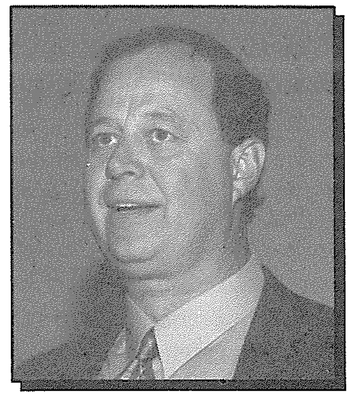

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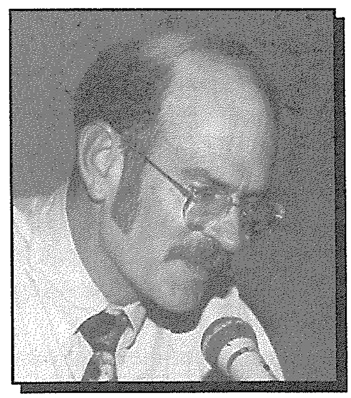

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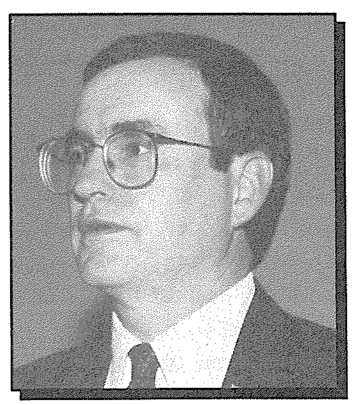

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INFORMATION NEEDS PANEL: WHAT TYPES OF NEW WATER INFORMATION DO WE NEED?

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Comments on Water Assessment Needs

I really appreciate all of you for staying this late in the day. I mentioned to Pete Kraai earlier this afternoon that most everything of substance has been said leaving not much to say and possibly not many to say it to. However, I look out here and see a good crowd and I appreciate that and I think that's a good indication of the statewide interest in our water resources.

During this conference you heard a variety of technical and legal experts talk in technical and legal terms about our state's water quality, quantity, availability, demand, future demands, legal rights and legal ownership. I am not a technical person and haven't been one for several years. However, I have had a lot of experience in condensing a variety of complex issues into tasks to be accomplished and getting that job done.

I've been asked to outline what new water information we need. I first looked at this topic strictly from an irrigation district manager's point of view then I realized that is only a very small part of the picture, statewide. So, I thought I would ramble here for a while, if you will indulge me, as to my opinion of the statewide assessment needs. I think it's time that we look at our water situation from a statewide perspective.

First, I think we need to know very accurately what are our current water supplies and demands. More importantly, we need to have the very best projections of the future water supplies and demands of the state, at least for the next 30 years.

Let me first deal with the current water supply. As I said, we need to know, with accuracy, what is our current water supply—the word accurate is important. We are a long way from having accurate information now. I know there is a tremendous amount of data out there, but, we don't know how accurate it is, we don't know what gaps there are in this information and we don't know what information needs to be gathered to fill in these gaps. We need to have some of these answers before we spend more money on additional assessments.

First, let me talk a little bit about the accuracy issue from where I stand. At Carlsbad Irrigation District we take a lot of pride in the accuracy of our water-delivery system. We accurately measure the water in our reservoirs. We measure this water again into the main canal and again at each ditch-rider division in our main canal system. We measure this water again as it goes into the lateral-delivery system from the main canal, and we measure this water again before it goes onto the farmer's land. So, we know what our diversions are fairly accurately. This information is kept and filed in a computerized data base on a 24-hour basis. It is available to our water users and it is no older than 24 hours.

However, there are a lot of things that we do not know. We do not know accurately what our crop-water demands are for different soil types. We don't know with any accuracy the return flows of the project into the Pecos River. We know what our reservoir storage is with the accuracy that is available with today's technology, but we don't know what to attribute the loss to when we move the water between reservoirs. We can measure that loss but we don't know where that water is going. This information is lacking in all the state's watersheds. That's just a good example of information needed on the water demand side.

An example on the water supply side is on the east side of the state; we need more information about the quality, quantity and availability of groundwater reserves. Some of this information is known to those in the water business, but I suspect, a lot of this information is more accurately known by those in the oil and gas business because they have been out there for years drilling hundreds of oil and gas wells, collecting miles and miles of three-dimensional seismographic information. A lot of remote sensing is being done. That information is out there and it's very accurate. We need to obtain it for our use in water planning.

I believe that we must have good, sound data for both supply and demand before we can responsibly plan for the future. So, let me issue a challenge to the governor and the leadership both in the House and the Senate of this state. I think that beginning next session we need to establish a clearinghouse to search out, categorize, electronically store and make available to the public all the information that's out there concerning our state's water supply, especially underground supplies. It's possible the Bureau of Mines and Mineral Resources could be this clearinghouse, or the Water Resources Research Institute, or possibly the State Engineer Office. But, we need to decide on which office will serve as the clearinghouse and what is going to be required to collect information, to categorize it, to quantify it and to store it properly so it is available to the public.

As I've said, a lot of that information is out there. The U.S. Geological Survey, Corps of Engineers, Bureau of Reclamation, State Engineer Office, Bureau of Mines and Mineral Resources, and oil and gas companies have been collecting this information for years. On the demand side, municipalities, rural water coops, irrigation districts, and conservancy districts have much of this information. But we need to begin right away to get that information into one place and categorize it, quantify it and determine what gaps exist. There is no reason for us to go out and begin collecting information or doing assessments if the information already exists.

Once we find out where the gaps are in this information, we could do a lot of things to collect the data that are lacking. There is a lot of state-of-the-art technology out there to gather this data accurately. Possibly, it could be done in cooperation with oil and gas producers, mining companies or others who are looking at these water resources, or are looking at the same information that would give us the data we need. For instance, we could use state-of-the-art three-dimensional seismographic technology or remote sensing along with well logs to help us map underground reservoirs in parts of the state where much of this information is lacking. We may need more accurate accounting of irrigation diversions and return flows. We need a lot of information linking groundwater pumping and river leakage. The great unknown is the relationship between surface and underground waters.

Once this information is collected and stored, I think we ought to establish a geographic information system (GIS) for this information, particularly in the more critical basins such as the middle Rio Grande basin or the lower Pecos basin and possibly the Las Cruces area. But certainly, we should start categorizing the information that's there, filling in the gaps, and establishing a GIS system to make this information more consumptive to the public.

I think once all of this is done, our future planning work will be made much easier and more meaningful. So, I think we must decide how to go about this effort. However, time waits for no one. At the same time we conduct this project, we are going to have to be doing water planning. And, there is going to be a time overlap. We can't just put planning on hold. A lot of us in this room are involved in regional water planning at this time. We are going to have to continue with that process, but those plans will be better once they are completed if they are based on accurate data. Next legislative session, we need to establish a clearinghouse to gather the information that's out there, categorize it, find the gaps, and collect the information to fill those gaps, then make this information available to everyone in the state who's involved with water planning. This is going to take an unprecedented focus and effort by political leaders, state and federal agencies, water managers, water users and it's going to be a tremendous job. I think it's important that all of us leave here, get organized, and persuade our political leaders and others to get this job started.

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New Data Requirements to Evaluate Water Use in New Mexico

Most of the discussion at this conference has dealt with water supply. I'd like to focus this discussion on the other side of the water resource coin, that is, the estimates of water use. The Albuquerque area is generally ahead of the rest of the state in being able to accurately estimate use, as I'll discuss later, so this discussion also is focused on estimates of water use statewide. The New Mexico State Engineer Office (SEO) publishes the only definitive statewide compilation of water use data in New Mexico. The water use report has been published by the SEO at five-year intervals since 1965, the most recent being for the 1990 calendar year. These data are used by all segments of the water resource engineering community, for all analyses of water use at scales above those of individual water systems or projects. Examples include:

- regional water plans and state water assessment
- groundwater basin assessments and models for water administration
- surface water analyses for project water supply, instream flow and riparian area needs analyses
- interstate compact analyses of deliveries and for interstate litigation

The present water use reporting system requires significant improvements to meet the needs of these tasks, in two basic areas: 1) more accurate and reliable estimates of water diversion requirements and depletions, and 2) more precise identification of points of diversion and centers of water use.

For instance, we are considering requiring analysis of all groundwater uses aggregating 100 acres of irrigation or its equivalent for the statewide water resource assessment. Or, we find ourselves in the position of needing to know the location of a groundwater pumping center and its annual withdrawal in order to calibrate a groundwater model against observed cones of depression in the groundwater table. Both of these cases require more information than is generally available at present.

Agricultural water uses were estimated to aggregate approximately 80 percent of New Mexico's water use in 1990. Our annual census of irrigated acreage and cropping pattern is conducted under contract to the SEO by Dr. Robert Lansford of New Mexico State University (NMSU). In each county, available data on crops are inventoried, including:

- Agricultural Stabilization and Conservation Service (ASCS) Cropping Inventory - done for purposes of administering Federal Crop payment programs
- published crop productions figures
- project water use figures, which are generally available for Bureau of Reclamation irrigation projects
- reports of county extension agents, based on their personal knowledge and interviews with area farmers

Dr. Lansford meets with ASCS personnel and extension agents in each county, and they hammer out a basic consensus estimate. The estimate is reported by county and by hydrologic basins. This is an inexpensive process. The SEO cost is approximately $14,000 per year for the whole state, with an additional $14,000 contributed by NMSU's College of Agriculture.

Disadvantages of this method include a variable level of accuracy across the state, and the method's inability to identify precise water use areas. Furthermore, the method does not evaluate those factors which affect diversion and depletion requirements regionally, including type and condition of irrigation systems, soil types, and level of farm management. For these reasons, uses of the resultant estimate of water use for purposes of administration, regional planning, and modeling is limited. It is noted that this method is also the primary tool used by Colorado to develop water use information.

A similar need has been identified to be able to better quantify public water supply diversions and consumptive uses. At present, many, but not all public water supplies report their diversions to the State Engineer annually. This is being addressed by the Water Conservation Program in the Special Projects Division. We currently are working with a committee of municipal water users to develop criteria which will be implemented in the water rights process for municipalities. A key recommendation that will probably be incorporated into a new regulation will be a routine water use reporting requirement, which provides a breakdown of diversions, losses, and major service categories. This should serve to greatly improve our water use data for public systems.

One method which is available to us to inventory agricultural and riparian water uses is the use of an aerial photobased GIS technique. The method was developed by the states of California and Utah, both of whom use it as their primary water use inventory tool. The method involves aerial photography using color infrared film, which is scaled using USGS quadrangles as controls. Fields are delineated on the photos, preliminary crop interpretations made, and the results digitized into a geographic information system (GIS). One-hundred percent ground truthing of crop classifications is required to ensure accuracy. The method has some limitations, particularly regarding off-season cropping and multiple cropped acreage. However, it is generally very precise regarding cropped acreage and irrigation location. The cost is high, estimated at approximately $1,000,000 for a single coverage of the major irrigation areas in the state. It's been difficult to find the funding to continue this statewide program.

To date, the following photobased water use inventories have been completed in New Mexico:

- Pecos River Basin - 1991/1992
- Lea County - 1991
- Roosevelt County - 1992
- Curry County - 1993
- Middle Rio Grande Conservancy District and Albuquerque area - completed by the Bureau of Reclamation in 1992
- San Juan/Animas rivers - 1994

In light of the high cost of photobased identification of irrigated areas, what alternatives are available to develop this information? Hydrographic survey is one source of this data, but it does not cover the entire state, and is not available in electronic format.

Recently, the SEO has made significant progress in using GIS software to automate the resolution of irrigated areas from earth satellite (Landsat) data. Landsat data are used as a primary tool by Arizona. We've discovered that we can resolve images of those bandwidths associated with irrigation and convert those images from raster data to vector polygons representing irrigated areas. Our experience with crop type interpretation using Landsat data has not been fruitful. However, this method has the potential to give us the ability to develop precise locations of irrigated acreage across the state with a minimal manhour investment, and thus at low cost. An adequate estimate of crop distribution and CIR can be applied using county-wide averages from the NMSU data. The SEO has a complete coverage of the state from Landsat in 1989. In areas where the photobased GIS data are not available, this method could be of great help for our regional water planning and state water assessment efforts as well as to our surface and groundwater modeling.

Regarding estimates of consumptive use requirements, the SEO has been working with the Bureau of Reclamation and Drs. Ted Sammis and Phil King at NMSU to develop and refine monthly consumptive use coefficients for crops and phreatophytes in the Middle and Lower Rio Grande using a modified Blaney-Criddle method. This has been accomplished by scaling back monthly evapotranspiration measurements from lysimeter studies, based on a comparison of evapotranspiration computed from crop production functions developed at NMSU, which correlates average crop yield with consumptive use. The report was completed in September 1994, and will be published by NMSU at a later date.

Finally, the SEO and Interstate Stream Commission are developing a program with the Soil Conservation Service to inventory irrigation systems statewide to improve our ability to estimate diversion requirements and irrigation depletions. At present, we estimate consumptive irrigation requirements based on crop. As appropriate, these estimates are adjusted for crop yield and known supply shortages. Incidental depletions are calculated to reflect known characteristics of the distribution system, and the type of irrigation practiced. However, data to be collected in the SCS studies offer the potential of significant improvement in our water use estimates. Such data include:

- type of irrigation system - flood, border, sprinkler
- age and condition of system
- soil type
- estimate of on-farm efficiency
- estimate of off-farm efficiency
- current and potential conservation practices

Each of these parameters can significantly affect water requirements for agricultural diversions and depletions. When we are able to adjust our estimates regionally and by project, we will have improved our abilities to match water supplies and demands, and to manage our surface and groundwater systems.

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What Types of New Technical and Scientific Water Information Do We Need?

The Middle Rio Grande Basin remains an enigma, despite forty years of cursory study in an attempt to define the water resources beneath the Albuquerque portion of the basin (e.g., Theis and Taylor 1939; Theis 1953; Bjorklund and Maxwell 1961; Reeder et al. 1967; Kelly 1979). In the last five years those studies have become more than cursory, and we are beginning to realize that the extent of our ignorance is greater than we thought (Hawley and Haese 1992; Thorn et al. 1993).

This is not an unusual development in hydrology. There is no aquifer in this country, or indeed the world, that anyone can claim to fully understand. Uncertainty rules. Aquifers are naturally complex arrangements of geological materials. Pervading the Middle Rio Grande Basin aquifer is a record of geologic events at all scales, and even the events themselves in the form of faults. Groundwater flow and the movement of both natural and contaminating chemicals are controlled by the spatially varying properties introduced by this complexity. Adding to the uncertainty is the relationship of the aquifer to nearby mountains and the overlying Rio Grande. We are only now coming to realize the significance of this connection to the river, and how little we know about it.

Borrowing words from Norman Gaume of the City of Albuquerque, this uncertainty affects our understanding of the extent and behavior of the water resources available to the city and the surrounding communities, and therefore will influence our water resources decisions. It is not the only information need. It alone does not define all of our water resources constraints. Elsewhere in this volume we learn that we need more information about water rights and other regulatory constraints, and we need more information about future demand for water resources.

In this brief paper, I will focus on the technical and scientific issues that are necessary to answer the questions that plague the City of Albuquerque and all other participants in water resources development within the basin. I divide the paper into sections, each one representing a specific issue demanding attention.

Collate and Synthesize Existing Data

The paper title puts the focus on new information, but as pointed out by Kelly Summers, it is clear that it need only be "new" to the people looking at the basin as a whole. There is much site specific engineering data that currently are being collected for aquifer remediation studies, foundation design, highway construction, sand and gravel excavation, and so on, that are never seen by the teams trying to understand how the hydrology of the basin works. Summers calls for sharing all of this data, perhaps by building and making available a data base. Add to it production data (pumping) by all parties within the basin, and petroleum data sitting on a shelf somewhere, and you have a significant resource, probably already paid for, just waiting to be organized so that it can be useful for the present purpose. John Hawley, of the New Mexico Bureau of Mines and Mineral Resources, has already shown how petroleum exploration data can significantly revise the hydrogeologic framework of the basin.

Back to Basics

We must return to the basics. That's how we finally learned something new over these last five years. Someone, or some group of people, decided that it was no longer business as usual. Summers, Hawley, Gaume, Kernodle, McAda and many others played a role in this important decision to return to the basics, to explore our assumptions, and to see if things actually behaved as we guessed they did. They discovered that we had been wrong about two fundamental issues.

The river is not as well connected to the aquifer as we had hoped, and the productive zones within the aquifer are much smaller in lateral and vertical extent than we had believed. It is important to realize that these conditions were not determined by hypothesizing them, and then taking a few carefully selected measurements to somehow validate the hypothesis. It required a careful integration of mostly existing but fundamental information through conceptual and computer modeling exercises designed to identify inconsistencies and important uncertainties.

We must continue this kind of fundamental work, but perhaps we now have enough information to begin to design some definitive experiments, testing individual hypotheses about system behavior. Thus, I see two kinds of new data needs: baseline data on pumping, recharge, aquifer properties, hydrogeology, and the like; and individual experiments designed to test some particular aspect of the system and how it behaves. The emphasis on the basics is to try and avoid, or at least attenuate, any future surprises.

Baseline data are necessary to elucidate the regional hydrology and hydrogeology. Data should include water levels (piezometers) and geochemical/isotopic composition in three-dimensions (multi-level monitoring wells, multi-completion wells, deep exploratory holes, core samples; according to Summers, "...we need deep holes, we need shallow holes..."). Three-dimensional flow is the norm in this basin, and three-dimensional data will help us understand how water and chemicals (like arsenic) move through the system under natural and anthropogenic gradients.

Hand-in-hand with this are additional three-dimensional hydrogeological data from logs, cores, and borehole geophysics. All new holes for whatever purpose should be treated in the most sophisticated manner, and special coreholes should be planned to confirm the logging effort. Surface geophysics should be employed, supplementing whatever can be gleaned from former efforts of the petroleum community, with particular attention to faults and aquifer compartmentalization.

Aquifer properties should be measured in cores and in well tests, for permeability, porosity and storage properties. All of this data should continue to be integrated in a hydrogeological conceptual model that accounts for the depositional environment of the basin, and subsequent diagenesis and structural changes. As in the last five years, this integration should be continued under a computer modeling and GIS framework.

So-called definitive or crucial experiments are now a necessity. For example, an experiment is already underway to use pumping wells to test the river-aquifer connection at one location in Albuquerque. For every important and uncertain process discovered during the baseline studies, one or more individual experiments should be designed, implemented and interpreted. Other areas of concern, besides the river-aquifer connection, are connections to the canals and ditches, mountain front recharge, stormwater recharge, potential for artificial recharge, geochemical changes caused by these various connections/recharge mechanisms, subsidence, decreased aquifer productivity with depth and laterally within the aquifer, and so forth. Experiments are already planned for some of these areas. In others, like the spatial pattern of aquifer productivity, we may simply use these notions to guide where the baseline data are collected.

Look for "Important" Data

An emphasis should be placed on new data that (eventually) make a difference in water resources decisions. That is, we should only collect new data that we believe are important to the decision (but not necessarily to the decision maker). This is a dangerous recommendation, because it is usually interpreted to mean data that the decision maker thinks he or she needs. But that would be misleading. After all, what decision maker in 1980 would have suggested that arsenic in the Middle Rio Grande Basin would be interesting to study? Yet today it is a issue of great importance to water supply managers. Decision makers may tend to be shortsighted, concerned about today's problems, and less interested in doing the homework due tomorrow. There is a quote from Francis Bacon (1620), writing about science, that may shed some light on this need for first doing our homework. Of course he puts it much more elegantly, noting that even God took one day just to shed light on His problem.

> "Now God on the first day of creation created light only, giving to that work an entire day, in which no material substance was created. So we must likewise from experience of every kind first endeavor to discover true causes and axioms; and seek for experiments of Light,

> not for experiments of Fruit. For axioms rightly discovered and established supply practice with its instruments, not one by one, but in clusters, and draw after them trains and troops of works."

How does one decide what aspect of the system is important? The conceptual or computer model can help with this exercise. In fact, this is how the problems with the river-aquifer connection and the extent of aquifer productivity came up. There is a formalism to this, referred to as sensitivity and uncertainty analysis, but it boils down to a few simple rules. First you must decide what you hope to accomplish with the model. In the Middle Rio Grande Basin this could include, for example, estimating future groundwater withdrawals taken from storage versus surface water induced to infiltrate into the aquifer or directly diverted. It could also include something about drawdowns, since they impact pumping costs. Let's call these "performance measures" that measure the performance of the aquifer system under natural and anthropogenic stresses.

The next issue is to determine the sensitivity of the performance measures to various aspects of the system. The greater the sensitivity, the more important the aspect. But you can't stop there. One more issue remains: the uncertainty of the aspect. After all, a completely certain but sensitive aspect is not a likely candidate for further data collection. Nothing would be gained. Equally uninteresting is an uncertain but insensitive aspect. What we seek are uncertain and sensitive aspects. Today the most interesting of these is the river-aquifer connection. We know almost nothing about it (uncertain), and yet it clearly influences the water balance in the basin, particularly from a water rights point of view (sensitive).

We can divide the aspects of interest into two other types or classes. The first class includes aspects that can be measured directly, such as productive zones, arsenic source or behavior, and so on. This is the class addressed by the formalism of sensitivity and uncertainty analysis. The second class is harder to address. Composed of aspects that are only indirectly measured, it includes descriptions of the aquifer depositional environment, diagenetic processes, etc. These are often ubiquitous processes within the aquifer, rather than measurable parameters. They may not show up in some formal or informal sensitivity analysis, but they may just be the most important aspects of all.

It's a Regional Problem

"We're all in this together," says Kelly Summers. "Since it's a regional problem it ought to be a regionally managed problem." There is no question that, technically, it's a regional problem. Water and water contamination do not respect political boundaries. There is sufficient consensus to suggest that water deliveries at Elephant Butte Reservoir make a logical, technical and regulatory focus. If not Elephant Butte, then San Acacia. It is apparent that the City of Albuquerque knows that what happens upstream of these points is relevant to them, especially from a water rights perspective.

Frank Titus echoes the regional theme with a proposal for a regional water resources management forum composed of technical and public representatives, and charged with getting the greatest use of our water resource with "the least discomfort." Current events show that cooperation is possible, and the unity of opinion on the nature of the important problems shows that we can get along when faced with a difficult issue like this. Or does it?

Integrate Efforts

The study of the Middle Rio Grande Basin requires a variety of talents. Fortunately we are blessed in New Mexico with a plethora of such talent, from individuals and institutions. Hawley and others have said that we should use it. It's unlikely that the present collaboration of the City of Albuquerque with the U.S. Geological Survey and the Bureau of Mines and Mineral Resources can continue unaltered. There are too many other players in the management game, and there is other talent to tap. Titus's forum or some other institution could help, and there are other new structures that have been proposed for consideration by our political leaders.

Peer Review

My final recommendation is that formal scientific peer review be brought into the process. It would help insure that the important issues are being pursued, and that good scientific practices are employed. The U.S. Geological Survey already practices peer review, but it is mostly at the time of publication, far after the important decisions have been made. Formal science advice and peer review should be implemented early in the effort, perhaps through a Technical or Scientific Review Committee. The committee would help insure that the new data collected are appropriate, properly interpreted, and appropriately integrated into the conceptual and mathematical models. They would help balance "experiments of light" with those of "fruit." Peer review also provides a clear-cut mechanism for pulling the plug on efforts that are going nowhere. Put more simply, peer review gives you a bigger bang for the buck.

Conclusions

New water information is needed in three areas: the water resource, institutional and legal constraints, and water demand. In this paper I have focused on the water resource, stressing six points. While collecting new information, some effort should be made to collate and synthesize existing and ancillary data. New data gathering efforts should stress the basics, both in terms of baseline data and crucial experiments meant to test important processes. These efforts should focus on data that will make a difference to the decisions that will need to be made, but not necessarily to the decision makers. The program should recognize that it is a regional problem, and that it would most effectively approach it by integrating the efforts of the very able pool of talent that blesses New Mexico. Finally, peer review could be a key ingredient to continued success.

Acknowledgments

I would like to acknowledge conversations with John Hawley, Frank Titus, and Mike Kernodle that helped me frame my ideas. Paul Hofmann suggested the quote from Bacon.

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