separate bin for reprocessing. The composted material will drop into bins and remain curing in the bins from four to six weeks. Table 1 shows estimated operating costs to process one pile of compost during the pilot project.

TABLE 1: COSTS INCURRED, EACH PILE (42 WET TONS or 10 DRY TONS) (1975)

ITEM	COST
ADS Flexible plastic pipe (37¢/foot) ----------------	56.00
Wood Chips ($3.25/cubic yd)[1]	585.00
Mixing equipment and labor[1]	120.00
Monitoring of pile ---------	52.00
Electric power -------------	3.00
Capital Costs[2] -----------	6.00
TOTAL ---------------------	$822.00
Cost per dry ton of sludge (42 wet tons per pile) ----	$19.57
Cost per dry ton of sludge (10 dry tons per pile) ----	$82.20

(The capital costs of the compost process were not included in the cost per pile.)

1 Use of loader and personnel (8 hours)

2 Capital expenditures spread over the life of the project; does not include construction of compost pad.

What can be done with the composted material? This question is still being debated. In Durham, the compost is being used to fertilize and condition soil along roadways and parks. Among Durham's residents, the compost is so popular for gardening that the town has to hide supplies when they are needed for a special project. Tests indicate that there are virtually no pathogens in the end product, and the State's Department of Public Health has given tentative approval for application of composted sludge as a soil conditioner.

Since Durham is a residential town, the compost is free of the heavy metals typically found in sludge from industrial areas. The compost is well suited for ornamental gardens and lawns since it creates good soil structure and provides needed aeration and water retention for plant growth. University of New Hampshire experiments indicate that it can be used on a layer of plastic sheeting to grow turf in half the usual time. There is still a reluctance on the part of many officials to sanction the use of sludge compost for food production. Fears of heavy metal or pathogen contamination still exist particularly if industrial wastewater is treated with the domestic sewage.

Although in some States composted sludge is sold or given to homeowners and farmers as a soil conditioner and organic fertilizer, the development of specific regulations will be needed to define acceptable standards for the use of compost in both ornamental and food-crop applications.

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METHANE CONVERSION FOR FUEL

MODESTO, CA In Modesto, California, a small fleet of cars and trucks are fueled with biogas produced at the city's wastewater treatment plant.

The biogas is a by-product of a bacterial process (anaerobic digestion) that is used at the plant to treat municipal sewage. The biogas from the digester contains methane gas, the essential ingredient in natural gas. Unfortunately, the gas also contains small amounts of potentially corrosive carbon dioxide and hydrogen sulfide. Engineers have long known that the methane is an energy source, but only recently have efforts been made to harness and use it.

"Initially," explained John Amstutz, "We saw the big flare stack here wasting close to 200,000 cubic feet of gas a day and we thought the vehicle idea would be pretty good. Then along came the energy crunch." As in many other situations, the energy crisis became the impetus for action.

The primary problem in using biogas is separating the methane from the other by-products. Diluted by carbon dioxide, raw biogas does not contain enough energy to run a vehicle. The hydrogen sulfide and carbon dioxide in the gas can produce excessive wear on the engine. However, once the biogas is cleaned, it can be compressed and stored as an efficient, clean burning vehicle fuel. Central Plants, Inc., a subsidiary of a major utility holding corporation in southern California (PLC), began working with the city of Modesto to develop the technology needed to harness biogas. The result of this research is a new process (Binax system) for processing small to medium volumes of biogas (25,000 - 2,000,000 scf/day). The system uses ordinary water under pressure to remove the contaminants in the gas.

To process the gas from the digester, it is first compressed and injected into the base of a pressurized tower. As the gas flows up the tower, water flows down through a series of trays and absorbs the contaminants. A second tower purifies the water for recycling. The end product, 98% pure methane, is essentially the same fuel as natural gas. It can be used for heating, generating electricity, or running machinery. But most important - it can be used as an effective and low cost fuel for vehicles. This is demonstrated in the Modesto study in which seven cars and trucks are operated with this new, renewable energy.

Few people realize that vehicles can easily be adapted to accept compressed natural gas yet still have the option of running on gasoline. The technology, developed by Dual Fuel Systems, Inc., an affiliate of Central Plants, Inc., is over a decade old. It has been successfully used in fleets throughout the world. It is a popular system in New Zealand where natural gas is plentiful and oil is scarce. The modifications are simple. They require little change to the engine itself and the equipment can easily be removed and used on replacement vehicles. Five basic parts are added to a standard vehicle:

1. <u>Refueling Connection</u>: a small refueling port located under the hood;

2. <u>Gas/Air Mixer</u>: mounted on top of the carburetor to replace

the air cleaner, this blends the methane and air for optimum combustion;

3. Storage Cylinders: each cylinder holds 350 cf of gas at 2,400 psig, the equivalent of about three and a half gallons of gasoline. Typically, cars are equipped with two cylinders, fitted into the trunk. Trucks may carry from two to eight cylinders depending on daily fuel demand.

4. Pressure Regulator: to control the pressure from the cylinders for the gas/air mixer;

5. Fuel Selector Control and Fuel Gauge: mounted on the dashboard, this allows the driver to check the gas supply and, if necessary, switch to gasoline.

Conversion equipment generally costs \$800 - \$1,850 per vehicle and typically takes 10-20 hours to install. The equipment can be transferred to other vehicles as replacement vehicles become necessary.

There are two methods for refueling the vehicle cylinders. They can be "Quick Filled" in two to five minutes from a cluster of high pressure storage tanks, (3600 psi) or "Timed Filled" over night, in 10-14 hours directly from the compressor. In both cases the methane is compressed and the pressure and refueling is automatically controlled. Either method can be carried out by a trained operator, usually the driver. Dual Fuel Systems, Inc. advises that both methods cost about the same. The quick fill method may require a greater initial capital investment in equipment, but the difference is usually offset by the additional costs to install underground piping to the parking area where the vehicles are time filled over night. Modesto uses a combination of both.

When Motor Trend Magazine tested this Dual Fuel System they found only one notable disadvantage in performance: methane causes a slightly lower acceleration and throttle response. However, they also found excellent starting, lower wear and tear on the engine, fewer oil changes, and longer plug and muffler life. In other words, methane is good for the car. Methane also burns cleaner and produces far less air pollution than gasoline.

So far the Modesto system indicates that methane can be produced from biogas at a cost equivalent to 30¢-50¢ per equivalent gallon of gasoline depending on the size of the system. Considering the cost of gasoline today (and the importance of preserving and diversifying energy resources) the advantages of this system are obvious. The Binax system at Modesto was a test unit capable of producing a 25,000 cf/day or 10% of the potential digestor gas available. Plans are ready for a full-scale system that processes 200,000 cf/day. This scaled up version will produce the equivalent of 1,200 gallons of gasoline per day, enough to fuel the city's entire fleet of 300 vehicles. This is economically feasible since the fleet returns to a centralized location each day.

The cost of a biogas scrubbing and conversion system will vary according to design requirements, size of system, and installation characteristics. In Modesto, the pilot conversion project cost

$300,000. In May 1982, after a successful trial, the Modesto City Council approved $1,000,000 to fund a full-scale project. This will enable the city to utilize the entire sewage treatment plant biogas production. Estimates indicate the entire system, including conversions, should pay for itself in less than three to six years, depending on the method of financing and the price of gasoline they are foregoing.

Since the first biogas processing system was installed in October 1978, the only time the system has not been operational was in late 1980 when chemical toxins were accidently discharged into the wastewater. This killed the bacteria in the digester tank. It took nearly a month to fully reactivate the plant. During that time the supply of biogas was cut off. Modesto will tie into the local gas company's pipelines to provide a backup in the event of future breakdowns in the digester tank.

Wastewater treatment plants are not the only source of biogas; landfill sites, animal feedlots, food processors and farms can also produce it. Nor is the methane limited to use by vehicles; a town could use methane to run machinery, heat a building, or produce electricity. Modesto plans to use its excess gas to fuel its boilers at city hall.

Any town with a population of more than a few thousand, particularly those which already have sewage treatment digesters, should consider following Modesto's example. As John Amstutz put it, "Otherwise we're talking about the equivalent of 1,000 to 2,000 gallons of gasoline going up in flames every day."

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NON-CONVENTIONAL SYSTEMS

OVERLAND FLOW LAND APPLICATION

EASLEY, S.C. Easley, South Carolina and neighboring Clemson University have been working together on a new approach to wastewater treatment. Known as overland flow, this type of land treatment system is in many ways so simple that many ask "Is that all there is to it?"

The basic concept is to distribute wastewater through pipes across the top of a hill, letting the wastewater flow evenly over a sloping grassy plot to the bottom. The only pretreatment necessary is screening out large solids and grinding up the remaining solids so they do not block the distribution system and are more receptive to further breakdown. As the sewage flows down the hill, grass, soil and bacteria remove the suspended solids, organic materials, and most of the nutrients such as nitrogen and phosphates. The water is caught in ditches at the bottom of the slope and disinfected if necessary before it discharges into a local stream. This remarkably simple process produces effluent of better quality than many secondary treatment plants using sophisticated technology.

Experiments at Easley have been carried out both with raw wastewater and wastewater that has been lagoon treated. Interestingly, applying raw sewage resulted in better treatment than applying the partially treated water from the lagoon. This is because algae growing in the lagoon water tend to survive the downhill trip, remaining in the effluent as suspended solids, causing a slight discoloration. However, the lagoon-treated effluent does tend to be lower in phosphorus and nitrogen. Dr. Abernathy, the program director, suggests that it may be possible to eliminate the lagoon in a completely new overland flow system.

Mechanically, the system is simple. Perforated pipes distribute the wastewater at the top of the hill. Experiments with a spray application system did not work as effectively because the sprayer nozzles tended to clog. Blockages in the half-open pipes can be cleared easily. A fine glass-like matting of solids accumulates at the top of the hill, near the pipes, but this has caused no problems during two years of operation.

There are several important design factors. Ideally the slope of the land should be between 2 and 8 percent. If the slope is greater, the water runs off too quickly and can cause erosion, and less effective treatment. If the slope is less than 2%, standing water may occur creating an open invitation to mosquitos, odors, and other nuisances. The land must also be evenly graded to maintain uniform flow. There must be enough topsoil to allow plant growth, but it should be impermeable enough that the wastewater will flow over the surface and not penetrate the soil.

The kind of grass grown on the slope is also an important consideration. Perennial grasses with long growing seasons, high moisture tolerance, and extensive root systems are best. In some projects this grass has been harvested for cattle feed. The Easley program is baling the hay and using it offsite for a number of purposes including animal feed, erosion control, etc.

A system of this kind can be very inexpensive to build and operate, but land costs will vary from site to site. The slope of the land, type of soil, and quality of the wastewater will affect the amount of land that is necessary. To give an idea of land requirements, Easley's experimental facility serves a population of 800 to 900. There are ten plots (more than actually needed) of land 100' x 150' which handle lagoon water; and three plots 110' x 165' that handle raw sewage. Easley spent from $600 to $800 a year on electricity to run the pumps and from $500 to $600 a year to cut the grass. Other operational expenses are fairly low because there is no need for highly skilled labor.

Dr. Abernathy warns that while overland flow is an economically sound, ecologically effective approach for some locations, it has quite a few limitations. The system is best suited to small towns that have land readily available at a low cost. The soil should have a high clay content to help prevent seepage of untreated effluent that could contaminate groundwater close to the surface. The Easley facility has had no trouble with odors.

Overland flow is also better suited for mild climates. Cold weather tends to slow the biological activity that is part of the cleansing process, and freezing weather can lead to frozen equipment. If there are long periods of freezing weather, adequately sized lagoons are necessary for winter effluent storage.

There is some irony in speaking of overland flow as an experimental system, for land treatment is as old as civilization itself. The Easley experiment was to determine how to achieve <u>consistent</u> results. Several studies are being carried out to define specific optimum operational requirements. It is encouraging to note that the Campbell Soup Company has been using an overland flow system in Texas for twenty years and is now treating between 5 and 7 million gallons of wastewater a day using overland flow. They have committed 900 acres of land to the program, much of it reclaimed from land which was previously heavily eroded.

During a 1980 conference at Clemson University, Paul Traina, Water Division Director for EPA Region IV, made some important comments about overland flow:

> "I've been the Water Division Director for only six months -- prior to that I was the Regional Enforcement Director. One of my first briefings was from David Ariail on the subject of land treatment for municipal wastes. I listened quietly, but when he started talking about using raw sewage on the land my old Public Health/Sanitary Engineering background erupted and I told Dave that he and all others involved in this hideous plot were crazy! Well, Dave is a patient fellow, and he kept giving me literature and reports, and yesterday he and Ray Abernathy took me to see the Easley site. Well, I've stood in the middle of all kinds of sewage treatment plants in my 20-plus years in this business, and no matter how well they were designed and operated I always knew where I was standing. Well, yesterday I stood in the middle of the Easley overland flow system, and while I won't tell you it was like standing in the middle of a wheat field -- it

sure wasn't like standing in the middle of a sewage treatment plant! The point of the comment is that I have come into this with a fairly closed mind, but it is being opened."

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HERCULES, CA Hercules is a "new town." Built on open industrial land, only 500 people lived here five years ago, today the population is 6,500. Hercules is expected to grow to 22,000 population by 1995. This planned growth would have overwhelmed even the newly expanded wastewater treatment plant in the neighboring city of Pinole. Pinole can handle Hercules wastewater now -- until the innovative Hercules plant is proven and certified by the State of California after a two year trial period. In order to carry out their plans for development of the "new town" and its rapid growth, Hercules had to go it alone in order to provide sanitary sewage facilities without State and Federal financial assistance. The experimental solar aquaculture plant was affordable and worth taking the risk of constructing the first large scale application of an innovative system.

Ralph Snyder, the city manager, explained Hercules' choice:

> "What we're simply doing is buying a little bit of high technology and confining it into an area in a greenhouse environment, but doing essentially the same thing as the sun and bugs, water plants and fish have done for thousands of years. In other words, they have created an environment, not unlike a marsh, using some modern technology to speed and control the process. The system is called solar aquaculture."

The basic structure is a series of ponds enclosed in a greenhouse made of double-layered plastic sheeting. The greenhouse helps maintain an average temperature of 70 degrees, year-round. The raw waste is first screened, and then piped into the primary anaerobic-treatment pond where one third of the solids are settled, digested, and converted to methane gas. The pond is lined and covered with a rubber membrane to control odors. Following anaerobic digestion, the wastewater flows to a second heavily aerated pond that contains activated bio-webbing, a seaweed-like plastic film which provides a high surface area for growth of the aerobic bacteria and protozoa that feed on sewage. In fact, this bio-webbing is one of the major innovations of the system and substantially speeds the treatment process.

The water then moves to a third pond where it is again aerated. This pond, in addition to containing bio-webbing, is planted with water hyacinths and duckweed. The pond also plays host to small, waste-consuming invertebrates which are, in turn, eaten by small fish. The hyacinths metabolize not only the wastewater nuturients, but also toxic compounds and heavy metals. In addition, this thick floating plant cover prevents the growth of unwanted algae, a problem which often plagues lagoon systems. Harvested water hyacinths can be composted and used as soil conditioner or digested to produce methane gas.

At the end of the treatment cycle the water passes through a sand filter, which removes any stray organic matter and finally is disinfected with ozone.

The process takes about three days to produce a secondary quality effluent that can be used for crop or landscaping irrigation. With six days of treatment the effluent is suitable for industrial reuse, stream enhancement, or groundwater recharge. Since 25 percent of the land in Hercules is being reserved for greenspace, the city intends to use some of the water for landscaping. Local industries will also be interested in using the recycled water.

The Hercules plant is still experimental. The first aquacell covers 1.5 acres and handles 350,000 gallons per day. If successful, the facility will eventually be expanded to 6 acres and be capable of treating 2 million gallons per day. The projected cost for a full scale facility (about $3.5 million) is approximately the same amount necessary to expand the secondary treatment plant in Pinole. Construction of an independent advanced treatment facility would cost two or three times that amount. Operation and maintenance costs should be about one-third those of a conventional plant. It is also anticipated that the sale of the recycled water will compensate for a large amount of the operation expense. User costs are currently $70 per year with water recycling.

One of the more interesting aspects of the Hercules plant is that almost everything going into the system can be transformed into a valuable by-product. Hercules intends to use the harvested water hyacinths, mixed with sludge, as a compost for landscaping. The hyacinths could also be used as animal feed or converted to methane gas and then to electricity. In Mississippi, another experimental program funded by NASA uses water hyacinths to remove precious metals from industrial wastewater. In other parts of the world, countries with food shortages employ aquaculture,using wastewater, to produce food for humans and animals. The efficiency of this system has drawn a great deal of attention from all over the world, particularly from countries with shortages in water and/or land. International visitors to the Hercules experimental plant are also interested in the potential for food and energy production. This system recognizes how precious our natural resources are. Even in an urban area, it is possible to wed the disciplines of biology and engineering to transform wastewater treatment into a means of preserving our precious natural resources.

<u>Postscript</u>:

March 1982.

After 2 years of innovative operation, the Hercules Town Council voted to shut their experimental plant down permanently. The Council evaluated and rejected the costs required to correct operational problems necessary before State certification could be given.

While the experiment was generally successful, it was plagued by some operating problems that were expensive to correct.

Much can be learned from the Hercules experience with full scale solar aquaculture: day to day operation at full-scale has indicated that the optimum pond depth is 1' to 3'; maintenance of moderate summer temperatures is vital to healthy aquatic plants; comminution of influent is necessary; clean-out of the anaerobic unit is necessary; the integrity of the impervious pond lining material must be respected; and the source of power for inflating a greenhouse cover, operating pumps, and aerators must include an emergency backup.

Meanwhile, the City of San Diego is presently designing a pilot aquaculture system that will treat up to 1 mgd of wastewater.

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PLANS FOR COMPLETE RECYCLING

SAN DIEGO, CA San Diego's water resource problems are, in most ways, quite similar to those of St. Petersburg, Florida. In San Diego the little fresh groundwater that originally existed was consumed long ago, leaving nothing but brine in the aquifer. Therefore as the city grew, nine dams and reservoirs were built to contain rainwater, but the rainfall could only supply a population of about 50,000. Already at 2 million, the San Diego area's population is expected to reach 4 or 5 million by the turn of the century. For decades the city has been buying water and transporting it from the Colorado River hundreds of miles away. But that supply is no longer dependable for future needs. Richard King, San Diego Water Utilities Director explains:

> "There are four thousand billion gallons of water that fall on the United States today, of which 1200 billion end up in the drinking water supply throughout the country. In 1975 we were using one-third of that supply. Now, if our future is a straight line projection, then within the foreseeable future, by the turn of the century, finding an adequate water supply for <u>any</u> place in the United States <u>is</u> going to be a major problem."

San Diego is somewhat unusual because both fresh water and sewage services are managed by one authority, the Water Utilities Department (WUD). It naturally follows then that water supply and wastewater treatment are considered together. Conservation of the severely limited supply was a natural first step and began with an attempt to reuse secondary effluent water for industrial and irrigation applications. Unfortunately San Diego's industry only accounts for 5% of water demand (50% is common in more industrial cities), and most of that is for food processing which requires potable water. Irrigation of golf courses and cattle range proved unsuccessful because the treated effluent's high salt content killed the grass. This problem coincided with the development and testing of a new technology, reverse osmosis, to remove salts, but this process is energy intensive, resulting in yet another problem.

To answer the question "How are we going to serve the water and sewer needs of the city of San Diego over the coming years?", a panel of experts was asked to consider the question in full perspective.

Breaking with convention, this panel came up with an innovative answer, "There's only one place for your sewage, and that's back in the drinking water." WUD realized that fully recycling their water supply would require strict controls and possibly new technologies to assure the prevention of disease. Many regulatory changes would also be necessary. The panel based its recommendation on the belief that it was wasteful to invest in treating wastewater only to dump it into the ocean, especially when recycling was a technically feasible alternative.

The first treatment concept

they explored was a bio-lake. Effluent would flow into an artificial lake which was oxygen enriched and stocked with flora and fauna that digest organic wastes. The study team was then directed to NASA's research on the use of water hyacinths for sewage treatment.

"Water hyacinths," (and a number of other aquatic plants) "as it turns out, have an affinity for heavy metals and things normally called toxic substances," Mr. King explained. Interestingly enough, water hyacinths also do a good job of removing DDT and pesticides. The hyacinths can also remove some of the salts in the wastewater which make the reclaimed water unsuitable for irrigation.

Without realizing it at first, San Diego was moving toward an aquaculture solution. In their proposed system the hyacinth crop will be harvested and processed in a digester (as in Modesto, CA) to produce methane to fuel the wastewater treatment system. The effluent will then be filtered through sand and the portion of water destined for farm irrigation drawn out of the system. The portion destined to the city's water supply will undergo further treatment by reverse osmosis to remove minerals; pass through a carbon adsorber to remove the last traces of organic matter; and be exposed, once again, to ozone for disinfection. The end product will be potable water.

An aqua-cell system large enough to handle San Diego's needs will require hundreds of acres of land. Since the water produced may exceed demand, planning for an agricultural facility will be included so that any excess water will not go to waste. Finally, since San Diego's sister city, Tiajuana, faces similar water shortage problems, the two cities are considering sharing the recycling facility. They may build it in a valley which lies between both cities.

Complete recycling for the San Diego area is a grandiose plan. It will cost hundreds of millions of dollars to realize. Yet, in the long run, it should be cost effective for a city like San Diego. Conventional treatment is expensive and it yields little or no usable end-products. It may require progressively more advanced and more expensive treatment in many locales to meet water quality discharge standards. These advanced technologies are energy intensive and require far more energy to operate than aqua-cell systems. Mr. King explains that, for the San Diego water utility district, the bottom line is not capital costs but the monthly charge to homeowners for operation and maintenance of water and sewage services. San Diego's "system-for-tomorrow" will provide water and sewer services at one-third the operating cost of conventional technologies and guarantee a continous supply of potable water for the future.

San Diego has already committed 3.5 million of local, state, and federal dollars to a pilot project. They recognize that convincing the public and solving all the technical problems may be difficult, but they are willing to take this bold step because it seems to be the least costly, best solution for San Diego.

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NON-STRUCTURAL APPROACHES FOR WASTEWATER MANAGEMENT

COMPREHENSIVE PLANNING FOR ENTIRE WATER SYSTEM

MONTEREY, CA California's severe drought in 1976-77 shocked residents and officials into planning for the future water needs of the Monterey Peninsula. It was the fourth severe dry period in less than a century -- future droughts were bound to occur. Just two consecutive years of less-than-average rainfall would strain the region's reservoirs and limited groundwater reserves. The crisis brought the region's water resources into focus. Clearly, responsibility for those resources could not remain fragmented among various agencies.

The Monterey Peninsula is not unique in terms of its water problems. However, it has taken a unique approach to solving them and avoiding more serious problems in the future. Until recently the management of their water resources was fragmented among many agencies with overlapping jurisdictions at different levels of government. This fragmentation made it difficult at best to coordinate management, policies, construction, etc. It reached a point where three different dam/reservoir proposals for more water supply were under consideration while at the same time other agencies responsible for treating wastewater were discharging it into the ocean, essentially lost for re-use. The fragmented system was fostering inefficient use of the resource.

Monterey was in a good position to eliminate these problems of fragmentation because its watershed is entirely confined within the borders of the towns that make up the peninsula. Many communities have to deal with several jurisdictions because they are importing or exporting their water outside their borders, but happily this is not so in Monterey. In an effort to develop a systematic and coordinated approach to managing their water, the Monterey Peninsula towns created a single water management district which was given the powers previously held by many separate agencies.

In 1977, the Monterey Water Management District was formed, according to the legislation, because:

> "...there is a need for conserving and augmenting the supplies of water by integrated management of ground and surface water supplies, for control and conservation of storm and wastewater, and for promotion of the reuse and reclamation of water. In this region of primarily scenic, cultural, and recreational resources, which are particularly sensitive to the threat of environmental degradation, such need cannot be effectively met on a piecemeal basis."

The key word in this legislation is <u>integrated</u>. The primary responsibility of the District is to assess and plan for the present and future water needs of the Monterey Peninsula. The District has been given a wide range of responsibilities and the power to administer them. They are pursuing many projects and programs, some of which are described below. However, the District's major strength is planning comprehensively for the community's entire water system, not just a part of it. Each project is assessed in relation to the whole and in relation to the other projects.

The District can levy taxes, establish charges for water, declare rationing, and contract for construction or research. District responsibilities such as preventing pollution of streams and urban reclamation are more commonly divided among several different agencies. In Monterey's case, everything from stocking water reserves to sewage treatment, from flood control to recreational facilities, is now, by law, under the auspices of one agency.

The District's first goal was to determine current water usage rates. To accomplish this, all water producing facilities, such as wells, are required to register with the District and report their usage rates. Through a permit process, the District can manage and control the existing and future demand for water. The District established the maximum number of connections possible in each water system, based on the available resources.

The District has also allocated the total supply among existing land use agencies. This gives each jurisdiction an incentive to conserve its resources and plan for new development without exceeding the available water supply. This procedure helps track growth in new demand for water.

The District has the advantage now of complete overview of the whole water management system. From that vantage point the district has the ability to evaluate modifications to the system and their net effects on the whole system, not just a small portion of it. For example, from the wastewater manager's viewpoint, an ocean outfall is an inexpensive means to dispose of effluent. However, the water lost via ocean outfall might be very expensive water to replace by constructing more supply (reservoirs, dams, etc.).

The systematic approach allows for a more thorough financial analysis of investment options for best overall system performance. A complementary investment mix including supply augmentation, wastewater treatment, supply protection, and end use efficiency can be orchestrated to produce an overall least-cost system to the community.

The district is not limited to structural approaches to water management. Controlling use of non-potable water in public facilities and in new construction is currently under study. For example, schools and other public buildings may be built or retrofitted with rainwater collection systems. The water from roofs or parking lots can be used for irrigation of playgrounds and open spaces. In new construction, developers may be required to meet 50% of the anticipated demand for water through resources other than groundwater supplies. Cisterns and/or other water recovery systems will be used. To encourage this effort, the District is reviewing the available technologies for reducing water demand in new construction.

A State funded reclamation study to demonstrate the use of treated wastewater (secondary effluent) to irrigate leafy vegetable crops is now underway.

This kind of water reclamation offers potential economic, water quality and water quantity benefits to the entire State.

Monterey instituted several programs to protect existing supplies. Preliminary tests indicated pollution of groundwaters from failing septic systems. So, the district is now drilling a network of water quality monitoring wells which will help spot these or other sources of pollutants entering the groundwaters. When severe erosion occurred on the banks of the Carmel River (their primary local water source), the District began a program to coordinate the mangement of this essential watershed. It will play a major role in bank stabilization and channel clearing.

The District promotes conservation of existing water supplies. For example, landscape gardeners are being encouraged to select plant vegetation requiring little water. This reduces the amount of water used for landscape irrigation.

The combination of regulations, conservation programs, and protection of the watershed represents the most feasible, cost-effective solution for extending supply. In turn, these programs help to indicate what additional reserve capacity is required to meet the anticipated future demand for water.

One of the projects being considered is tapping and recharging the District's groundwater aquifers (water bearing rock formations). A computer model has been developed to analyze the implications and potential of such a program.

Plans for a new dam and off-stream reservoirs are also being studied. Such a large project does require approval by popular vote and by the state government. Impacted by the famous Proposition 13 of 1978, efforts of this magnitude are certainly beyond the scope of any private water supplier. Even more significant, the District's new ability to view the water system as a whole will assure taxpayers that such major investments yield optimum benefits. Several sites and capacities are under consideration. The District's decision will be based on how the new facilities can best interact with the rest of the water supply system.

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WATERSHED ORDINANCE

CRESTED BUTTE, CO

Water is a limited resource. Until recently, the abundant water supply in the United States has been ample to meet our needs, but increasing population demands, water-intensive activities, and pollution, have rapidly been depleting and degrading that supply.

The inappropriate use of water resources creates costs which the taxpayer must ultimately bear. For these reasons, a small town in Colorado has resolved to protect its water supply for all potential users.

Crested Butte is located in the Rocky Mountains near the Gunnison National Forest. Recently, a mining company expressed interest in a mining venture within the watershed that supplies the town's drinking water. Crested Butte understands that if the mining venture changes the quality of the water available in the watershed it also affects the quantity available for potential users. Therefore, the town has passed a watershed ordinance which attempts to protect the watershed for all users. Thus, if the mining company can conduct their activities without destroying other's ability to use the water, then the mining company may use the watershed.

The Watershed Ordinance shifts the burden of proof to the mining company or the timber harvester or the developer to assess the worst-case situation; the cumulative impacts of these activities; and, in a potential high-risk situation, to post a reclamation bond which would insure the clean-up or replacement of water supply in the event of major pollution. Crested Butte defines pollution as any alteration of the physical, chemical, biological or radiological quality of their water that is or may become injurious to the public health, safety and welfare. This includes activities which are injurious to domestic, commercial, industrial, agricultural or recreational uses of water. Activities which are injurious to the utility of riparian lands, livestock, wildlife, the value of fish or game are also considered pollution. This includes activities which produce water which is offensive to sight, taste or smell.

The town requires a permit for any activities which affect the town's waterworks. The town defines its waterworks as any and all human-made components and any and all natural components of the airshed/watershed surface and groundwater basin included in the operation and design of the town's water supply system. These components include, but are not limited to, all storage facilities such as water tanks, reservoirs, stream courses and groundwater basins; all transmitting facilities such as pipes, drains, pumps, stream channels, hillside slopes and bedrock; and all filtration facilities including plant life and soils necessary for the construction, operation and maintenance of the town's water system.

Types of activities for which the town would require a permit include:

a) cloud seeding or other aerial activities, such as herbicide or pesticide spraying;
b) operating or constructing a sewage or industrial waste disposal system;
c) removing vegetation, such as timber harvesting;
d) excavating, grading, filling or subsurfacing, as encountered in drilling operations or mining;
e) altering surface or subsurface drainage courses;
f) diverting water in any consumptive manner that increases concentration of pathogens or toxic substances in the water supply;
g) handling, using, storing or transmitting toxic or hazardous substances including, but not limited to, radioactive materials;
h) using, handling or transmitting flammable or explosive materials except for domestic purposes or within vehicular fuel storage tanks.

Thus, Crested Butte's Watershed Ordinance attempts to coordinate and plan for all activities that may affect water users' access to a limited water supply. The ordinance provides controls for all activities that affect the town's watershed. By preserving their water quality, Crested Butte is insuring a continuing supply to all potential users, not only today but in the future.

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VARIOUS COMMUNITIES

Conservation, the least expensive and frequently the most viable solution for many communities' water problems is often overlooked. When water supply is temporarily short, particularly in crisis situations, conservation is viewed as a stop-gap measure. Interestingly, many towns find that these steps, when instituted as an emergency measure, continue to be effective on a long-term basis. During a 1977 drought in Marin County, California a conservation campaign reduced water consumption by 60%. After the drought was over, the consumption rate remained 30% lower than it had been in 1976. Unfortunately, communities often fail to realize that conservation can also reduce the wastewater stream and, therefore, reduce the demand on existing sewage treatment systems.

Recently, Elmhurst, Illinois faced water shortages. While the town is only 20 miles from Lake Michigan, the competition between Chicago and its suburbs for the lake's water meant that Elmhurst had to look elsewhere for additional water supply. Their choices were to spend $400,000 for a new deep well or to use their existing supply more carefully. Elmhurst chose to launch a door-to-door campaign teaching residents about their water system. Emphasis was on how to repair household plumbing and other ways to conserve water at home. The campaign distributed two devices: shower head flow restrictors, and toilet dams which help reduce water use. The cost for the entire program was $50,000 or about $1.00 per household. The resulting 13% reduction in water demand not only eliminated the need to dig a well, but effectively "expanded" the capacity of their wastewater treatment facility. Elmhurst can now allow additional housing units to be built in their community without investing additional funds in treatment facilities.

In another town, Tisbury, Massachusetts, residents were using more water than their septic tanks could handle. The over-flow and septage from some malfunctioning tanks were deposited in the town dump -- just 500 feet away from the town well. There was an obvious danger of contaminating the fresh water supply so Tisbury began to hunt for a treatment solution. Engineers first suggested a $12 million sewer and treatment plant. The town voted against such an expensive proposal. Then the engineers recommended a watered down $8 million version to serve 700 homes and businesses. This, too, was rejected as were the recommendations of another group of engineers who suggested a $2 million treatment plant for 120 homes.

In evaluating these proposals, the board of health realized that there had never been a study to pin-point the problem. Members of the community performed the study and found a rather simple, inexpensive solution. They identified a few failed septic tanks which needed to be repaired or replaced. Homes and commercial establishments using more water than their septic systems could handle purchased low-flow devices and toilets which used only two quarts instead of five gallons per flush. This seems to have greatly improved the functioning of the septic systems.

Low-flow shower heads and toilet dams are only two of many devices on the market which aid in reducing water use with little or no extra effort by the user. Below is a list of these devices, how they work, how much they save, and how much they cost.

Flow Control Devices: Valves which restrict the flow of showers and faucets to 2.5 gallons per minute. Water Savings: 50-60%. Cost: $.50-$5.00.

Flow Reducing Showerheads: These replace regular showerheads. Water Savings: up to 75%. Cost: about $10.00-$15.00.

Thermostatic and Pressure Balancing Mixing Valves: These mix hot and cold water to preset temperatures eliminating the need to waste water while adjusting the temperature. Savings: Varies according to family size and ambient water temperature. Cost: $75.00-$125.00.

Toilet Dams: These are flexible plastic panels that are inserted into toilet tanks to hold back a reservoir of water when the toilet is flushed. You can also weight a plastic bottle and put it in the tank for a similar result. Savings: 1 to 2 qts. per flush for bottles; 1 to 2 gallons per flush for dams. Cost: up to $8.00.

Shallow-Trap Toilets: These fixtures have a smaller reservoir than conventional toilets. Water Savings: 1 1/2 to 4 1/2 gallons per flush. Cost: about $80.00.

Pressure Toilets: a variety of toilets are available in which air pressure rather than a large volume of water provides the velocity needed to clean the bowl. Savings: 2 1/2 to 7 1/2 gallons per flush. Cost: $60.00 to $600.00.

Dry Composting Toilets: These collect waste in an impervious container and compost them into a soil conditioner. The toilet uses no water, creates no odor, and is approved for use in 30 states. However operation and maintenance of composting toilets are sensitive to temperature control and liquid volume. Savings: 5 to 8 gallons per flush. Cost: $1,000 to $2,000.

There are other devices available and other means for communities to conserve. A leak detection and repair program for both the public water supply system and home plumbing can effect significant water savings especially in older towns. Changes in plumbing, building, and health codes can encourage water savings in new construction.

Greywater (water that does not contain feces or urine) can be reused for irrigating gardens, washing cars, and flushing toilets. This approach can also be applied in industry. For example, an IBM complex built in Tucson, AZ. was designed to capture rainfall from roofs and parking lots and recycle it for irrigation and other uses.

Water pricing can also impact usage rates. During a drought, Marin County, CA, alloted 40 gallons of water to each person, per day. A penalty rate structure increased cost of water used over the basic 40 gallons a day from 6¢ per 100 cubic feet to $1.22. Wastewater flow reductions of between 25% and 60% were reported. This was an emergency measure but other utilities are now instituting similar (but less severe) increasing block rate structures.

In the long run it is people and the way they use water that have the greatest impact on water supply. The way an individual washes dishes or clothing, makes landscaping decisions, bathes, and considers water as a valuable resource, will reduce the amount of water wasted.

An aggressive community water conservation program can reduce failing septic problems; forestall the cost of developing a new source of water supply; and improve the quality of wastewater treatment by reducing wastewater volume; all for a relatively low cost.