Municipal Wastewater Reuse News

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SEPTEMBER-OCTOBER 1985

VOLUME 3, NO. 5

News of the Field

WATER REUSE IN SPACE

As the National Aeronautics and Space Administration continues with plans to orbit a permanent space station within the next seven to ten years, it faces a significant challenge of supplying potable water for crew members who will work and live on the space station for months at a time. Supplying a dependable water source will be both difficult and costly. For example, water can be delivered only once every three months. The cost of delivering one pound (approximately two cups) of water via a space shuttle is $1000.

With these types of constraints it's obvious why NASA must evaluate water conservation and direct potable reuse measures. For example, technologies like ultrafiltration and reverse osmosis are being evaluated for treating wastewater to recover potable water. Current RO and ultrafiltration membrane designs cannot be used however; they are too heavy or too easily fouled by bacteria. A NASA contractor is therefore designing and testing a lightweight synthetic membrane module.

In this Issue

Roundtable

ARTIFICAL RECHARGE OF GROUNDWATER WITH RECLAIMED WASTEWATER--A ROUNDTABLE DISCUSSION

EDITOR'S NOTE: With a format different from that which usually appears in this newsletter, this feature article focuses on several issues related to recharge with reclaimed water: water resources, water quality and treatment, economics, public health, barriers to implementation, and research needs.

The discussion took place October 23, 1985, during the California-Nevada AWWA section's fall conference in San Diego, California. John Gaston, senior consultant for CH2M Hill, served as moderator. The other participants were: David Argo, chief engineer, Orange County Water District; James Crook, senior sanitary engineer, California Department of Health Services; Wiley Horne, director of planning, Metropolitan Water District of Southern California; Margaret Nellor, project engineer, Los Angeles County Sanitation Districts; and Pete Rogers, chief of the Sanitary Engineering Branch, California Department of Health Services.

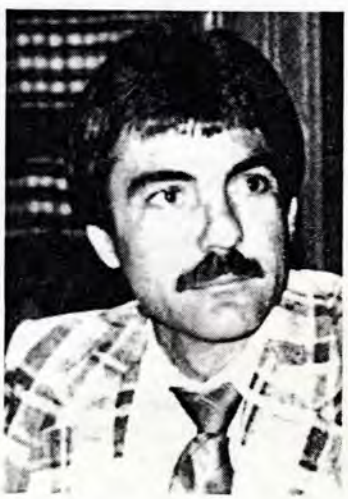
In addition to thanking the participants for fitting the roundtable into their busy schedules, I would like to thank the chairman and the secretary of the California-Nevada section, George Adrian and Ken Boyd, respectively, for their assistance in providing a meeting place.

WATER RESOURCES

Gaston: First, let's talk about water resources in general. We have two major, planned groundwater replenishment projects here in California, one in Orange County and one in the central Los Angeles area. Take just a few moments if you will and tell us why we are recharging the groundwater in these areas. What choices had to be made by the regulatory agencies and also by the wastewater agencies to come to the conclusion that artificial recharge was an important part of the water resources.

John Gaston

Argo: The Orange County Water District during the early 60's started to investigate the feasibility of reclaiming wastewater, and that work culminated in the construction of Water Factory 21. That project produces up to 15 million gallons per day of reclaimed wastewater for injection along the Orange County Coast in an area known as the Talbert Gap, an area that is subject to seawater intrusion.



Dave Argo

As part of our groundwater management program, it's necessary for us during particularly dry weather periods to mine or overdraft our groundwater supply. In the studies to determine what source of water supply would best be suited for groundwater recharge, we looked at the alternatives of purchasing imported water, of pumping other well water supplies, and of using reclaimed water.

The decision was made to use reclaimed water because the barrier is most needed when there is a water shortage throughout the entire watershed and maybe even throughout the entire state. Under these conditions, the likelihood of overdrafting the basin and not finding additional supplies to operate the barrier is very real; however, wastewater is always available.

Using reclaimed wastewater for injection barrier supply provides considerable drought proofing and protects the Orange County Groundwater Basin, which contains some 500,000 to 600,000 acre-feet of potable supplies and furnishes up to two-thirds of the water used in Orange County annually.

Gaston: What about groundwater recharge in the Whittier Narrows?

Nellor: Our involvement with that project began in the 1950's when we first considered building water reclamation plants as a means of relieving sewer capacity within our treatment/collection system. The first facility was constructed in 1962 directly upstream of the Whittier Narrows Groundwater Replenishment Project, which is managed by the Central and West Basin Water Replenishment District. Our water, in addition to storm runoff, Colorado River water, and State Project water, has been used for groundwater replenishment by surface spreading since that time. The average amount of reclaimed water used annually is 27,000 acre-feet with a maximum limit

Margaret Nellor

not to exceed 32,700 acre-feet. The Sanitation Districts and Replenishment District are interested in using more reclaimed water for that project and are in the process of working with the State Department of Health Services and the Regional Water Quality Control Board to implement just such an expanded use.

Gaston: Wiley, from an overall planning standpoint, you looked at these and at other projects in the area. Is there room for more groundwater recharge in Los Angeles or anywhere else?

Horne: Yes, there is room for more, but there are some limitations that we have to address.

Metropolitan feels that the strongest water resource mix that we can provide is a diversified mix. Water reuse of all types, including groundwater recharge, fits into a diversified water plan.

Groundwater recharge can be complementary to imported water sources and to native runoff in recharging our groundwater basins. Of course, as a complementary supply, water of reclaimed origin is unique in that it requires special blending and pretreatment so that it can be safely incorporated.

Wiley Horne

The question then becomes: How significant can recharge be within the total water supply mix? I think that the future of groundwater recharge is going to remain limited until we can achieve known, treatment-based standards for the application.

Gaston: Pete, you have the special role of being on both sides of the question for regulatory standpoint both on the waste discharge side and on the health side. Do you see that this is an expanding role? Is the Central Arizona Project cut back on the Colorado River going to put more emphasis on this reuse option?

Rogers: I agree with what Wiley said; I think groundwater recharge is going to be limited. I don't really see groundwater recharge with reclaimed wastewater as being of any major significance other than in Southern California. I certainly don't see it as a major influence in the Central Valley or in Northern California or even in the Bay Area. But in Southern California, because of the unique combination of a dry climate and large population and limited water resources, there will obviously be a demand to make the maximum utilization of what exists there.

The impact of the reduction in river imports remains to be seen. The politicians in California seem to have accepted the fact that no major new water projects are likely to be developed in the state in the foreseeable future and that they are going to have to make do with what we have. Given that situation, I think there will be an increase in demand for groundwater recharge in Southern California.

RECHARGE OPERATIONS

Gaston: Looking at current recharge operations, let's discuss what has to be done to recharge reclaimed wastewater and how it may differ from other recharge.

Both of the practical applications we are talking about here use a variety of waters. In Orange County, well water is mixed with treated wastewater; in Los Angeles County, wastewater is mixed with stormwater runoff and imported water. Is there any difference, from a practical, mechanical standpoint, between the recharge operations because of the water you're recharging?

Argo: The levels of treatment provided at the two locations are probably a little different in that the treatment for the injection of reclaimed water as opposed to that for percolation is somewhat more demanding. A higher level of treatment aimed at further removal of suspended solids and particulates is needed primarily to avoid clogging and binding of the injection wells.

I don't think the actual quality differences are significant here. In Orange County we have high TDS and have developed a rather elaborate treatment system in an attempt to produce water that meets potable standards before it is injected. We do not depend on further treatment of the water as it moves through the ground.

Gaston: How is recharge managed in Los Angeles County? Who owns the water once it is put into the ground?

Nellor: The overall management of the groundwater basin and purchase of replenishment supplies is the responsibility of the Central and West Basin Water Replenishment District. The spreading facilities are operated by the Los Angeles County Department of Public Works. Once the water has been spread and becomes part of the aquifer system, ownership becomes a matter of water rights which are adjudicated in the Los Angeles Coastal Plain groundwater basins. In terms of treatment, because we discharge to concrete-lined flood control channels, which convey the reclaimed water to the spreading grounds, we are required to produce an effluent suitable for nonrestricted recreational use. At present, this level of treatment produces an effluent that meets all drinking water standards and contains no detectable virus.

Gaston: Do you see any quality differences among the three water sources? Does water quality cause any difficulties in getting it into the ground?

Nellor: In terms of physically getting the water into the ground, there are some differences between the replenishment supplies, the most notable being direct storm runoff which due to its high turbidity in addition to the great variability in storm occurrence and intensity, makes it the most challenging source to recharge. We also see differences in water quality, particularly regarding organic content. In general, the Colorado River and State Project waters usually have the lowest levels of trace organics, with higher levels found in storm waters and reclaimed waters.

ECONOMICS

Gaston: If you started today to put together a new groundwater recharge project, either injection or basin recharge, how would you deal with the economics from a planning standpoint, Wiley? How can you justify the expenses when you are looking at expenses of other waters?

Horne: The starting point for groundwater recharge economics is the alternative cost of other water supply projects. For purposes of this discussion, the first thing you have to assume is that the wastewater disposal end of the treatment train has already been provided. In other words, you already have waste treatment up through secondary or filtered secondary, according to the receiving water requirements. Any additional treatment, delivery, and spreading cost would be allocated to the water supply portion of groundwater recharge, and that is what you want to compare with the alternative cost of other types of projects.

We are finding in our own planning that the cost of new conventional water supply projects may vary anywhere from $50 to $100 per acre-foot up to $300 or $400 per acre-foot. There is a rather wide range. But, probably at the margin, one could say that conventional water supply projects available to Southern California from the Colorado River or from Northern California are somewhere between $200 and $300 per acre-foot. It is to this cost that you have to compare the incremental cost of recharge.

Making that comparison is rather difficult now because we don't know the cost of recharge projects. As I said before, the real future of groundwater recharge is going to lie with treatment-based

standards, and these standards do not exist. In other words, if an agency wanted to build a new groundwater recharge project right now, it would not know where to begin in terms of a treatment standard.

We think Metropolitan has a role in helping local agencies implement their projects, and within the next few months we expect to be coming forward with a proposal under which Metropolitan would contribute its avoided energy costs to qualifying local projects. That is, the cost that we save in not having to pump water into Southern California would be returned to local projects. For the near term, our contribution would be in the range of $75-$100 per acre-foot.

Argo: I agree with Wiley 100 percent that we have to compare our reclamation project cost with the marginal cost of developing additional water supplies. The tendency in the water business is to look at what it costs to build a new reclamation project and compare that to the current rate for buying water. If the new project is more expensive, it isn't given further consideration and acquiring water from a wholesaler continues. I also agree that, besides the marginal cost, there has to be some consideration in any economic analysis for the difference in energy costs associated with importation of water into Southern California as compared to reclaiming or producing water within the basin. Metropolitan, through good planning and engineering, has fortunately been able to secure very low power rates for providing water through its two aqueducts. However, when you reclaim water, you're buying market energy from Southern California Edison or others, and the difference is substantial. Unless you factor avoided energy costs into a marginal cost analysis, you don't have a basis, in my opinion, for a fair comparison of alternative project costs. But the type of program that Metropolitan may implement would certainly go a long way and, I think, would result in possibly quite a few new projects in the Southern California area because prices would be competitive.

PUBLIC HEALTH

Gaston: It seems to me that there are two potential concerns for public health when you are looking at groundwater recharge projects or at any kind of recharge project. One is the possibility for public exposure to the water as it is being recharged, and that certainly is a much greater possibility with a situation like the recharge basins in Los Angeles County. The second concern is exposure of the ultimate consumer via the water supplier who is pumping water that contains some percentage of reclaimed wastewater.

What are the public attitudes toward these two issues? Are public attitudes something that the agencies have had to address specifically?

Nellor: It is important to consider public attitudes related to health concerns. Our approach to date has been to actively conduct a public information program related to all of our reclamation activities. This consists of both a speakers bureau type program and a school education program. However, in general, the people who live in the Whittier Narrows area and drink groundwater probably don't know that their water supply contains reclaimed water. In fact, if you asked them what type of water they were drinking, they wouldn't be able to tell you whether it was groundwater or surface water. This situation may soon change as we proceed

with our proposal to expand the project, particularly given the recent concerns over groundwater contamination in other areas of Los Angeles County.

Gaston: You have completed an extensive health effects study for the districts, which is the background work for this proposed expansion. Why don't you give us a short summary of that study.

Nellor: We looked at the Whittier Narrows project both in terms of its impact on groundwater quality and its impact on human health. We evaluated all the different sources of replenishment for their chemical quality and microbiological quality. We looked at specific trace organics, trying to identify and isolate those that may be of health significance. We also evaluated the population receiving reclaimed water in comparison to two demographical similar control populations for a wide variety of health outcomes.

Essentially, we found that the existing level of replenishment had no measurable impact either on groundwater quality or the health of the people drinking the water. We recommended that the project continue but also that consideration be given to expanding the project.

Gaston: How many acre-feet per year are put in the ground now? How much does the expansion proposal call for?

Nellor: Right now the maximum amount of water applied in any given year is 32,700 acre-feet, a number somewhat arbitrarily selected as the historical maximum in any given period. The initial concern was to provide enough dilution to control for nitrogen, but 32,700 acre-feet gives a wide margin of safety. We want to expand up to 50,000 acre-feet per year as an average and, in any given year, not more than 60,000 acre-feet.

Rogers: With regard to public acceptance, one key factor we have to bear in mind is that the public's understanding and concern over contaminants in drinking water supplies is much different today than it was ten years ago. I think there is much greater sensitivity and concern about toxic substances in drinking water than there was when this project got started. When public announcement of the project's second phase begins, I think public reaction will be different from what it was initially. It may sound strange coming from a health official, but I think the health effects are more perceived than actual, and the big difficulty is going to be selling the public on the aesthetics rather than talking about specific health risks.

Gaston: I was going to ask a question along those lines, and maybe now is the time.

The drinking water branch of EPA is in the process of regulating organic chemicals in all water supplies. All or some of you may have seen those regulations. We've seen on a practical basis throughout the United States a wide variety in the kinds of concerns that come up when people are faced with contamination of their water supplies. Sometimes the reaction is very ho-hum, and sometimes it is hysterical; the reactions cover a wide gamut.

Do you know what to expect when you go to the public and say, we've been augmenting your water supply five percent, or whatever, with reclaimed wastewater and we'd like to increase that amount? Margaret, have the districts put together a plan on how they may want to deal with an adverse reaction?

Nellor: We don't as yet have a specific plan, although we do have significant experience dealing with public reaction

as a result of our solid waste management activities. The water people in the area are aware of what's being planned and so far their reactions have been rather low key, except in one instance. They seem to accept the idea of a low-cost program, which in this case involves using more reclaimed water in lieu of the more expensive imported water. I don't know how the people in the specific area will react. They haven't been faced with any groundwater contamination problems to date. However, if the project is perceived as a threat to groundwater quality, the reaction could be significant.

James Crook

Gaston: Pete, over the years, various blue-ribbon panels have looked at groundwater recharge and research needs in health effects. Is the Scientific Advisory Panel on Groundwater Recharge a new panel that will look at these issues?

Rogers: It is a new panel. Based on the work done over the past five years, the Water Resources Control Board and our department feel that it is time to restructure a technical committee to look at the progress made and the results of various studies. We want to evaluate how far the state-of-the-art technology has advanced in terms of reliability, and so forth. We think it is time to reevaluate our criteria and regulations in terms of all the studies and data that have been generated.

Crook: The Scientific Advisory Panel on Groundwater Recharge is jointly sponsored by the Department of Water Resources, the State Water Resources Control Board, and the Department of Health Services. It will be similar in makeup to the previous so-called blue-ribbon panel that the same three agencies formed in 1975 to consider groundwater recharge. The panel will consist of nationally recognized experts in such areas as epidemiology, toxicology, microbiology, organic chemistry, groundwater hydrology, sanitary engineering, and water quality criteria. We are in the process of selecting the panel members at the present time.

The charge to the panel will be similar to that of the previous one. This panel will provide a state-of-the-art review and evaluation of aspects of groundwater recharge, such as treatment technology, health assessment, and monitoring. The panel will evaluate research and operational data generated in the intervening ten years since the previous blue-ribbon panel, including the Health Effects Study that was performed by the Los Angeles County Sanitation Districts, and, hopefully, will provide recommendations needed for the establishment of criteria for groundwater recharge with reclaimed water.

As Wiley said, at the present time it is extremely difficult for an agency planning a recharge project to anticipate the regulations and standards with which they will have to comply. I expect regulatory agencies to proceed cautiously in developing standards and initially set very conservative criteria to offset a lack of knowledge in some areas and,

if it is later deemed to be appropriate, to make the criteria less restrictive as relevant information becomes available. In my opinion, it would be irresponsible for public health agencies not to take this conservative approach.

TREATMENT

Gaston: You can see several threads moving through the whole groundwater recharge issue. One of them is public acceptance. We don't know whether it is going to be an issue or not, but it has to be considered. Another thread is economics. You can do anything with technology and money, but if a project is clearly not economical, no one in his right mind is going to do it for very long. Yet another thread is the linkage with the existing drinking water program.

The federal drinking water program and that of the state will have new regulations on a variety of compounds. There are going to be recommended maximum contaminant levels at zero for many of the common metals, such as arsenic, cadmium, and a few others.

There will be lower inorganic chemical standards for many of the other compounds as well. The recommended maximum contaminant level for many of the organic substances will be zero, with very small amounts in the drinking water standard side.

Right now we are recharging the groundwater with advanced waste treatment effluent--AWT effluent--with the exception of Orange County which also uses reverse osmosis. How much more treatment can we afford to put on? What if it is found that organics removal is necessary from the standpoints of public health and drinking water supply? Is there another incremental treatment step that is going to make it impossible to recharge the groundwater? If you indeed did have to have additional treatment, what would it do to your program?

Nellor: In our case, removal of purgeable organics will probably not be an issue due to concentration levels and frequency of occurrence. However, if the concern were directed toward the nonpurgeable organic fraction and if we were required to add treatment to reduce the levels of those materials then the question becomes: How much should be removed, and what actually are we trying to remove?

Our plants are designed so that we can replace the dual media in our tertiary filters with granular activated carbon and provide about a ten-minute empty bed contact time. The conversion of the inert filters would also require the construction of a carbon regeneration furnace. Our best estimate at present is that the additional cost would be somewhere around $55 per acre-foot for capital and O&M. That is not very expensive when you compare it to the cost of imported Metropolitan water. However, before blithely converting our dual media filters to carbon, we feel that there are a number of unanswered questions that need to be addressed: Is ten minutes of contact time sufficient to remove organics of concern? What specific compounds must be removed and to what extent? Should operational performance be based on surrogate parameters? If so, which ones can be used--COD, TOX, Ames mutagenicity? Without answers to these questions, the design of an advanced treatment system is virtually impossible and makes cost considerations and consequently project viability impossible to determine.

Consideration should also be given to the other potential environmental impacts resulting from implementation of additional treatment. For example, if we were required to add carbon and build a regeneration furnace, which happens to

be in an area where air pollution is a real concern, it appears that the problem would only be pushed to another area of the environment--maybe with more significant impacts. Such trade offs should be carefully evaluated when considering the need for additional treatment of water and certainly deserve further scrutiny.

Gaston: What about Orange County, Dave? Have you done any treatment studies, looked at any costs?

Argo: When we first started, we took the approach of providing all the technology we could possibly incorporate in the reclamation system. More recently our thrust has been to eliminate some of the processes in order to reduce costs. Using activated carbon and reverse osmosis, we can produce waters that have very few equals among other water supplies, be they conventional or whatever, as far as the types of constituents they contain. With a reverse osmosis system using the newer membrane technology, we can produce water from reclaimed wastewater that has a TOC concentration of less than one-tenth of a milligram per liter. There aren't many drinking water supplies in the whole country that have that level of background TOC. We certainly think the technology is sufficient, and now we're going backward trying to see how much we can eliminate and still maintain acceptable constituent levels.

Nellor: I agree with Dave. I think we are always penalized because of the type of water we are dealing with. And certainly our water may be equivalent to other drinking waters in the country, yet because it's wastewater it automatically has some stigma attached to it.

Argo: We have a perfect example in our own basin. We are a groundwater replenishment agency; we not only reclaim water and inject it, but we also very zealously capture every possible drop of the Santa Ana River flow and sink it.

The base flow of the Santa Ana River in the last few years has been around 100,000 acre-feet per year. All that water is stopped and spread in the area of our basin known as the Anaheim Forebay. In the last few years, some 60 to 70 percent of that water, the base flow, is secondary treated water discharged from Chino, Riverside, and all the upstream cities in the Santa Ana watershed. As the EPA and the drinking water people come up with some standards, we probably will have to focus our attention not on our water factory operation where we are deliberately recharging reclaimed water, but on our "natural supply," which is the Santa Ana River.

Gaston: Which is, in effect, groundwater recharge of a different nature.

Argo: Yes. We do that through spreading, which is the same as the Whittier Narrows project. We simply divert the water and hold it in ponds and sink it into the ground.

Rogers: There is another aspect that is really going to affect costs and type of treatment. As Wiley pointed out earlier, no treatment requirements exist and perhaps never will. Looking at the Whittier Narrows proposed expansion for a moment, there are two distinctive issues that need to be addressed. One is the protection of potential users of that groundwater basin, mainly people who use the groundwater for drinking water supplies. And the other issue is protection of the groundwater basin itself, the nondegradation issue. The state legislature in the past session became strongly interested in the issue of nondegradation of groundwater supplies. And we likely will see, in this coming session, legislation addressing that specific issue.

We have stated that for the Whittier Narrows expansion project, activated carbon doesn't appear to be necessary in order to protect the people that use that basin for a drinking water supply. Even with new drinking water standards for organic chemicals, we can say that as long as the organics in the drinking water supply stay below those standards, the consumers aren't being subjected to any undue risks. However, if those standards allow that basin to be degraded up to those levels, that approach would violate both the nondegradation policy of the state board and the proposed legislative intent. So what may very well happen is that the regional board may have no choice but to impose activated carbon treatment in order to keep that basin from being degraded.

If that becomes the policy, which the legislature is now saying it wants, a reasonably pristine basin will have to be protected from degradation. This, in turn, means that groundwater recharge projects may have to use activated carbon even if the basin is not currently a source of drinking water. These factors are going to affect not only the cost but also perhaps the viability of certain groundwater recharge projects.

Nellor: The nondegradation issue is going to affect the viability of a replenishment project whether it uses reclaimed water or not. That is, using a replenishment source like Colorado River water in conjunctive use would degrade a groundwater basin in terms of mineral content even though the replenishment source is an acceptable water supply.

Rogers: That's right. The primary fallacy in the nondegradation concept is that it only applies to things that can be regulated. It ignores the limitations of the regional boards' regulatory authority. They can't regulate irrigation, use of imported water, or natural runoff, but they can regulate wastewater discharges. And so, you are right, it does impose that inequity.

Argo: Recently I heard a very interesting presentation by an attorney who works for a San Francisco firm. She addressed the issue of nondegradation of groundwater basins by saying that the constitution of the state of California really does not provide any basis for a nondegradation policy.

If you look at all of our other water resources, our local water supplies and our surface supplies, they've all assumed some amount of assimilative capacity or some allowable amount of degradation. And groundwater is no exception. She interpreted the state constitution as saying that everyone has the right to use groundwater just as they do surface water. A reasonable amount of degradation is allowed by the law.

I'm not an attorney; I don't know if she is correct. But we certainly have used some of the assimilative capacity of our other water supplies, rivers, lakes, etc. As she expressed it, under the constitution, the water user has the same right to use the groundwater basin, up to a reasonable point, as long as such use does not destroy any of the beneficial uses of that supply. In other words, maybe you can put one part per billion of TCE in the groundwater supply because it doesn't exceed any action level, and you wouldn't necessarily have to remove all of a spill. That was the example the lawyer gave.

I think we will probably hear more on how the law is actually going to be interpreted. If we have a nondegradation policy, certainly it is unique to groundwater because we have degraded every other water supply.

Rogers: She may be right, but she is definitely in the minority. The Porter-

Cologne Act is written specifically along different lines that say no one in the state has the right to pollute. Nondegradation does apply specifically to surface waters; trying to extend it to groundwater is more difficult.

Gaston: From an economic and a water resources standpoint, it always has occurred to me that groundwater recharge, as you are doing it in Los Angeles County, is probably the most economical reuse of reclaimed wastewater, if indeed it is not hazardous. You don't have many pipes laying around; you don't have high pumping costs if you can deliver the water by gravity. The land cost is there, of course. You may even get some beneficial uses from recreational lakes or whatever. So from an operational standpoint, it appears to be most cost-effective.

There are other options along these same lines. From the water supply standpoint, if there do appear to be problems, the water can be treated when it is taken out of the ground. Although I would think, from an economic standpoint, that might be much more expensive than treating it before you put it into the ground.

Has your work or any work done at Metropolitan looked at any additional treatment costs that you think the wastewater reclamation market could bear?

Horne: We evaluated the economics of treatment upgrading during the OLAC study--the Orange and Los Angeles Counties Water Reuse Study. My recollection is that at that time, one could add activated carbon contact to a spreading operation and it would still pencil out as being economical compared to the alternatives. I recall that the incremental cost of 30 minutes of activated carbon contact was about $200 per acre-foot. That study is out of date, however, and I don't know what the current figures and thinking are, for example, at the Los Angeles County Sanitation Districts or at the Orange County Water District.

Gaston: In terms of operating in Orange County and in Los Angeles, what are the worst things that you have had to deal with, from the practical treatment standpoint, in running your recharge operation?

Nellor: Our only major operational problem occurs when we have a plant upset. Of the two reclamation plants supplying water to the replenishment project, one discharges directly to the spreading grounds and the second to a pipeline which allows for water to be drawn off to the spreading grounds. In the latter case, if we have a plant upset, we can easily bypass the spreading grounds, ultimately discharging to the ocean. However, in the former case, if there is an upset, we have to essentially shut the plant down and divert its flow to other parts of the treatment system.

Gaston: Does Los Angeles County have a very strong industrial waste ordinance that enables you to control what's coming in?

Nellor: Yes. Source controls on industrial flows became effective in 1977 with enforcement of our own industrial waste discharge limitations. Additional controls on industrial wastes have more recently been implemented with promulgation of federal industrial categorical pretreatment regulations. Our treatment plants are also connected by a network of interceptors which provide flexibility in selecting residential, low mineral content sewerage for treatment at the reclamation plants.

Gaston: David, what are the main problems you have faced in Orange County?

Argo: We have been highly successful in producing water that meets drinking water standards, essentially all the time. We have done a lot of work in that area, looking not only at those constituents presently addressed in drinking water standards but also at other lists, particularly in the area of organics, such as health criteria of one in a million cancer risks. We have found that with our full treatment, we produce water that meets these criteria as well.

Our biggest quality problem is TDS and salts. Of all of the criteria on our plant, the few violations that we ever have of our injection standards generally involve sodium or chloride or TDS. We don't control the operation of the wastewater sewage collection system or treatment system. However, our counterpart, the Orange County Sanitation District, has a very aggressive pretreatment program and has reduced the levels of most of the trace elements below drinking water standards before we even get the water into our plant. This has been most helpful. There is some segregation of industrial waste.

MAJOR UNKNOWNS

Gaston: What would you like to see done in terms of new techology or advancements in the scientific art that you think would further the use of reclaimed wastewater for groundwater recharge? Are there any number of things you might identify as either problems or major unknowns in any aspect of this?

Crook: One of the major problems is the lack of information that we have on the presence, concentration, and health significance of organic constituents, and the removal mechanisms for these substances. We have the results of the Health Effects Study, which indicated that there were no adverse health effects based on epidemiological studies, health surveys, etc. However, it should be noted that it may take 20 years or more for some cancers to manifest themselves. At the present time, as in the past, there are relatively low percentages of reclaimed water in the extracted water that is used for potable purposes--a maximum of 23 percent, and in most cases much less than that. So you really could have predicted the results of the Health Effects Study from the epidemiological standpoint. I don't think that the data developed during that study can be extrapolated to sufficiently demonstrate the absence of possible long-term health effects; that may very well be the case, but you can't confidently state that at this time. Therefore, one question that has to be addressed is whether there really may be adverse health effects at the levels we have now or are likely to encounter and, in the absence of definitive health-related data, whether we should assume an as yet undefined risk and proceed with new or expanded groundwater recharge operations. Personally, I would prefer to see the organics reduced to the lowest levels practicable with current technology, and it would not be unreasonable to require advanced treatment such as carbon adsorption.

On another subject, it's obvious that control of pathogenic organisms is an absolute necessity in any reuse scheme involving ingestion. A considerable amount of monitoring, particularly for viruses, has been done at the existing recharge operations in Southern California. There is general agreement that current technology is adequate from a disinfection standpoint, and the ability to remove or inactivate pathogens does not appear to be a major issue. However, an argument could be made that it may be desirable to disinfect the water upon extraction rather than prior to spreading to take advantage of micro-

organism reduction in the subsurface system and to reduce the possible formation of chlorinated organic constituents. In my view, carbon adsorption prior to disinfection would eliminate many of the precursors of chlorinated organics, and disinfection should be practiced prior to recharge to protect the aquifer from microbiological contamination. Removals resulting from soil percolation and time in the underground would provide an additional degree of reliability to the overall system.

Finally, the issue of treatment reliability must be addressed. Groundwater recharge projects must be designed and managed to assure that appropriate water quality is maintained at all times that recharge occurs. This includes not only unit process reliability, but emergency storage or disposal provisions, monitoring, contingency plans, etc. The goal is to approach fail-safe reliability. However, we all recognize that economic and other constraints may limit the full achievement of that goal, although I should add that wastewater reclamation plant reliability has been improving in recent years.

Rogers: Another unknown is transferability of data. A good study of the Whittier Narrows basin established certain things in which you have some confidence. Now there are a half dozen or more proposed projects around the state, but they have a different groundwater basin, different hydraulics, different flow rates, different type of sewage, and different treatments. How can we take the Whittier Narrows data and model it so that we can be reasonably predictive in another situation? Or do we require a five-year health effects study in order to establish that a particular groundwater basin is equivalent to the Whittier Narrows basin?

Horne: We need research relating toxicity reduction to specific treatment technology. The treatment technology exists to produce almost any quality of effluent. But we're at a point where we have to decide on the list of parameters that we are trying to control before we can go very much further with research to develop standard technology for groundwater recharge. The best process for removing gross organics may or may not be the best process for removing toxicity or mutagenicity. I'd like to see treatment trains and design parameters optimized to reduce specific toxicity measures.

Argo: Ideally I would like to see the research that is needed to identify and establish a set of standards, not just for reuse but also to establish some national drinking water standards that can be applied regardless of source.

Long-standing drinking water requirements have emphasized that we should obtain waters from the highest and best source, and I don't disagree with that. But, unfortunately, as our environment becomes more crowded, those highest and best sources become more scarce. In many areas, particularly the arid Southwest, the reality is that our natural sources are wastewater. They are just not in pipes; they happen to be in rivers.

A research effort is needed on the national level for drinking water in general, so that we can develop some standards that we and our regulators have some reasonable level of confidence in. If these are met, the waters that are being used, regardless of source, are safe for public consumption.

Unfortunately, the research that is needed is a matter of great debate, and it's going to be a matter of considerable cost. It won't be done in the name of reuse, but I think it is going to

have to be done in the name of public drinking water supply. I hope we get on with that as soon as we can. Once that is accomplished, great advances can be made on both sides--conventional supplies as well as reuse.

Nellor: I would agree with Dave that the research needs of wastewater reclamation are directly tied to the resolution of drinking water issues.

Based on our work, we found that more research is needed to determine the actual health significance of specific trace organics and organic mixtures. Ideally, it would be advantageous to have some sort of surrogate toxicity test, similar to the Ames test in terms of convenience and cost, but with a more direct application to human health effects. Otherwise, you must still rely on the results of animal studies, which for environmental samples like water and wastewater are difficult and costly to conduct and even more difficult to interpret. More work is also needed to develop better methods for isolating and identifying organics.

I also think it's important not to entirely discount epidemiology as a tool for evaluating health effects because of the various problems inherent with the methodology. Epidemiology, like any other analytical method, has a sensitivity relative to the experimental setting. Further refinements of epidemiological study methods and development of better population based data sets should enhance the use of epidemiology for health effects research.

Gaston: We have talked exclusively about groundwater recharge with reclaimed wastewater and domestic reuse. Has anyone given any thought, to your knowledge, of designated groundwater recharge for other than domestic reuse purposes, such as agricultural storage and reuse for industrial purposes? Has there been any work going on in your agencies or any others to consider those options?

Horne: I am not aware of any in this country. I think that in Israel they have implemented programs where they use the ground simply as a storage reservoir and locate a circle of interception wells around spreading areas, and then extract the water for a variety of purposes, generally nonpotable. This would involve the dedication of a groundwater basin to nonpotable purposes, and I don't think it has been done in this country.

Rogers: Certainly, the whole idea of conjunctive use of groundwater basins is not new. I think the real problem is that, with the exception of the adjudicated counties in Southern California, there is no control over groundwater usage or groundwater pumping. No mechanism is in place by which you can equitably put it in the bank when you have a surplus and take it out in times of shortage. Though everyone agrees it is a great idea, no one has yet figured out how to do that on a statewide basis without an extensive groundwater regulatory program.

Crook: A few years ago the Irvine Ranch Water District in Orange County considered an injection-extraction project to store approximately 6000 acre-feet of reclaimed water in the underground for use during the high-demand irrigation season. The underground storage location was a subbasin not used for domestic purposes. However, a small-scale demonstration study to determine the feasibility of the project was never implemented due to lack of funding, and the proposed project did not receive any further consideration by the water district.