Water Supply Community Work Group (WSCWG) Report

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PROLOGUE

As a consequence of the historic drought of 2002, the San Juan Water Conservancy (SJWC) embarked on a series of activities that they believed would mitigate the effect of future droughts and resultant water needs. They determined that that a massive new water storage reservoir, aptly named Dry Gulch, was required, and submitted their proposal to the voters of Archuleta County. The voters promptly rejected this proposal.

Following the rejection of this initiative, the SJWC and PAWSD Board of Directors elected to pursue the purchase of the Dry Gulch site, utilizing a plan that allowed for the acquisition and development of the property, without voter approval. This surreptitious end-run of the taxpayers was led by Fred W. Schmidt; an individual with a tangled civil court record involving land deals, resulting in numerous judgments against him. Unfortunately, SJWC and the PAWSD Board largely ignored Mr. Schmidt's history of land dealings.

To justify the acquisition of the property, exaggerated forecasts of future water requirements were developed. These exaggerations were created through the manipulation of equivalent unit values, and by ignoring actual demand for treated water. To further justify the overstated water storage requirements, PAWSD assumed that the worst drought in recorded history (2002) would be followed by 365 straight days without a single drop of rain or a flake of snow falling on the San Juan watershed. If SJWC and the Board had adequately reviewed the project, and/or selected another person to be in charge of the proposal, there is a very good chance that Dry Gulch would never have been purchased, saving the ratepayers millions of dollars. In April 2010, Water Judge Gregory concluded that SJWC / PAWSD forecasts of water storage were grossly overstated.

The intensity and focus of PAWSD efforts on the Weber (Dry Gulch) land purchase created unintended collateral damage. Day-to-day operations of the district were ignored. As a result, water loss skyrocketed to 40% of the amount of raw water treated, and cost control measures were ignored. This lack of attention to day-to-day operations, conveniently contributed to the assumed "need" for additional reservoir storage. PAWSD encourages their customers to embrace this conservation. Yet, they seem to be oblivious to it in their own operations. They do not record, nor disseminate accurate water information. They have not followed critical recommendations, submitted by their hired consultants. E.g., Harris (1989) recommended immediate measurement of the water flow in Four Mile Creek. Over a decade later, PAWSD has not acted. Nor, has PAWSD sought senior water rights, per his later recommendations. At the April 12, 2011 Board of Directors meeting, Mr. Tautges announced that the district does not have the proper equipment to conduct pressure testing for leak detection. This is the latest of a litany of statements that PAWSD is not prepared to address water loss. His report follows repeated presentations on diagnoses failures, due to equipment malfunction or inadequate interfaces.

It should be noted that at the outset of the WSCWG deliberations in August 2010, several members supported the Dry Gulch plan, having assumed the accuracy of the assumptions provided by the board, and the missives that PAWSD posted on its website. These reports include "Appraisal Report to Evaluate Future Raw Water Demands and Water Supply Alternative Plans" (March 2001), "Estimated PAWSD Future Raw Water Demands" (Jan. 2007), and "Current Projections for Future Growth, Water Demand and Storage" (Feb. 23, 2009), as

well as the older reports. As WSCWG organized, Sheila Berger provided the critical data and supporting information that was used for this report. In an earlier report WSCWG addressed demand requirements by constructing rational forecasts of population growth.

In addition to evaluating alternative water resources, Group members have been active in the field. Dusty Pierce, a member of the WSCWG members discovered a "spring," in the course of his regular work. A PAWSD crew investigated the site, and discovered a large leak in the main pipeline. Dusty estimated the loss at approximately 5 gallons per minute, which is a loss of 246,000 gallons per month or 3 Mgal per year. This leak was not a new one, as exhibited by the extensive wetlands that it supported. On April 13, 2011, John Ramberg discovered a leak at the Pagosa Springs Medical Center, near south Pagosa Boulevard. PAWSD investigated immediately, and found one leak at the fire hydrant. A week later there is still at least one significant leak at this site. Several of our members have offered to assist and provide technical support, as requested. We repeat that offer.

Figure 0 provides an overview of the last decade. It gives the time trajectories of water treated (top), water delivered (middle) and water lost (bottom). The amount of water delivered, following a substantial decrease in the drought year, 2002, has remained essentially level. However, the water loss increased until 2010. The amount of water treated vacillated; any increases were due to loss, not demand. Until the economy rebounds, it seems unlikely that demand will increase significantly. In fact, if water loss is effectively addressed, the amount of water treated should go down. A value of 500 Mgal per year would seem to be an appropriate value, perhaps for the next decade.

The hiring of Mr. Edwin Winton as district manager is a step in the right directions. We hope that this report will provide Mr. Winton and the Board with a roadmap for a new direction for PAWSD.

Prior to specifying our recommendations, we present arguments, both for and against reservoir construction, followed by a statement of rationale or philosophy for the review of future projects, and facilities operation. This philosophy is in consonance with recent statements by Governor Hickenlooper concerning water planning for the state of Colorado. "In our house, you didn't waste anything. It's striking to see how casual water waste is, not just in urban areas but in every area of the state."

The case for reservoir storage: The primary reason for reservoir storage is to guarantee a water supply during drought periods. Variation in day-to-day and month-to-month demand during a normal year can also require storage to meet demands. In addition, reservoir storage allows water districts to meet firefighting needs, and to operate if a loss of a source occurs due to a pipeline break, or contamination, such as that caused by a forest fire.

The case against reservoir storage: When water is stored in a reservoir, a substantial loss takes place through evaporation and seepage. The amount of this loss depends upon the surface area of a reservoir. This is not just a loss to local users; it is a loss to all those requesting water downstream. Harris (2010) estimates that the annual loss on PAWSD reservoirs is roughly equal to the amount of treated water demanded. That is, when water is stored in a reservoir, in order to meet demands, double the amount of water demanded must be acquired. Water quality deteriorates during reservoir storage, and requires additional treatment, increasing costs.

A Water Reservoir Philosophy: PAWSD should access and treat fresh water directly from streams and rivers, wherever and whenever possible; it should do this by gravity, where feasible. Through this approach, the highest quality water will be delivered at the lowest cost.

Storage facility design capacities for District 1 should be limited the capacity required to meeting demand during drought conditions, when stream water sources are limited. Even under drought conditions, the West Fork is sufficient to supply fresh water for District 2 throughout the year.

The committee applied this rationale together with population growth forecasts, to assess the credibility of the Dry Gulch purchase, and we were astounded. We recommend that no additional money be spent on Dry Gulch, and that the property be sold.

The new priority for PAWSD should be to achieve a major reduction in water loss, and to implement cost control measures. To meet any increases in water demand over the next 25 years, we recommend that increases in water access and storage be constructed, only when clearly justified, and be located where needed.

We think that a major challenge for our new district manger will be to organize the operation, so that the authority for these improvement efforts is delegated and responsibilities made clear. A longer-term challenge is the need to change the "institutional culture." We urge the board to support him in this important task.

Our report is organized in a top down format, as follows. We begin with detailed recommendations for the improvement of PAWSD resource planning and operations. The conclusions that led to these recommendations are detailed next. For the reader, who would like addition information, we provide a discussion of each item. Appendix A provides the equations underlying our calculation of the impact loss. Appendix B exhibits the misleading spreadsheet being used by PAWSD. We prepared our document in this form so that a reader, who agrees with a specific conclusion, need not read further. Those desiring more information on a specific recommendation can read the corresponding conclusion statement, and further details in the numbered section of the discussion. Recommendations 1, 2 and 3 should be receive immediate consideration. WSCWG recognizes that PAWSD has initiated improvement programs, following preliminary reports by the water group, and that the WSCWG recommendations must be assessed in light of their work.

RECOMMENDATIONS:

1. Create an "instrument cluster" display of important water information, such as monthly loss percentage, and other pertinent information, reservoir levels, water content of watersheds.

2. Formulate a results oriented reporting scheme for water loss investigations; expand water loss studies; hire an outside water loss consulting service.
    a. Report explicit results for diagnostic measurement equipment installed at Lake Hatcher and Snowball Treatment Plants, specifying water losses, meter inaccuracies and recalibration results.
3. Install measurement equipment on Four Mile Creek and on the Dutton Ditch Diversion immediately to record daily flows for future planning.
    a. Investigate leasing and/or purchase of senior water rights on the Four Mile Creek; initiate negotiations for acquiring these senior rights, if necessary.
    b. Construct an extension of Dutton Ditch Pipeline from the northeast edge of Lake Hatcher directly to the treatment plant.
    c. Investigate supplemental reservoir storage, such as Martinez.
    d. Evaluate the economics of the construction of a water treatment facility plant at Stevens Reservoir.

4. Consider alternatives for accessing water from the portion of Lake Hatcher that is not available to the treatment plant.

5. Investigate senior water rights at the San Juan pumping site, downstream from Pagosa Springs, and initiate negotiations for purchase or lease of senior rights if current rights are inadequate or in jeopardy due to junior status.
    a. Investigate the cost effectiveness of constructing a turbine system to capture energy from the downhill flow of water, after he has been pumped over the ridge between the San Juan and the treatment facility.
6. Construct pipeline, as planned, to connect Lake Forrest to the San Juan Treatment Plant, and to gain access to the three other reservoirs of this system.
    a. Consider construction of a pipeline to directly connect the Dutton Ditch Pipeline at Stevens Reservoir to the San Juan Treatment Plant.
7. Investigate the replacement of the pipeline connecting the West Fork of the San Juan to the Snowball Treatment Plant. (Conflicts with the Dry Gulch plan.)

8. Investigate the renovation or replacement of the Snowball Treatment Plant.

9. Investigate the advantages of the construction of a pump station and pipeline from District 2 to District 1.

10. Investigate reservoir storage options for the West Fork, Turkey Creek and the confluence of Four Mile and Snowball Creeks.

CONCLUSIONS:

1. Reports on water losses and another critical information at board meeting have confusing and misleading. Posting the critical values from these reports could help staff focus on objectives, and might discourage the manipulation and misrepresentation of these values, and lead to transparency. Harris (2011) emphasizes the need to properly schedule operations of treatment facilities to maximize the availability of water during drought situations. Information for making decisions, based on the potential water supply, based on snow levels, reservoir levels, and stream flows, should be presented in comparison to historic levels. For example, the Durango Herald regularly posts the flow of the Animas River.

2. Water loss continues at a rate of <u>four</u> times that of comparable water districts. This loss, which averaged 40% over the last three years, means that the district must <u>access and treat 67% more raw water</u> than would be required if it were eliminated. The district incurs similar increased costs for operations, facilities construction, and capital equipment purchase. See Table 1 ~~and 2~~ and Figures 1 and 2 for the correct loss values, calculated from the PAWSD records. The values differ significantly (10%) from PAWSD verbal presentations (The Pagosa Springs Sun, April 14, 2011, byline Lindsey Bright), because they were not constructed according to water reporting protocol. See Appendix B for the misleading spreadsheet. 2a
    a. Despite the purchase of diagnostic equipment, as recommended by this committee five months ago, no meaningful outcome of these diagnostic experiments has been reported, nor has a report form been designed that specifies the outcome of

each investigation. When reports have been made, they focus on details, usually equipment and interface setbacks, and not on results. Reporting information should include results on metering mistakes, water loss discovery and correction, and calibration corrections. These results, if significant, should also be detailed on future monthly and annual reports.

b. At March board meeting, a staff member intimated that a reduction is water losses could mean an increase in water rates!

3. The availability of water from Four Mile Creek via Dutton Ditch Pipeline is uncertain and unknown. Harris (2011) found it necessary to "correlate" limited data on Four Mile Creek with comparable data for Vallecito Creek to make crude estimates for his 2000 – 2009 simulation study. Complete information is necessary for future planning.
    a. The 2002 simulation results show limited availability of water, during drought.
    b. Direct connection of this source to the treatment facility would reduce evaporation losses during drought periods, and provide clean water.
4. A large portion of Lake Hatcher water is not available to the treatment plant.
5. Harris (2011) questions the seniority of PAWSD water rights on the San Juan below Pagosa Springs. During the presentation of his report, he noted that the Bass senior right, that could jeopardize the supply of water during a drought.
    a. The current system requires pumping stations to raise the water over a 700-foot ridge, but no provision has been made to capture the energy that could be harvested from the flow of water down to the treatment facility.
6. The only source of water for the San Juan Treatment Plant is the San Juan River. The four-reservoir system is not accessible. Direct pipeline connections should be reviewed.
7. The pipeline supplying Snowball Treatment Plant from West Fork is old, and will need replacement in the future. Access to this pristine water source should be guaranteed for the future through timely replacement.
8. The Snowball Treatment Plant is old and will need upgrading or replacement.
9. There is only a limited capability for supplying water from one district to the other. Larger pipeline(s) and a pumping station are needed. The reliability of the system in the event of failures or loss of a water source demands consideration.
10. District 2 has no reservoir storage. Sites on the West Fork of the San Juan, Turkey Creek and the confluence of Four Mile and Snowball Creeks are possibilities.

Introduction:

Members of the Water Supply Community Work Group (WSCWG) visited and reviewed water sources, reservoirs, and treatment facilities. Several of the committee members have substantive experience in water systems, including PAWSD. Others are knowledgeable in statistical modeling and computer simulation.

The committee recommends that all plans and expenditures on creation of Dry Gulch Reservoir be postponed, and consideration be given to several enhancements of the water supply system, instead. These system enhancements can be accomplished over time, as needed, and as finances permit. The growth areas of the PAWSD districts will suggest the order.

The ability of PAWSD to supply its customer depends upon water sources, pipeline systems, facilities, and the planning of management. A failure in any part of this system will result in additional costs, and could mean water rationing for the community. Some of the enhancements will improve the reliability of the system so that PAWSD will be better able to respond to drought situations, and source interruptions. Dryburgh (2010) developed reasonable population and water demand forecasts. Huft (2010) gave a plan for sequential improvement of

the water system. Ramberg (2010) summarized water demand, production and losses over the last decade, and provided fundamental values for planning and forecasting.

The residents in District 1, the west side of Pagosa Springs, receive most of their water from Four Mile Creek via the Dutton Ditch pipeline to Lake Hatcher, and the Lake Hatcher Treatment Plant. They also receive water from the San Juan River below the town of Pagosa Springs, via the San Juan Treatment Plant. The water supplied to the residents of District 2, downtown Pagosa Springs, comes from the West Fork of the San Juan River via a pipeline to Snowball Treatment Plant. The West Fork and Four Mile Creek supply pristine water, requiring a minimum of treatment, and they do this by gravity, avoiding pumping expenses. While the former is a very dependable source, the latter is not. Hence, the need for a reservoir system. In addition to Lake Hatcher, the reservoir system includes Stevens, Pagosa, Village, and Lake Forrest Reservoirs. The latter have been called the four reservoir system is some reports.

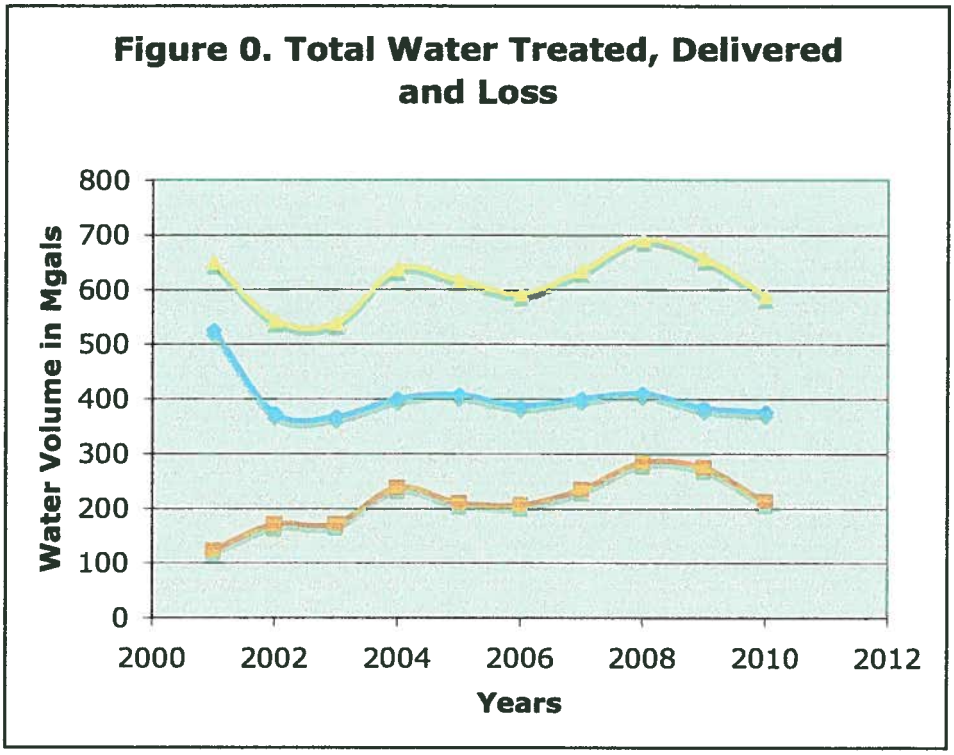
Construction is nearly complete on the replacement of the Lake Hatcher Treatment Plant. The completion of this facility, and the completion of the planned pipeline connecting Lake Forrest, and thus, the four-reservoir system, to the San Juan Treatment Plant, will provide sufficient access to water during droughts, and the redundancy to make the system reliable.

The San Juan River source requires pump stations to lift the water about seven hundred feet over a ridge, where it flows by gravity to the San Juan Treatment Plant. This source further improves the reliability of the system for District 1, and serves as a backup for District 2, with the two caveats, discussed by Harris (2011). We will address these critical caveats later. Incidentally, turbines could capture the energy from this flow.

District 2 has no storage, and PAWSD must rely on District 1 sources as a backup. However, barring a major failure, the West Fork source adequately addresses short-term variation, as well as droughts. Upgrading of this system should allow it to meet demand for the next twenty-five years.

Year	Delivered	Loss	Treated	% Loss
2001	525	124	649	19
2002	373	170	543	31
2003	367	172	539	32
2004	400	238	638	37
2005	407	210	617	34
2006	387	206	593	35
2007	400	234	634	37
2008	409	283	692	41
2009	384	274	658	42
2010	376	212	588	36

Table 0. Water Treated, Delivered, Loss and % Loss - 2001 to 2010



Discussion:

Over the last decade, while PAWSD focused attention on Dry Gulch Reservoir, alternative solutions to future water requirements, including the reduction of water loss were ignored. Forecasts of future water requirements were radically over stated for this reason, and through the unorthodox use of a little understood term, equivalent unit (EU). Population, the accepted measure for prediction of future demand, was ignored. Unfortunately, EU values, while useful in assessing water charges, can be and were manipulated, to create inflated forecasts for the treated water production requirements.

A local leader, determined to create a problem for which he had the land solution, promulgated "chicken little" paranoia in the community. He did this following a negative vote on the proposition by the community. He procured a forecast (Harris, 2002), based on false assumptions. When the PAWSD board did not properly review the forecasts, decisions based on fear, not fact, resulted. The board ignored community input, and proceeded to purchase the Dry Gulch property.

The WSCWG questioned these assumptions and forecasts, prepared factual summaries, presented accurate water demand forecasts, based on reasonable population growth models, and created alternative ideas for expansion. The demand forecasts are considerably lower than those that aroused the boards' fears over the last decade, and the alternative expansion plan is flexible and cost effective. The majority of the current board members, through their recent actions, seem to have acknowledged, and accepted previous reports. PAWSD is currently correcting their definition of EU values, to conform with recommended guidelines.

1. Many agencies, industrial and governmental, now present important decision variables in a format similar to that of an automobile or an airplane cockpit dashboard. PAWSD staff should go through the exercise of defining the important information that is necessary for their operation

decisions. For example, Harris calls attention to the importance of utilizing the San Juan River source early in the year, if mountain precipitation levels indicate the potential for drought. Other information such as reservoir levels is also relevant. Elaborating other important information sources could be informative. PAWSD should also follow standards for reporting operation information. Since the water group drew attention to the high level of loss, spreadsheets have been devised. These spreadsheets purport improvement, but are deceptions. They even confuse PAWSD employees when they provide information.

2. The most important finding by WSCWG Committee 1 is the recurring loss of 40% of amount of treated water produced, the fallacious notions concerning the reasons for this loss, and PAWSD's history of accepting the loss and minimizing its importance. This loss contributed to the justification of Dry Gulch Reservoir, because it alone increases projected water needs by over fifty percent, as will be explained.

Over the last decade, demand for treated water, while variable, has been essentially level. Meanwhile, the amount lost has not only grown, the percentage loss has grown! Over the last three years these losses have averaged 40%! Comparable water districts report their loss as less than 10%. Thus, PAWSD treated water loss is <u>four</u> times the loss of comparable districts. Appendix A details loss calculations and statements, and gives the standard practice for loss reporting. Recently PAWSD began to deviate from this practice. It should return to the standard form, rather than creating a questionable approach. E.g., at the April 13 meeting water loss percentage was reported as 31%. At the same time I received an email reporting loss at 14%. Neither was correct. Properly calculated the water loss percentage was 40%. It was through similar practices that faulty forecasts led to the Dry Gulch debacle. See Appendix B for the confusing calculation in the spreadsheet.

To set the record straight, water districts should report their loss straightforwardly, as

Water Loss (L) = Water Treated (WT) - Water Delivered (WD)

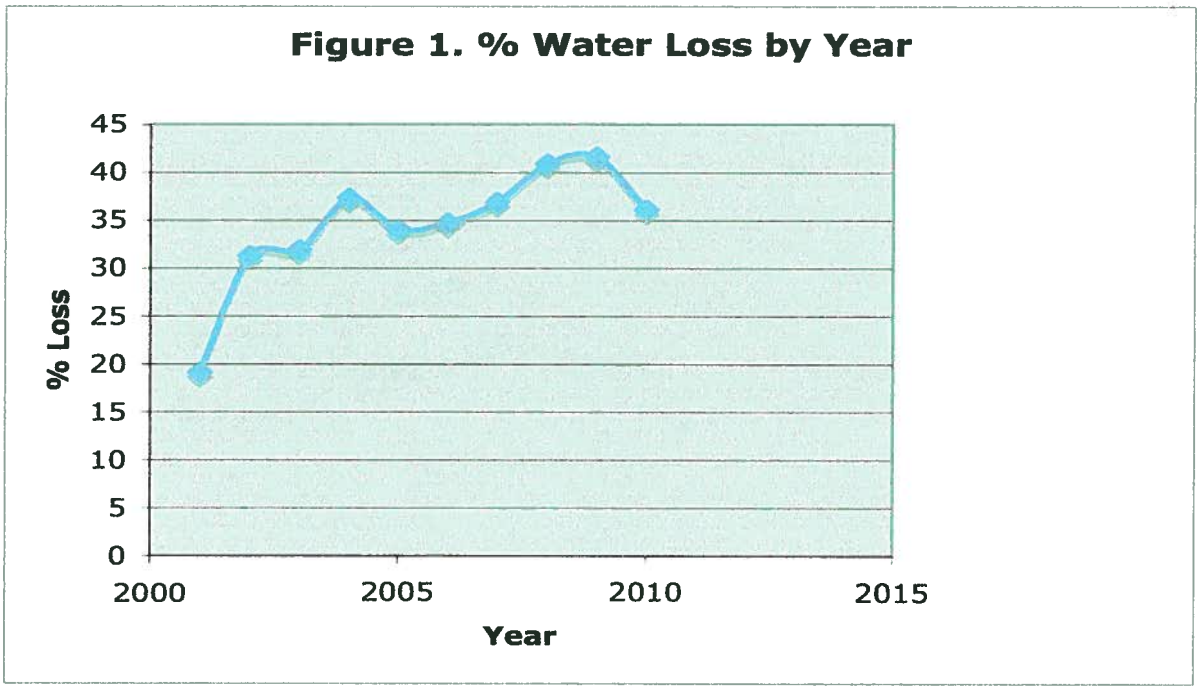
followed by the percentage loss

$$\%L = 100 \bullet \frac{TW - DW}{TW}$$

This simple calculation facilitates fair comparisons between districts. PAWSD has created a confusing calculation in a planning document; they allow an unjustified percentage for internal losses, a percentage that exceeds the total losses reported by many other water districts. To this percentage loss they add on another unreasonable loss percentage.

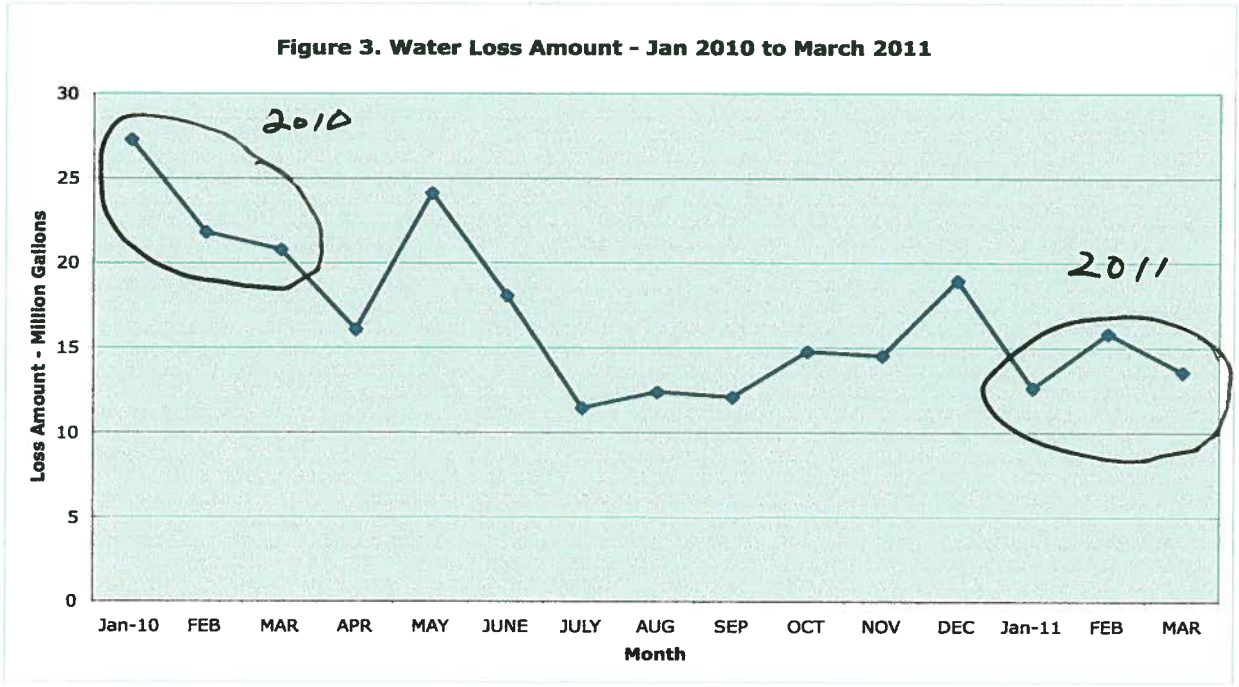
Table 2 provides water production, the amount of water sold, the amount of water loss, and the percentage loss by month in Mgal for January 2010 to March 2011. The data for 2011 were just received, and they provide the first real evidence, that water loss is getting smaller. E.g., by comparing the first three months of 2011 with the same period in 2010, it appears that the loss has dropped by 10%!

By plotting the amount of water treated, the amount of water demanded, the amount and percentage of water loss, all by month as in Figures x,xx,xxx,xxxx, one can learn a lot about the current situation. Figure 2 suggests that amount of water treated is lower in the first quarter of 2011 than in 2010. Figure 3 shows that the amount of water loss declined in 2010 and has remained relatively constant since July 2010.



Month	Prod	Sold	Lost	% Lost
Jan-10	50.6	23.3	27.3	53.9
FEB	43.6	21.8	21.8	50.0
MAR	41.5	20.8	20.8	50.0
APR	37.5	21.9	16.1	42.8
MAY	52.0	27.9	24.1	46.4
JUNE	75.9	57.9	18.1	23.8
JULY	72.7	61.3	11.4	15.7
AUG	49.9	37.5	12.4	24.8
SEP	47.5	35.4	12.1	25.5
OCT	42.5	27.7	14.8	34.8
NOV	35.7	21.1	14.5	40.7
DEC	39.1	20.4	19.0	48.4
Jan-11	37.3	24.6	12.6	33.9
FEB	36.9	21.1	15.8	42.9
MAR	33.6	20.1	13.6	40.4

Table 1. Monthly Production, Sold, Lost and % Lost by Month in Mgal - Jan 2010 to March 2011



The impact of losses is even greater than if first seems. A 40% loss means that 67% more water must be treated than if there was no loss. If the 40% loss was reduced to the 10% level achieved by other districts, then the reduction in the amount of treated water production would be 56%. This means that the district incurs 67% more in operational costs associated with the treatment of raw water. This water is not simply wasted; it is not available to this district, nor is it available to others on the San Juan / Colorado River. Each time PAWSD makes a projection on capital and operating costs, they plan for over half again as much as would be needed if they were able to achieve the performance of comparable water districts.

Legitimate planning for the future is impossible under current water loss conditions. The monthly water losses for 2010 reveal a process that is statistically "out of control." This means that future losses are not predictable. It also means that statements made by staff, based on monthly values, such as those reported at the February 2011 meeting, are meaningless.

PAWSD staff continues to state that the major source of losses of treated water is over registration by PAWSD meters, which they term a "paper loss." That is, they state that the PAWSD meters are over registering the amount of water treated. Until they abandon this notion, they have little chance of learning the real problem and solving it. Whether the loss is a paper one or not, any substantive loss has a huge impact on planning.

To dispel the notion that the loss is a paper one, we give the following analysis based on PAWSD data. If "meter over registration" were a major factor, then the amount of water lost would increase as the amount of water treated increases. The 2010 monthly data, Figure 2a, show that it did not! In fact, the loss during the months of highest production is lower than during months of low production! This means that alternative explanations should be evaluated. Rather than speculate on these causes, we suggest that studies be conducted to investigate their origin. The only way to do this is to conduct experiments through intervention, such as the use of the "strap on meters." This committee recommended the purchase of equipment for performing these experiments; the equipment was purchased. Unfortunately, this equipment has not been used in a manner appropriate for diagnosis, nor were any results reported in a reasonable engineering form, such as leakage amounts or meter discrepancies.

We repeat our request that staff report the results of their studies of the meter accuracies and precision in engineering terms. To date, haphazard reports detailing software and hardware glitches, with no documentation on losses have been the pattern. The reports have been a distraction to the board.

3. The Harris report (2011) provides a base for comparison of the utility of proposed projects. His report provides a benchmark for natural water supply, the three-year period that includes the 2002 drought. Simulation of this three-year period allows a crude review of each proposal for improving the system. Hence, it facilitates the assessment of the contribution to alleviate the results of a severe drought. (Some as a 100 to 200 year worst-case scenario has stated that drought.) As a caveat to his analysis / conclusions, carefully stated that his results are based on very limited data and that he was forced to extrapolate Four Mile Creek results, by using values from the Vallecito water shed. Hence, it calls attention to the importance of immediately establishing appropriate measurement operations on Four Mile Creek, to provide a benchmark based on actual data. He also stresses that this source is limited by the nature of PAWSD senior water rights.

The Harris simulation addresses PAWSD District 1. District 2 has no storage, and therefore was not modeled. He treats District 1 reservoir storage in two parts, the Hatcher Reservoir and the Stephens Reservoir System. The latter also includes Pagosa Lake, Village Lake and Lake Forrest. PAWSD plans construction of the infrastructure to connect these five reservoirs and the San Juan Treatment Plant for 2011. The data extracted from Harris report provides interesting results. Mr. Harris provided an Excel simulation file, from which Ramberg summarized the following.

Figures 3 and 4 show the dynamic availability of raw water from Four Mile Creek, via the Dutton Ditch pipeline for 2002 and 2008. It is important to understand this dynamic over the year. Annual total supply could exceed the annual total demand, yet water might not be available at a specific time of year when it is needed. This is a reason for reservoir storage. It is also a reason, as we previously stated, that PAWSD should immediately begin to measure and record these values on a daily or weekly basis.

In the drought year of 2002, the water availability from the Dutton Ditch pipeline was limited to about one month in April, and about seven weeks in November and December. This is probably the smallest amount of water that was ever available, and for the shortest duration of time. The total amount available for the year was only 1552 AF.

In 2008, a year of adequate precipitation, the total amount of water delivered through the Dutton Ditch pipeline for the year was 3591 AF, which is over double the mount that was delivered in 2002. There were short periods in April, July and August of zero flow, again illustrating the need for storage, and / or acquiring additional senior water rights.

In the Harris simulation, the four-reservoir system was started, as full at 3540 AF in 1/1/2000 as was Hatcher, at 798 AF. The four-reservoir system dropped to about 1700 AF in the summer of 2002. Then in the summer of 2003, despite reasonable winter snow levels, the four-reservoir system dropped even further to about 1500 AF. Its minimum value in the next year was 2000 AF. After that, it peaked at full capacity of 3540 AF each winter and oscillated between that value and 3000 AF year at low stage, a 500 AF range.

To understand these numbers in terms of demand for treated water, the conversion from Acre Feet to Mgal is to divide by 3.07. Hence, the values for 2002 and 2008 are 506 Mgal and 1169 Mgal, respectively. These values compare with the total PAWSD demand for treated water for <u>both</u> districts of 373 Mgal and 409 Mgal, respectively. That is, over the full year, there was

sufficient water from the West Fork alone to supply both PAWSD districts if treated water losses were reduced to acceptable values. The dynamic nature of the supply shows a different result.

The Lake Hatcher part of the Dutton Ditch pipeline terminates at the northeast shore of Lake Hatcher. Extending this pipeline to the treatment plant would reduce evaporation losses and provide the plant with water that requires much less treatment.

4. The Huft (2010) report details the advantage of constructing access to water currently not available from Lake Hatcher, as well as a number of other small projects that could provide water for near term demand growth.

5. Harris expressed concern, his second caveat, about PAWSD water rights on the San Juan River below Pagosa Springs. In his presentation, he mentioned the Bass properties, and commented on their potential plans for using their water rights. He indicated that these rights might be senior to those of PAWSD. Hence, the seniority of PAWSD rights should be evaluated as soon as possible. It is imperative that PAWSD obtain senior rights, if current rights are not. Incidentally, consideration should also be given to exploiting the energy lost through pumping the water over the ridge to the San Juan Water Treatment Plant, and in other parts of the system. Because of the drop from the ridge down to the San Juan Treatment Plan, the water flow exceeds the handling capacity at the plant. The excess water from this source overflows into Village Lake, and is essentially lost.

6. Planning has been done and construction should begin in the near future on the connection of the reservoir system to the San Juan Treatment Plant. This report assumes that these projects will be completed in a timely manner.

7&8. PAWSD has evaluated the cost for upgrading / replacement of the Snowball Treatment Plant and the pipeline supplying it. These plans should be updated and a statement prepared concerning the timing of these projects. The reliability of these operations is critical since there is no reservoir storage. The gravity feed of water from the West Fork to the Snowball Treatment Plant, and then to District 2 users makes this a cost effective system.

Fig 4a

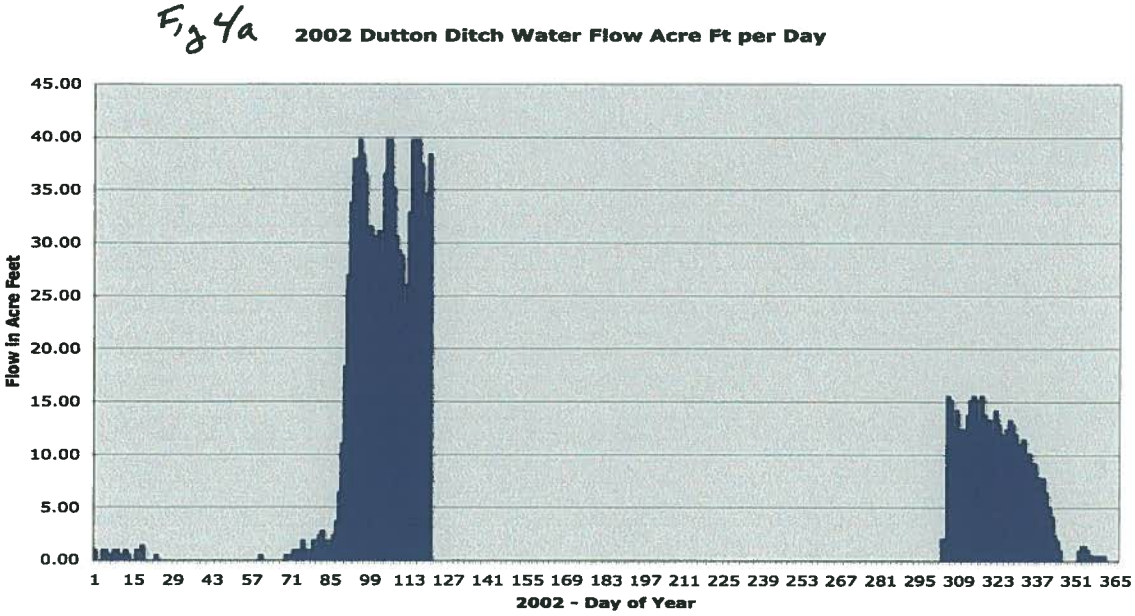
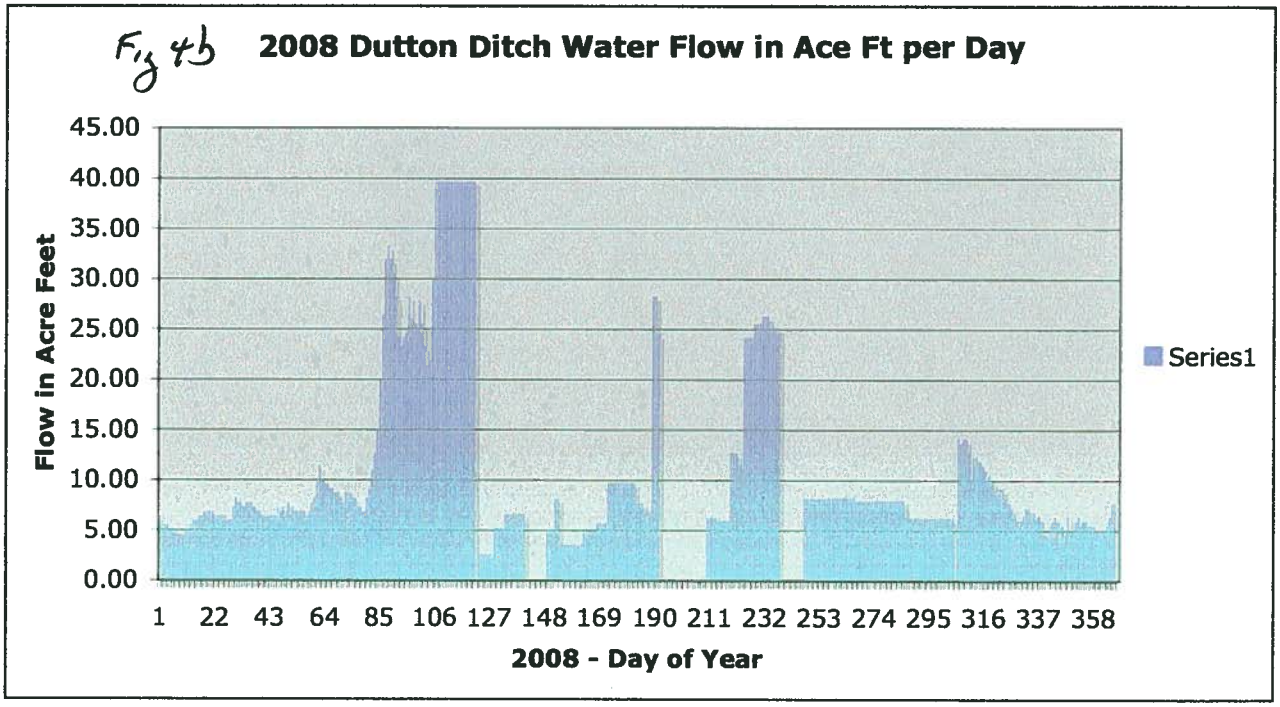


Fig 4b



9. There is a limited capability for transferring water from District 1 to District 2. This capability should quantified to learn if District 2 demand can be satisfied in the case of a major failure in its primary supply system. Then recommendations should be prepared for enlarging the capacity if this is deemed necessary. The reverse is not true. Since District 1 has two sources and reservoir storage, is not as important as the former. However, it is more economical to supply District 1 with treated water from the Snowball Plant, then to pump untreated water from the lower San Juan River over the ridge to the San Juan Treatment Plant. This capability would greatly increase the reliability of water delivery throughout PAWSD Districts 1 and 2.

10. Committee members suggested a number of alternate sites for reservoir storage of raw water, which seem to have discarded in the rush to purchase the Weber property. Thee include

Martinez, Turkey creek and the confluence of Four Mile and Snowball Creeks. Many of the committee members have knowledge of many water issues. Perhaps the only way to gather this knowledge is for a member of PAWSD staff or board, to conduct interviews.

Appendix A. The Impact of Water Loss

What is the impact of a 40% water loss? It is much more than 40%! It means that PAWSD must:

- acquire 67% more water!
- construct 67% more facilities!
- purchase 67% more capital equipment!
- buy 67% more treatment chemicals!

and PAWSD customers must pay for this through increased water rates!

This can be understood as follows. Suppose we denote treated water by *TW*, demanded water by *DW*, percent water loss by *%L*, and the percent of additional water that must be obtained and treated as *%REQ*. Then

$$\%L = 100 \bullet \frac{TW - DW}{TW}$$

This is the equation employed by agencies such as Western Water Resources and others to compare the operational effectiveness of water districts.

Through a bit of algebra, we have

$$\frac{\%L}{100} \bullet TW = TW - DW \quad \text{or} \quad \frac{\%L}{100} \bullet TW - TW = -DW \quad \text{or} \quad TW - \frac{\%L}{100} \bullet TW = DW$$

The result is $$TW = \frac{1}{\left(1 - \frac{\%L}{100}\right)} \bullet DW$$

That is, the percent of water that must be secured or is required, %REQ, is

$$\%REQ = \frac{100}{\left(1 - \frac{\%L}{100}\right)}$$

Since the percentage water loss for PAWSD is 40%, the *%REQ* is 167%. Comparable water districts report water loss at 10%, and their *%REQ* is 111%. Hence, a savings of 167% - 111% or 56% is a reasonable goal. The following table provides these calculations.

% Loss	% Required
10	111
20	125
30	143
40	**167**
50	200

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