possibility of ground-in dirt, wetprinting is a method that certainly merits high priority.

The author is thoroughly committed to the continuing development of total immersion wetprinting. He has presented a contact printing machine specifically designed to obtain the maximum number of advantages afforded by total immersion wetprinting. It is the author's hope that his efforts and the efforts of others will hasten the day when wetprinting becomes a routinely accepted laboratory procedure for all printing operations and for the greater enhancement of overall print quality.

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# Cost-Effective Water Conservation

By JOHN F. MOTCH

**Through attention to waste, the Eastman Kodak Color Print and Processing Laboratory in Palo Alto, California, has waged a successful campaign to reduce water consumption since 1968. In the period from 1968 through 1976, water usage was reduced by 70% and over a quarter of a million dollars was saved in water costs. The key elements of the campaign were simple: identify waste, use existing technology, and economically justify the solution. When northern California's drought extended into its second year in 1977, the laboratory's efforts were stepped up to satisfy a mandatory 28% rationing plan. Part of this step-up was an educational/motivational plan for employees, designed to show them where the water comes from, where it is used, how important it is, and what the company is doing about the shortage. Again the stress was on waste, existing technology, and economic solutions, and again the campaign worked; water usage in 1977 was cut by almost 50% compared with 1976, and cost cuts were commensurate. These reductions were effected without resorting to "big technology."**

Recently a number of articles have appeared in newspapers around the country concerning the substantial water-use reduction achieved at the Eastman Kodak Color Print and Processing Laboratory in Palo Alto, California, over the past decade. Surprisingly, most of the savings were obtained through attention to waste rather than through the application of "high technology" methods. Over a ten-year span, the approach to water-use reduction that Kodak has found to be most cost-effective is to reduce waste.

Our program has been simple. Find where water is being wasted, propose a simple solution using existing technology to minimize or eliminate that waste, and economically justify that solution. Over the first years the program worked well enough providing a slow, continuous, orderly, and cost-effective reduction in water consumption. Nevertheless, when 1977 was recognized as the second consecutive year of drought in northern California, the challenge was clear. Waste was still too high and waste reduction would be where the fastest savings could be realized. Therefore, a commitment was made to redouble our conservation efforts until the drought was broken.

One aspect of that effort has been an educational/motivational slide talk program for all laboratory employees in the form of a personal presentation designed to convince them of the reality of the water shortage, to make them aware of our past efforts in the water-conservation area, and to enlist their aid in getting through this difficult time.

### History of the Water Problem in California

At the outset, the employees were told of the history of the water problem and how it had affected the company and what the company was going to do.

The climate around Palo Alto, California is semiarid, with an average annual rainfall of 12 – 13 in (about 32 cm). Rainfall is measured from July to July, and most rain falls in November through February. This means that the fields are green by Christmas and golden brown by July — hence the nickname "the Golden State."

Early settlers turned to agriculture, mainly planting orchards in our particular area. Ground water was available for irrigation, since in those days all it took was a 5-ft (1½-m) hole to produce an artesian well. As a result the valley was ablaze with fruit blossoms every spring. Soon, however, wells with pumps were required to reach the water table. The need for more and more water and the switch to more water-intensive row crops soon led to deeper and deeper wells. No one seemed to recognize that there would be any limit to the water available, and worse, no one anticipated the consequences of an ever-dropping water table.

Finally, the water table dropped to 150 ft (46 m) below sea level, and at that point the land started to drop, too, in what is called subsidence. The South Bay Yacht Club once looked proudly over San Francisco Bay, but during the subsidence years it dropped 13 ft (4 m) and now requires a levee to hold back the bay waters. Other areas of San Jose, such as the area where the county buildings are now located, have dropped almost 8 ft (2½ m).

Obviously something had to be done to replenish the ground water, and construction of a system of 11 county lakes was started to catch the surplus winter rain, and through a system of percolation ponds, to put that water back into the ground rather than permitting it to just run off into the ocean. Conceived during the 1920s and essentially completed about 1935, the lakes have a capacity of almost 180,000 acre-feet

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Presented on 15 October 1977 at the meeting of the Association of Cinema and Video Laboratories (ACVL) in Los Angeles. The paper, adapted from a primarily visual presentation, was received on 17 March 1978. The author, John F. Motch, is with the Kodak Processing Laboratory, 925 Page Mill Road, Palo Alto, CA 94304. 

**Table I. Water bank, San Francisco Bay area.**

| Lake | Capacity (acre-feet) | February 1977 (acre-feet) | October 1977 (acre-feet) |
|---|---|---|---|
| Almaden | 1,780 | 98 | Empty |
| Anderson | 91,780 | 26,038 | 13,651 |
| Calero | 10,160 | 1,170 | 328 |
| Chesbro | 8,086 | Empty | Empty |
| Coyote | 23,700 | 5,624 | Empty |
| Guadalupe | 1,740 | 133 | 189 |
| Lexington | 20,210 | 672 | Empty |
| Pacheco | 6,135 | 174 | Empty |
| Stevens Creek | 3,600 | 134 | Empty |
| Uvas | 10,000 | Empty | Empty |
| Vasona | 410 | 389 | 165 |
| Totals | 177,601 | 34,432 | 14,333 |

**Table II. Local storage, Hetch-Hetchy system.**

| Facility | Capacity (billion gallons) |
|---|---|
| Calaveras | 31.6 |
| San Antonio | 16.5 |
| Crystal Springs | 22.6 |
| San Andreas | 6.2 |
| Pilarcitos | 1.0 |
| Total | 77.9 |

(58.7 billion gallons or 222 $hm^3$);* Table I incidentally shows that 1977 was not a good year for keeping them filled. But for nearly three decades, the system *did* manage not only to supply the needs of the valley but to restore the water table, halt subsidence, and allow continued urban and suburban growth of the lower Bay area, with wells for a water system.

Meanwhile the city of San Francisco started to build a water system in the Sierra Nevada Mountains, which was called the Hetch-Hetchy System (completed in 1931). It would capture snow run-off in mountain lakes and channel the water to the Bay area, providing fresh, clean, soft water without treatment or pumping. The plan was to provide a local storage of almost 78 billion gallons (295 $hm^3$). As shown in Table II, this was to be divided among five facilities, all of which exist today. These are supplied from three mountain lakes — Eleanor, Hetch-Hetchy, and Cherry. Don Pedro is a foothill lake where, in the past, surplus Hetch-Hetchy water was stored to meet irrigation rights that predate the system.

As the population of the valley grew, there was seen more housing, more industry, and more business; this and dissatisfaction with hard well water led more and more local areas to buy into the Hetch-Hetchy System. When our laboratory was built in 1954, we connected directly to the Hetch-Hetchy line, even though the city of Palo Alto still used much well water. Today Palo Alto uses Hetch-Hetchy water, with the wells for back-up, and our laboratory still receives only Hetch-Hetchy water, except in the fire mains.

Just how bad is the present situation? Moisture in California during 1977 was about 75% of normal and the preceding year was worse. The normal annual rainfall is 13.1 in (33.3 cm); in 1976 we received 5.77 in (14.66 cm); and in 1977, 8.97 in (22.78 cm). Consider the 78-billion-gallon local Hetch-Hetchy storage. Normally on 1 December there are 50 billion gallons stored (189 $hm^3$). By 1 February the stored volume should increase to 56 billion gallons (212 $hm^3$) and by 1 May, 65 billion gallons (246 $hm^3$) are expected.

Figure 1 compares the normal year to the 1976/1977 season. On 1 December there were 36.5 billion gallons (138 $hm^3$) stored, but by 1 February the stored volume had decreased to 35 billion gallons (132.5 $hm^3$). It was estimated that, without special conservation measures, by 1 November there would only be 22.4 billion gallons (85 $hm^3$) left which would not be enough to get through another dry year. With 25% rationing, however, there would be 41.2 billion gallons (156 $hm^3$) by 1 November, and along with what remained in mountain storage, that could see us through another year.

Regarding the mountain lakes: at the time of writing, Lake Eleanor was empty and Cherry had a scant year's supply at reduced delivery rates. Don Pedro was very low, with less than two years' total supply, and since it "banks" water for the prior-right irrigation customers the water system might have to honor its water withdrawal commitments. Hetch-Hetchy Reservoir was at about the 10% mark in April of 1977.

What about ground water? In April 1977 the water table was at 50 ft (15 m) below sea level (Fig. 2). By 1 September high pumping rates had brought it to 117 ft (36 m) below sea level. Subsidence and strict ration-

*In this paper, various metric conversions are appropriate. Gallons will be shown with their liter (L) equivalents; millions of gallons will be converted to megaliters (ML): billions of gallons will be expressed as cubic hectometers ($hm^3$) — a volume equal to a cube 100 m on an edge. For comparison, 1 acre-ft = 326,111 gallons = 1.23 ML = 0.00123 $hm^3$.

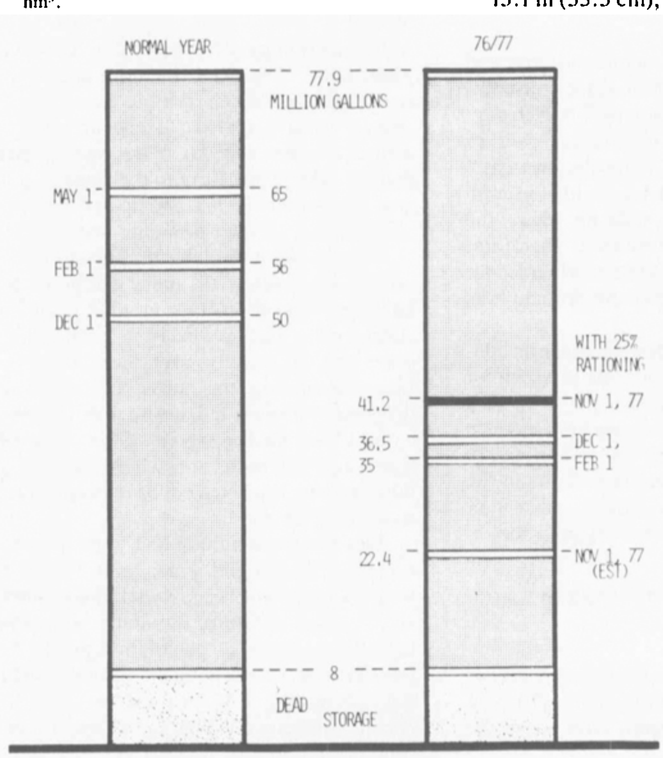


**Fig. 1. Combined local storage, normal year vs. 1976/1977.**

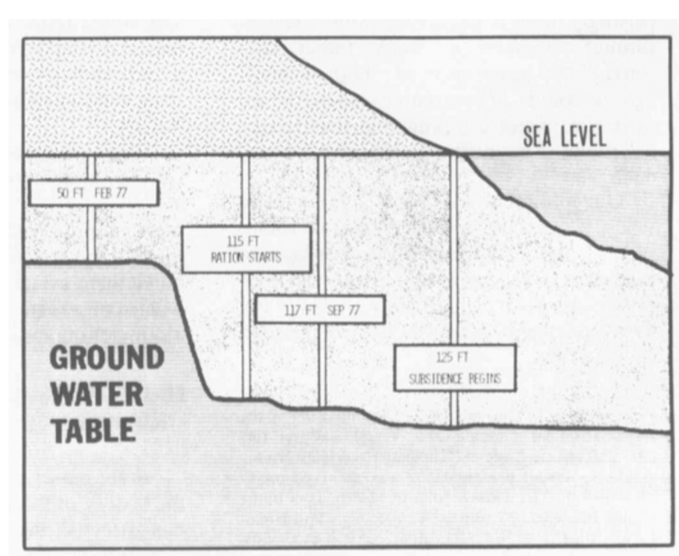


**Fig. 2. Ground water table, April 1977.**

**Table III. Palo Alto's mandatory water rationing plan.**

| Category | Reduction (%) |
|---|---|
| Single family | 22 |
| Multifamily | 22 |
| Commercial | 24 |
| Industrial | 28 |
| Public facilities | 30 |
| City departments | 40 |
| Overall reduction | 26 |
| Industrial process water | |
| 0 – 10 units | Voluntary reduction |
| Over 10 units | 20% reduction |
| 50% reduction in irrigation water | |

**Table IV. Fines and penalties for failure to comply with mandatory water rationing.**

Units used in excess of allotment will be billed at regular rate plus:

| Percentage | Excess use charge |
|---|---|
| 0 – 5 | None |
| 5 – 10 | 2 × unit rate |
| 11 – 20 | 3 × unit rate |
| 20 – 30 | 4 × unit rate |
| 30 – 40 | 5 × unit rate |
| ≥ 50 | 10 × unit rate |

Charges for installation of flow-restricting devices or for restoring service will be levied as follows:

| Meter size (inches) | Installation cost (dollars) | Removal cost (dollars) |
|---|---|---|
| ⅝ – 1 | 25.00 | 25.00 |
| 1½ – 2 | 50.00 | 50.00 |
| > 3 | Actual cost* | Actual cost* |

*Actual cost will include all material, labor, equipment, and overhead charges.

ing could be expected to start at about 125 ft (38 m) below sea level. Ground water would not be any long-term help.

To cope with this situation, the entire Bay Area was put on some form of water-conservation plan. The San Francisco Water Department mandated a 25% reduction in 1977 water use, which was translated into the plan shown in Table III by Palo Alto. Industry was asked to reduce consumption by 28%, which would be achievable by reducing process water consumption by 20% and irrigation water by 50%. If industry failed to do this, there would be penalties, including increased charges for water, up to ten times the normal rate; flow restrictions would be imposed if the penalties were not sufficient. The fines and penalties are shown in Table IV. The Palo Alto plan observed that "There is a system for good faith variance for industry to minimize economic impact, but the intention is serious and action must be taken now."

### The Water Problem and Our Laboratory

In 1968 our laboratory consumed, or perhaps passed through, almost 130 million gallons — 490 ML (million liters) — enough to fill a lake of 397 acre-ft, and for that water we paid $48,300. That was a lot of water, a lot of dollars, and a lot more of both than really necessary for our operations, but in those days we were just waking up to water waste and like many others had many wasteful operations. Our first efforts to find where the water was being wasted and to do something about it were just common-sense measures:

1. Our processes (all running continuously from Sunday night until Saturday) were heated by running domestic hot water through a heat exchanger to the sewer. This waste was eliminated when we installed a steam-heated hot-water recirculation loop.

2. The Nash process air-compressors were sealed and cooled by running city water through them to the sewer, and here a recirculation loop with a cooling heat exchanger was installed.

3. Both high pressure air-compressors were also cooled by city water to the sewer, but now they are cooled by a chilled-water recirculation loop.

4. The refrigeration units that supplied chilled water had their gear boxes cooled with sewered city water, and this was changed so that they cool themselves.

5. Process machine washes were studied closely since they require a lot of water. To supply the washes, hot and cold water is mixed in a tank and then pumped to the process machines through a sand filter. We started automating this tempered-water system by adding a "water tree" with electrical solenoid and flow-regulation valves at each machine. These valves could be controlled directly by the machine operator. This automating took time, but it was important because the "manual" washes used a lot of water running on a Sunday through Saturday schedule.

6. Everyone started looking for drips and for leaks. Water-awareness was the word, and extra washdowns or needlessly running hoses were discouraged.

By 1972 consumption was down 60% to 54 million gallons (204 ML) (Fig. 3), despite substantial business growth. In addition, the annual water cost was held down to $23,100, despite a rate increase (Fig. 4). This was good, but could we do better? To answer that question we examined water usage in 1972 (Table V). Both the 40 million gallons (151 ML) used for operations and the 7.5 million gallons (28 ML) for landscaping seemed much too high.

We pushed even harder for employee awareness to stop the running-hose syndrome and then pressed ahead with wash automation on the machines not yet completed. The system was made even easier to use by tying into an existing automatic chemical replenisher system.

Machines that required a stand-by flow were reduced to the absolute minimum. On a machine like the Ektachrome autoprocessor, this meant a reduction from 9 to 2 gal/min (34 to 7.6 L/min).

Landscaping and the 7.5 million gallons it required got a long hard look. The problem was twofold: a nonautomatic sprinkler system that was poorly attended by the gardener and too much water-intensive planting. A plan was formulated to relandscape and to automate sprinkling. Large areas of lawn were replaced by trees and drought-tolerant ground cover to reduce water need and to provide cooling shade for the building.

The sprinkler system was automated with a solid state controller selected to provide maximum flexibility. The system was then refined by burying moisture-sensors in

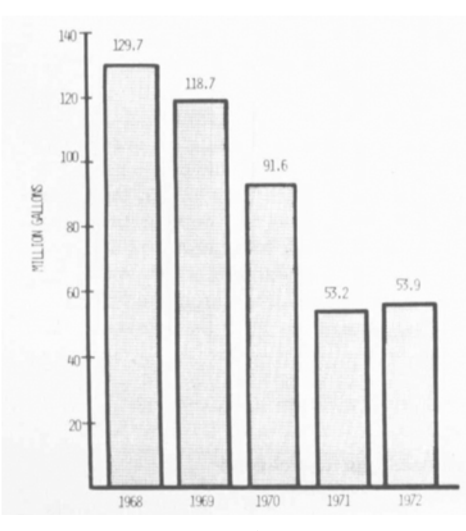


**Fig. 3. Water usage, 1968 – 1972.**

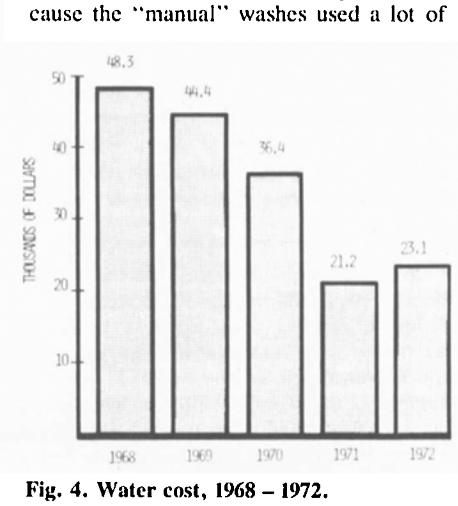


**Fig. 4. Water cost, 1968 – 1972.**

**Table V. 1972 Water usage (gallons).**

| | |
|---|---|
| Landscaping | 7,480,000 |
| Sanitary | 2,870,000 |
| Cooling towers | 3,010,000 |
| Boilers | 160,000 |
| Humidification | 417,000 |
| Process operations | 40,055,000 |
| Total | 53,992,000 |

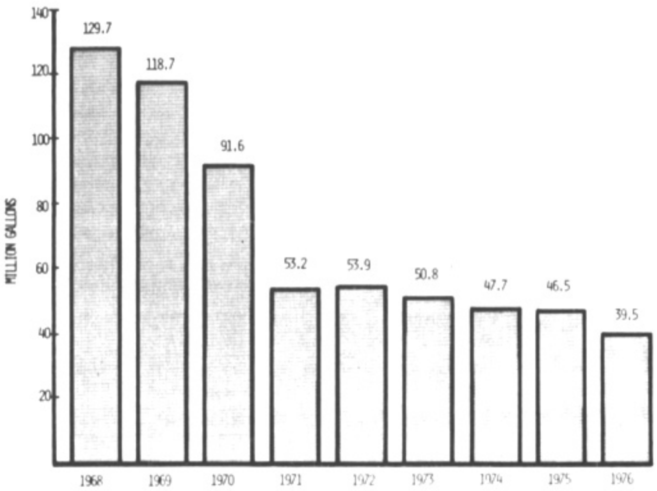


Fig. 5. Water usage, 1968 – 1976.

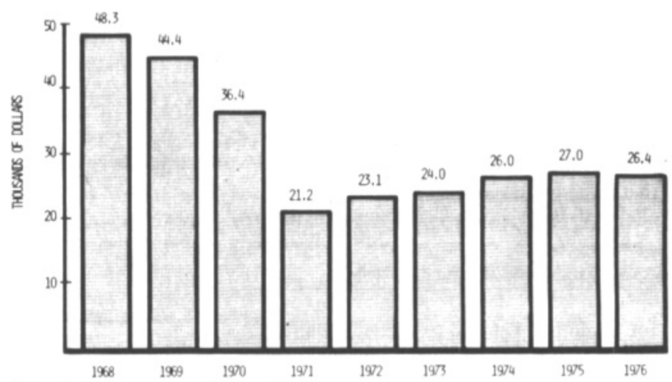


Fig. 6. Water cost, 1968 – 1976.

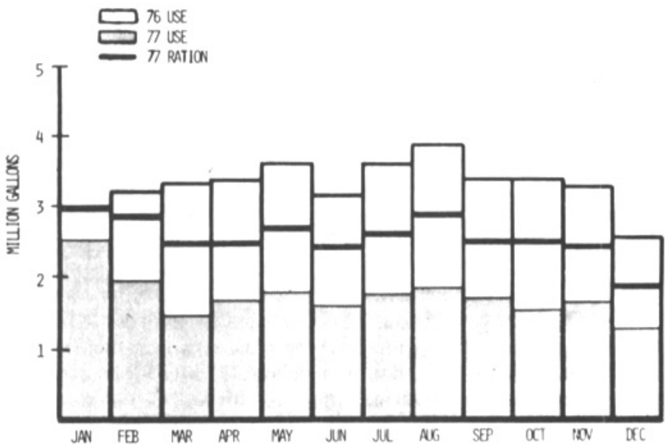


Fig. 7. Monthly water usage, 1976/1977.

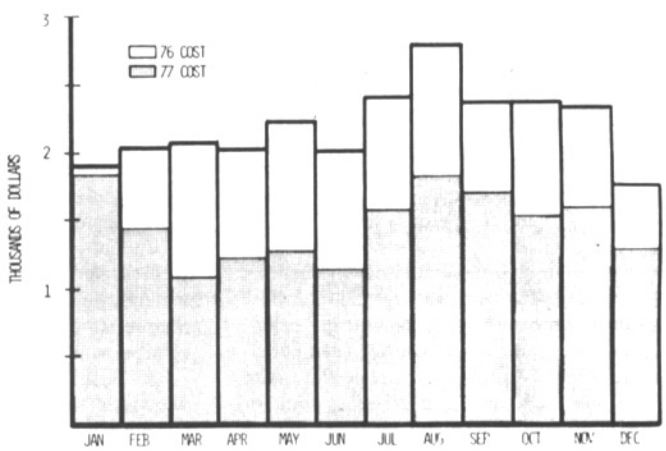


Fig. 8. Monthly water cost, 1976/1977.

the ground which turn on the sprinklers only when the soil is dry. As a further refinement, a rain sensor on the roof lets unneeded watering cycles be skipped. We expect this system to save more than 3.75 million gallons (14.2 ML) of water per year, or more than the 50% of the irrigation ration.

The awareness program, the continued process automation, and some relandscaping proceeded through 1976, and consumption continued to fall until at year end the total was 39.5 million gallons (150 ML) or 70% less than in 1968 (Fig. 5). This was achieved even though our production volume had never been greater. And despite more rate increases, water cost for 1976 was held to $26,400 (Fig. 6). Allowing for rate increases, if consumption had continued at the 1968 level our water costs would have been $272,800 higher for the eight years involved.

## Redoubled Efforts

As previously mentioned, by the end of 1976 the magnitude of water problem in our area was apparent to all, and at first a call went out for a voluntary 10% reduction in water usage. This was soon replaced by a mandatory 28% cutback for industry in Palo Alto. This meant that in 1977 our water usage was to be held to 28.4 million gallons (108 ML). Having already reduced consumption by almost 70% in eight years, we were doubtful that we could achieve another 28% reduction in one year, but we had no choice but to try. It was not evident just where we could save another 11.1 million gallons (42.0 ML), but we knew some would have to come from landscaping. Our studies continued.

It was stressed to employees just how much their jobs depended on water. We used the bulletin boards for tips. Signs were placed throughout the laboratory. *Palorama*, our local employee paper, also played its part. We needed everyone's cooperation.

Then we decided to measure actual process wash rates and found many flow-control valves to be over specification. For instance, a Kodacolor continuous process machine was using 7.8 gal/min (29.5 L/min) instead of 6 gal/min (22.7 L/min), and an internegative process was found to be 4.5 gal/min (17 L/min) over specification.

We also looked at the specifications themselves. From the days when water was cheap and inexhaustible, our paper process machine washes had always been run at a flow rate designed for 10-in-wide (25.4-cm) suitable for the average width, saving 5 gal/ paper. We reduced these washes to a rate min (18.9 L/min). In consultation with our technical staff we reduced the stop wash by 2 gal/min (7.6 L/min). Finally, we found that the stop wash could be supplied from the final wash, thus giving an overall reduction of 10 gal/min (37.9 L/min), an average savings of 45,000 gal/week, or well over 2 million gallons per year (7.6 ML/year).

To gain efficiency in other processes, we rescheduled small products into batched runs once or twice a week. We reduced rack wash rinse time to an absolute minimum, and of course, we began to realize the full benefit of the lawn program. Sanitary usage was looked at, and a "water watch group" was formed to watch over leaks, flushometer settings, etc.

Finally to keep better control of the program, we started calculating a water-use efficiency number that would compensate for changing production volume. In this case we considered efficiency to be proportional to the total square footage of product processed divided by the total water consumed in our laboratory. Comparing the first nine 4-week periods of 1976 to the same time span in 1977, water efficiency went from 0.0313 to 0.0534 $ft^2/gal$ (77 $cm^2/L$ to 131 $cm^2/L$) — a 70.6% improvement.

## Results and Conclusion

It is evident that our redoubled efforts also paid off; as can be seen in Fig. 7, we are well below the ration level, with an almost 50% usage reduction below the 1976 consumption. Also, the dollar savings still accrue, despite a 40% rate increase in July of 1977 (Fig. 8).

Our water-conservation program is continuing. Process specifications are under constant review, and in some cases further reductions in water use seem possible. We are fine-tuning the lawn system to find survival level. Our employees are aware and concerned and continue to bring in water-saving suggestions. We are studying "gray water" from the sand-filter back wash and from the cooling tower bleed-down, which amounts to over 3000 gal/day, and are using this water for irrigation. The ration level set by Palo Alto is 28% less than the 1976 consumption, but we expect to continue at nearly 50% less than that base rate.

Our program was not startling. It was based on sensible housekeeping and conservation rather than on "big technology" that might or might not have been economical. Our program has shown that where incentive, concern, and motivation come together to solve an immediate problem a great deal may be accomplished in a short time.

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# Television Studio Design — Signal Routing and Measurement

By DONALD ROURKE

**Conventional methods for routing signals in a television plant, with their associated limitations, may include patch panels, passive switching, and electronic routing switchers. The production-quality color television routing and measurement system concept discussed here utilizes a modern, standard production, video/audio routing switcher as the central system element. This system eliminates the need for testing through the production switcher (the conventional method) by providing facilities for accurate testing of all sources at the engineering area during full operation. This is of particular significance where unattended switchers are in operation. Other precision timing benefits become possible and practical, further reducing the number of chances for errors. The "path length accuracy" principle is demonstrated in a practical operational model.**

## Introduction

Routing signals in a color television plant while attempting to maintain path length accuracies to prevent color errors is an age-old problem for the television engineer. As an example, one foot of coaxial cable is capable of producing a visible flesh-tone error of 2° when introduced incorrectly or accidentally into a video line. A modern production facility may utilize more than 20 video/audio sources, providing many possibilities for errors. These sources will generally consist of recording/playback and processing equipment or input/output devices.

From a studio design and operational standpoint, the primary objective is to achieve conditions where signals from all of these sources arrive at the input of the production switcher (where mixing and effects with the sources are to be accomplished) with precisely the same timing. Timing must be considered in two components: synchronizing information (sometimes referred to as monochrome timing) and color timing. These components are interrelated but are generally treated separately.*

Monochrome errors are easily detected by horizontal shifts between consecutively switched signals. The tolerance for monochrome timing in a high quality, post production studio is as tight as possible for initial editing purposes because program material may be re-edited and any position shifts may not be acceptable. A minus B methods providing high accuracy will be shown for this purpose.

Generally, the color timing error is the greater problem encountered with production switching and signal routing systems. As stated earlier, 2° (1.5 ns) color errors during program assembly are visible and therefore unacceptable. The degree of accuracy required would appear to be something less than 1° (less than 0.77 ns). It is this type of accuracy on an overall system basis that one should expect to achieve.

Another equally important aspect of plant (studio) design is signal routing and distribution to and from all equipment. In order to accommodate real situations, it is required that source signals must change position from time to time, and in order to function efficiently and effectively, a television plant must be flexible in terms of inputs and outputs. As we shall see, the production switcher and the routing switching systems must be considered together in the overall plant design.

## Types of Routing

There are several methods available to the television engineer to accomplish signal routing. The oldest and most obvious method is the patch panel. With great care to detail, adequate accuracy within limitations is obtainable. An additional panel will be required for audio signals. Some disadvantages of video and audio patch panel switching include: excessive rack space; slow, nonsynchronous switching; no possibility for remote or computer control; greater chance for operator errors; the necessity for large numbers of distribution amplifiers; the increased probability of mechanical failure; and the unsightly cabling.

Another method of signal routing is passive switching. Passive switching is not recommended at video frequencies unless coaxial switches are used. In this case, the hardware limitations are prohibitive unless the systems are very simple. A separate audio panel will also be required.

The third and currently most popular method is electronic routing where all video and audio inputs can be electronically routed to any or all outputs. There are numerous standard production configurations available ranging from 5 × 1 to greater than

A contribution submitted on 28 June 1978 and in final form on 28 June 1979 by Donald Rourke, Television Engineering Consultant, P.O. Box 257, Wellborn, FL 32094. 

*A good source of additional information is the pamphlet "Timing Fundamentals in Color and Monochrome Television Systems," RCA Form 3J5689, available from RCA Broadcast Systems, Marketing, Bldg. 2-2, Camden, NJ 08102.