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First Fundamental Step(s) Towards Improved Urban Water Sustainability and Reliability:

UNSOLICITED PROPOSAL FOR AN ECONOMICAL HIGH-PRECISION LARGE WATER FLOW CALIBRATION FACILITY TO BE ESTABLISHED AS A PUBLIC-PRIVATE PARTNERSHIP FOR THE PURPOSES OF CONSERVATION OF WATER, RECOVERY OF NON-REVENUE/LOST WATER, TO FACILITATE ACCURATE/MEANINGFUL WATER AUDITS AND WATER PIPELINE INFRASTRUCTURE LEAK DETECTION / PRIORITIZATION

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ABSTRACT

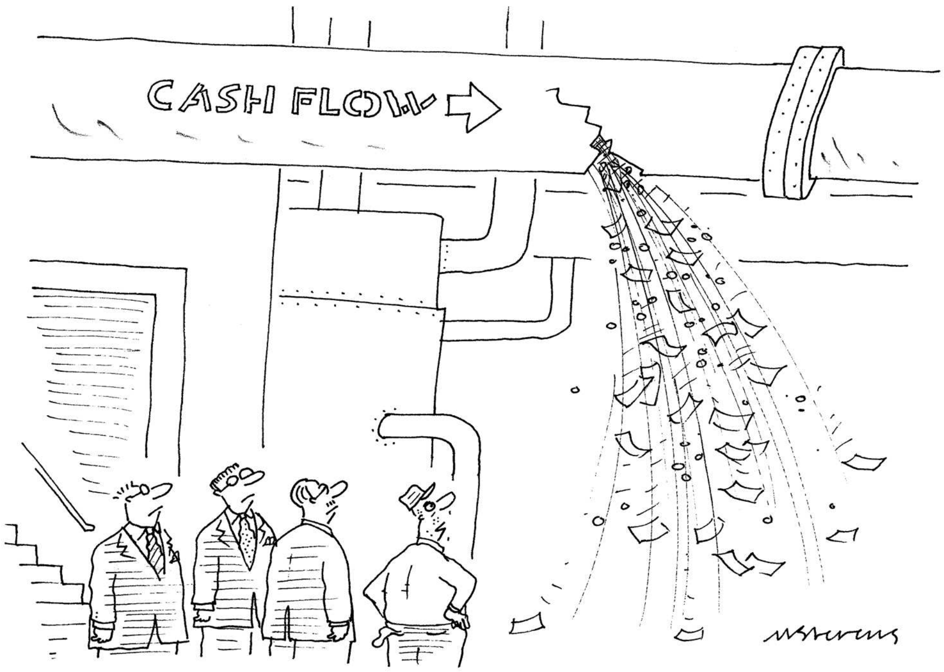
The average distribution system water loss is 22.6% per the American Water Works Association, whereof up to 75% is theoretically recoverable per EPA estimates. An April 2018 analysis of the 2016 California water audit estimated the value of the 2016 statewide recoverable water to be $131,522,263. The oldest municipal infrastructure are the water mains, now the greatest leakers and and failing with ever increasing frequency. Especially in view of California's water shortages, growing population, and aging water infrastructure, the minimization of water loss is of the highest priority — reducing the need for large scale public water conservation, minimizing the need to find new water sources, keeping consumer costs reasonable, facilitating economic growth, etc.

The key to water sustainability is reducing the difference in quantity between available supply and actually delivered water. Noting that the recovery of lost water is the least expensive form of "new" water, this document proposes a high precision water flow calibration facility for large municipal water distribution meters, thus providing the ultimate — and rigorous — basis for a comprehensive approach to municipal water infrastructure management: *accurate and reliable water metering and audits, with the goal of optimizing water consumption, eventual/future water pipeline infrastructure leak detection and location using rigorous and proven mass/volume balance methodologies, and prioritization of water distribution pipeline repair/replacement.*

NOTICE

This unsolicited proposal is submitted under the guidelines/provisions of the Federal Acquisition Regulation (FAR), Subpart 15.6, for unsolicited proposals.

Per FAR 15.6: This proposal includes data that shall not be disclosed outside of the evaluating agency and shall not be duplicated, used, or disclosed — in whole or in part — for any purpose other than to evaluate this proposal. However, if a contract is awarded to the offerer as a result of — or in connection with — the submission of these data, the agency shall have the right to duplicate, use, or disclose the data to the extent provided in the resulting contract. This restriction does not limit the agency's right to use information if they are obtained from another source without restriction. The data subject to this restriction are contained in Section 3 (Pages 3-1 and 3-2) and in Appendix 1.



"Well, gentlemen, there's your problem."

This proposal is available in electronic distribution format as
QD_WaterCal.pdf

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1. Introduction: Briefing for Water Policy Makers, Environmental and Legal Background

Global warming, changing weather patterns / drought,[1] increasing population, and leakage from aging / rapidly deteriorating water supply systems are presenting challenges to the World's — and specifically California's — water supply infrastructure.

> "Water loss is a particularly important issue in California, where approximately 96% of the population is served by public water suppliers."[2]
>
> "44% of all U.S. water infrastructure is near the end of life or failing and within the next ten years will be out of life. Over 20% that we have treated, we put into pipes and it just leaks."[3]

The oldest parts of any municipal infrastructure are its water mains. Not only do these systems leak the most water over prolonged periods of time, but their failures cause the greatest damage: loss of water supply for entire areas of cities, potholes and street cave-ins that obstruct traffic, and potential health hazards due to ingress of polluted water during repairs. The water loss leads not only to critical water shortages during drought periods, but also continuous wasting of water processing and transportation costs — with the resultant higher consumer costs.

The gravity and impact of the water supply problem on health, food supply, energy, jobs, etc., is clearly stated in numerous analysis publications.[4] These analyses point out not only looming water supply problems — and resulting geo-instability that they cause — in third world countries, but also in California.

- In 2015 EPA estimated that California will expend a minimum of $44.5 billion for water infrastructure improvements during the next 20 years to insure safe drinking water.[5] Said figure does not include the possibility of climate change related water shortages, nor any related costs for damages due to water infrastructure failure, loss of revenue during pipe repairs/replacement, etc.
- CA SB 555 now requires annual reporting, beginning in 2017, thus daylighting this important information on water leaks and losses annually, rather than every 5 years as in the past. The American Water Works Association (AWWA) water audit software is commonly used to provide the framework for such audit.
- CA SB 1420 requires that all suppliers include a quantification of distribution system water losses in their respective urban water management plans.
- Directive 5 of Governor Brown's Executive Order B-37-16 "Making Water Conservation a California Way of Life" (May 2016) calls for the California Department of Water Resources and the Water Board to "direct actions to minimize water system leaks that waste large amounts of water."

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1. It should be noted that a recent scientific study indicates that the Western United States are likely entering the worst megadrought in centuries. Park *et al.*, "Large contribution from anthropogenic warming to an emerging North American megadrought", *Science* **368**, AAAS, pp. 314 - 318 (17 April 2020). Therein, based on the analysis of 1,200 years of tree rings and comparisons with several recent decades of soil moisture measurements. a team of noted climatologists and paleo-climatologists conclude that the western North America climate is trending towards the worst megadrought since 800 AD.

2. Natural Resources Defense Council (NRDC) report www.nrdc.org/sites/default/files/wat_14111801as.pdf.

3. Susan Story, CEO of American Water, the Nation's largest investor-owned water utility company, on Fox Business, December 12, 2018, 6:14, www.youtube.com/watch?v=yOiWGxwh1xU

5. *Drinking Water Infrastructure Needs Survery and Assessment: Fifth Report to Congress*, EPA 816-R-13-0006, Exhibit 2.1, www.epa.gov/sites/production/files/2015-07/documents/epa816r006.pdf. Costs are in unadjusted 2011 dollars.

- Directive 7 of said Executive Order of B-37-16 also directs the California Energy Commission to evaluate options for water loss detection and control technologies that also increase energy efficiency.

  By minimizing water loss, energy expended for water transportation, pumping, etc., is reduced. E.g. elimination of a 10% loss of water due to leakage results in a 10% reduction in pumping costs.

- Directive 7 of EO B-37-16 is again re-enforced by Directive 7 of Governor Brown's EO B-40-17 (April 2017), demonstrating the clear and continuing importance of minimizing water leaks.
- The City of Los Angeles' Executive Directive No. 5 establishes a Water Cabinet that is to focus on long-term issues, the first of which is "Increasing local water supply via an integrated water strategy."[6]
- Govornor Newsom's recent (April 29, 2019) Executive Order N-10-19 directs California agencies to prepare a water resiliance portfolio that meets the needs of California through the 21st century.
- In the January 2020 California Department of Water Resources Report to the Legislature *Recommendations for Urban Wholesale Distribution Systerms Water-Loss Audit Reporting* the second and third bullet points of "Section 3.0: Primary Issues" specifically call out *the need "for accuracy flow testing on large delivery meters"*, noting that *"urban retail water suppliers are particularly concerned about the accuracy of the large meters that determine water input values"*, while "Section 4.0: Recommendations", Item 2, directs DWR to establish large meter testing protocols.

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4. Publications dealing with the implications of water shortages/loss include, for example:

   - The implications of the instability and threats caused by water shortages is the number one concern in the United States Intelligence Community Assessment ICA 2012-08, *Global Water Security*, www.state.gov/e/oes/water/ica/index.htm: "We assess that during the next 10 years, water problems will contribute to instability in states important to US national security interests. Water shortages, poor water quality, and floods by themselves are unlikely to result in state failure. However, water problems — when combined with poverty, social tensions, environmental degradation, ineffectual leadership, and weak political institutions — contribute to social disruptions that can result in state failure."

     "Global water crises — from drought in the world's most productive farmlands to the hundreds of millions of people without access to safe drinking water — are the biggest threat facing the planet over the next decade." — World Economic Forum (Davos 2015), www.weforum.org/agenda/2015/01/why-world-water-crises-are-a-top-global-risk/

     "Water is the ultimate systems challenge. It is a unique resource that underpins all drivers of growth â be it agricultural production, energy generation, industry or manufacturing. It also connects these sectors into a broader economic system that must balance social development and environmental interests." — World Economic Forum (Davos 2018), www.weforum.org/projects/global-water-initiative

     "The water supply crisis is considered to be one of the biggest risks to society over the next decade." — World Economic Forum (Davos 2019), www.weforum.org/reports/WEF_Global_Risks_Report_2019.pdf

     Note that such concerns apply equally to California — one of "the world's most productive farmlands" — affecting its economic growth and business prosperity, and the ability to sustain the water needs of its population.

     Additionally, the Directorate of National Intelligence's *Global Trends 2030*, http://www.dni.gov/files/documents /GlobalTrends_2030.pdf, which among other future issues facing the world, lists the "growing food, water, and energy nexus" as one of its most important "Megatrends."

   - "Water, therefore, is the ultimate global connector in the global commitments towards a sustainable future: the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) are highly dependent on improved water management." The United Nations World Water Development Report 2020 *Waterand Climate Change*, https://unesdoc.unesco.org/ark:A/48223/pf0000372985.locale=en
   - EPA's *Water Audits and Water Loss Control for Public Water Systems*, www.epa.gov/sites/production/files/2015-04/documents/epa816f13002.pdf.
   - The AWWA publications on water loss and audits, e.g. *Water Audits and Loss Control Programs*, etc.

Per Sturm and Thornton's treatise on water loss control:[7]

"It is the main responsibility of the water utility to manage both the demand and supply of water responsibily and efficiently. ***Distribution side conservation through reduction and efficient management of water losses provides real advantages to a water utility.*** These benefits include:

- ***Most effective and economic way of reducing level of losses from distribution system***[8]
- Improved public health protection
- Increases the level of service provided to customers through increased reliability of water supplies
- ***Leakage recovery often stands as the best source for new water resources for systems facing water supply shortage***
- Reduced pressure on water resources and therefore environmental improvement
- Deferment of capital expenditure on water resources and supply schemes
- Improved public perception of water companies
- Applying ***best leakage management practice*** reduces liability to water supplier."

A water distribution system's water loss is the quantitative difference between the water input into the system and the water actually consumed/used. Leakage in a pipeline section is the difference between its input measurement and its output measurement.

Clearly, one of the most basic ways of leakage management is to improve measurement — and the basis of good measurement ALWAYS rests on the ability to provide accurate and reliable calibration of the measurement systems themselves. This is a basic tenet of all quality management systems, as pointed out in ISO 9000/9001/9002.

WHAT IS CALIBRATION AND WHY IS IT IMPORTANT?

Calibration is the process by which a measurement instrument (Unit Under Test = "UUT") is compared to a standard of known accuracy/uncertainty to determine the UUT's bias/error with respect to the known uncertainty of the standard. Obviously, the lower the standard's uncertainty, the better the accuracy of the UUT can be determined — *and the sooner leakage can be determined.*

Once one knows the bias of the UUT,

1. It can be adjusted to conform to the accuracy of the standard, within the UUT's repeatability; or
2. If the UUT is deemed to be adequate for its intended operation, but its readings cannot be adjusted, then its readings can be numerically adjusted *ex post facto* during the subsequent processing of its data; or
3. If the UUT is deemed to be inadequate or irreparable for its intended operation, then it must be replaced.

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6. ED_5_-_Emergency_Drought_Response_-_Creating_a_Waterwise_City.pdf, https://www.lamayor.org/mayor_garcetti_s_executive_directives

7. Sturm, R. and Thornton, J.; *Water Loss Control in North America: More Cost Effective Than Consumer Side Conservation*; www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=2626. (Italics by author of this proposal.)

8. The recovery of water that would otherwise be lost to leakage is orders of magnitude less expensive than producing desalinated water. *Why produce desalinated water and then put it into water distribution infrastructures that still leak and whose leakage rate will only continue to increase?*

WHAT IS CALIBRATION AND WHY IS IT IMPORTANT? (CONTINUED)

If two identical meters each have a 3% error, then the lowest verifiable leak of a nominally incompressible fluid flowing between them is around 6%. However, if each of their known/calibrated accuracies is 0.1%, then the lowest detectable leak is reduced to around 0.2%.

Therefore, low uncertainty calibration is necessary for leak detection: the lower the calibration uncertainty, the smaller the leaks that can be determined. Leakage is determined more quickly, repairs can be performed earlier, and water is saved.

Knowing the rate of leakages in a water distribution system and how fast they are changing also allows us to prioritize repairs or replacement of the leaking pipeline section.

(This assumes that no cavitation of the fluid occurs. Cavitation at water distribution system velocities and temperatures does not occur.)

The water audit figures published by the American Water Works (AWWA) for 2011 indicate that the range of water losses for the 21 utilities answering the survey was 6.8 - 45.5%, with an average loss of 22.6%.[9] The real losses given in gallons/mile of main/day are 645.42 - 3,496.21, with an average of 1,821.15 gallons/mile of main/day. That's significant, and **certainly enough to have significantly lessened and/or completely eliminated the mandatory water cutbacks that that were imposed 2016-2017 due to California's ongoing drought. Note that the consumer side conservation efforts only achieved a statewide 17.4% reduction in consumption.**[10]

NOTE

In April 2018 a report commissioned by the California Department of Water Resources analyzing the 2016 water audits reported that the ***statewide California "Potentially Recoverable Water Financial Impact" to be $131,522,263.***[11] Note that this estimate is for the ***single year*** 2016.

Even though the mandatory cutbacks have been lifted due to the rain/snow fall last winter 2016-2017, California will surely have future water shortages. And water leakage and pipeline failures will still remain the cause of

– Higher water costs to the consumer;

– Water shortages in drought years;

– Unplanned/unscheduled water main shutoffs for water distribution system repairs,

– Difficult repairs of sudden catastrophic and unplanned pipeline failures — with their associated high costs;

9. *Validated Water Audit Data for Reliable Utility Benchmarking*, AWWA. The difference between the EPA's estimate of average water losses, 16%, and the AWWA's estimate of 22.6%, further emphasizes how poorly water is measured and accounted for. Inasmuch as the AWWA water audit methodology is the *de facto* standard method of performing water audits, the author believes that the AWWA estimates may be the more accurate of the two.

10. California Water Boards fact sheet "June 2017 Statewide Conservation Data", fs080117_june_conservation-1.pdf

11. *Report on the Evaluation of 2016 Validated Water Audit Data of California Water Utilities*, Kunkel Water Efficiency Consulting, Table 4, p. 7 (2018). www.nrdc.org/sites/default/files/report-on-the-evaluation-of-2016-validated-water-audit-data-of-california-water-utilities_2018-05-16.pdf

– Potential assaults on public health due to the introduction of contaminants into the water distribution system when the pipeline loses positive pressure during shutdown and repairs;

– Traffic interruptions due to sinkholes;

– Water damage liabilities, e.g. such as occurred at UCLA when the Sunset Blvd. water main failed;

– Destabilization of hillside properties, etc.;

unless detected early, as the leaks begin.

NOTE

Water pipeline leakage commonly starts as a small corrosion pit pinhole leak, which gradually enlarges due to long term flow erosion.

Early detection of leaks would allow inexpensive repair via a saddle patch and/or planned/scheduled bypass/shutdown if an entire section of a failing pipeline must be replaced. Either/both are considerably less expensive than repair/replacement under the duress and mess of catastrophic failures.

In older municipal water systems with large numbers of leaks, determination of the leakage flowrates and their rate of change — how quickly the leak is growing — also allows the prioritization of repairs.

EPA 816-F-13-002 *Water Audits and Water Loss Control for Public Water Systems* and EPA 816-R-019 *Control and Mitigation of Drinking Water Losses in Distribution Systems* both emphasize **the importance of water audits and the vital role of metering systems therein.**

However, without the ability to determine the accuracy of metering systems, water audits are only approximate, and there is no basis for the detection of leaks in water distribution pipelines.[12]

NOTE

The fundamental underlying importance of calibration is clearly stated in *all quality management systems*, e.g. ISO 9000/9001/9002, ANSI/ASME NQA-1, MIL-I-45208, etc. Calibration forms the basis of rigorous and accurate measurement.

Thus, *the water industry does not actually have rigorous quality management*, with the exception of its very small household meters. Even there, calibration intervals are not rigorously maintained, and meter caibration / replacement is typically performed only after the most grievous measurement errors are suspected.

Once leakage between two measurement points has been confirmed, the leak location can then be determined by iterating the pressure drop downstream from the input point and upstream from the outlet point to their point of convergence.[13]

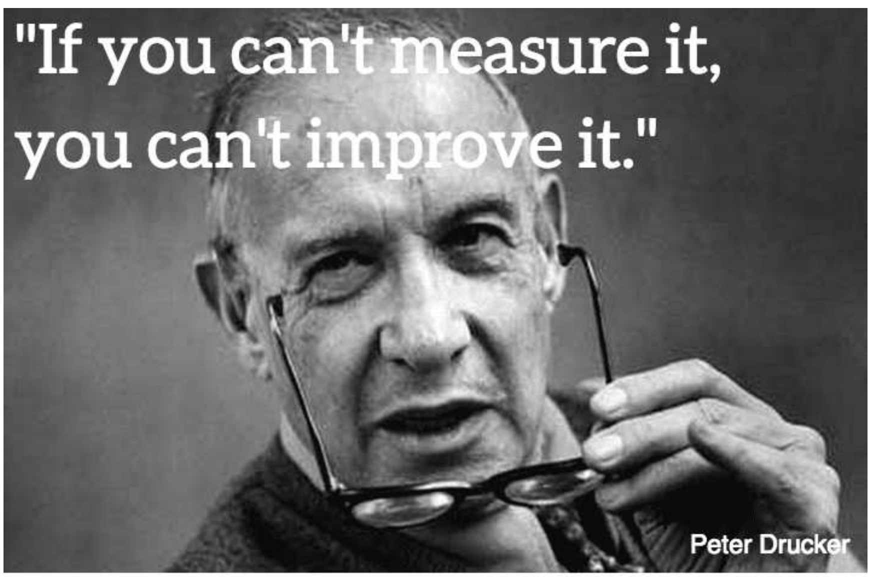
12. Also see the **NOTE** of Page 13 of Appendix 4, a white paper on pipeline leak detection (also available on the Pipeline Safety Trust website as www.pstrust.org/docs/massbalance_ld.pdf) regarding the importance of the configuration of calibration systems for leak detection systems. Through the thoughtful planning and usage of the calibration system, improvements in the confirmable detectability levels of leakage can be improved by one order of magnitude, opening the possibility of eventual detection of "background leaks" and/or "unreported leaks" long before they emerge as clearly visible / catastrophic "reported leaks".

13. See Appendix 4, Pages 10 - 11.

NOTE

> **The establishment of a low uncertainly large flow calibration facility is the first — and most vital/necessary — step on the long path to on-line, near real-time, detection/location/prioritization of leakage in municipal water systems.** This is a mission esssential step towards the effective management of any major water distribution system.
>
> Initially targeting the leakage from large water mains, through which all distribution system water flows, once the condition/integrity of large water mains is established one can begin to consider the integrity of ***branch lines*** using large data set analysis methods. For example, by determining whether the slope of the water loss is proportional to the flow in a branch line, etc. This opens up the possibility of extending leak detection throughout all major distribution system lines.

Clearly, something real and effective has to be done to address the problem of distribution system leakage ***on a fundamental basis***. As the noted management authority Peter Drucker repeatedly emphasized, "If you can’t measure it, you can’t manage it" and



Let us now assume that the establishment of a low uncertainty large water flow calibration facility results in only a 5% reduction of the aforementioned 2016 California statewide water loss of $131,522,263. ***The resulting annual water savings would be equivalent to $6,576,113 per year. This savings per year is already significantly more than the initial cost for the establishment of the calibration facility plus annual operational costs of $3-5 million and $300K-500K, respectively.***[14] ***Note that this is a recurring annual savings, and with the further improvement of measurement and further minimization of leakage due to calibration, said savings of $6.5 million/year will only continue to grow. Note furthermore that these are direct cost savings, and do not include minimization of losses due to potential loss of economic development due to water unavailability, crop losses, etc.***

14. Costs for the initial construction and commissioning of the low uncertainty large flow calibration facility are estimated to be $3-5 million, depending on what is currently available on site, degree of desired automation, etc. Most of the costs will be for the piping runs/manifolds and large (automated) valves. After the initial establishment of the facility, subsequent annual operational costs would be approximately $300K-500K, depending on calibration volume.

Several years ago, in a private conversation during the Pipeline Safety Trust's annual meeting on pipeline safety issues, the Environmental Defense Fund's Vice President Mark Brownstein made QUANTUM DYNAMICS aware of EDF's concern about water losses, commenting that the magnitude of leakage was much greater than that experienced in the petrochemical industries — and that said ongoing/continuous losses had potentially greater societal implications.

Additionally, in conversations with authorities regarding *petrochemical / natural gas* pipeline leak detection, several state authorities pointed out the seriousness of water losses, e.g. New Mexico's Secretary of Energy Joanna Prukop pointed out that Albuquerque has an estimated 30% loss from its municipal water system — in a state with extreme water shortages — and that said continuous/ongoing losses were considered as having potentially more serious consequences for the state's economic development than losses from its natural gas transmission system.

In December 2018, the CEO of the United States largest investor owned water utility, commented on the failing state of the country's water infrastructure:

> "44% of all U.S. water infrastructure is near the end of life or failing and within the next ten years will be out of life. Over 20% that we have treated, we put in pipes and it just leaks."[15]

This means that over 20% of water supply costs are simply wasted. Such high levels of loss are not acceptable from the fiscal management, nor logistical, nor environmental points of view.

Moreover, a recent study of water main breaks indicated that "overall pipe breaks [are] up 27% in six years."[16] ***As the oldest municipal infrastructures — some over a century old — the water main failure rate will only increase in the forthcoming years.***

QUANTUM DYNAMICS, a small Southern California "boutique" aerospace flow metrology research and development organization,

+ The *only* supplier of flow metrology systems that is a US Defense Logistics Agency "Certified Quality Vendor" and US Navy "Quality / Best Value Contractor";
+ The supplier of the world's *de facto* standard flow measurement systems for military and civilian jet engine test stands;[17]
+ Due to military/aerospace standardization, ***the world's largest supplier of flow transfer standards***, those ultra-high precision flow systems used to calibrate conventional flow sensors;
+ A recognized supplier of flow measurement systems for compressible gas **pipeline leak detection**;[18]
+ The organization whose flow instrumentation controlled all ***Apollo mid-course corrections and lunar landings***, as well as the ***Apollo 13 rescue trajectory*** — unbeknownst to the television viewing public the most widely viewed instances of precision mission essential flow measurement and control in history;
+ The organization that designed and supplied the "man rated" ***water flow measurement systems for the International Space Station (ISS)*** that control the heat transfer from the hot sunny side of the ISS to the cold dark side for heat dissipation, keeping the ISS habitable;

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15. Susan Story, CEO of American Water, the Nation's largest investor-owned water utility, on Fox Business, December 12, 2018, 6:14, www.youtube.com/watch?v=yOiWGxwh1xU
16. *Water Main Break Rates in the USA and Canada: A Comprehensive Study*, Utah State University (March 2018).
17. This is significant since the selection of a jet engine for entire fleets of aircraft is commonly based on specific fuel consumption advantages as small as 0.1%.
18. *Pipeline Rules of Thumb Handbook*, Gulf Publishing (Houston), 1998, pp. 457-458, 481-483.

    Note that the detection of leakage in pipelines for compressible media is a considerably more difficult problem than the detection of leaks in (relatively) incompressible liquid media systems, such as water. See Appendix 4.

+ The organization that supplied the ***heavy water*** and tritium gas flow measurement/accounting systems for the U.S. Department of Energy's nuclear materials production facilities;
+ The organization that designed a large natural gas flow calibration system that NIST deemed "would be a significant advancement in natural gas flow measurement";[19]

wishes to contribute to the solution of the water measurement and audit problem, as the *necessary first step* towards eventual municipal water distribution pipeline leak detection, location, and prioritization.

The necessary first step on the long path towards a reliable and efficient water distribution system is the fundamental ability to accurately calibrate large municipal meters with high resolution: without the ability to accurately quantify flow, no real improvement can be made in water audits and no real progress made towards early detection, location, and prioritization of leakage. The sooner that such calibration is possible, the sooner the fiscal benefits will begin to accrue — and the less expensive the the facility will be.

NOTE

> As a proven and long time military/aerospace supplier/contractor for critical flow metrology systems, QUANTUM DYNAMICS considers the establishment of a low uncertainty, high-precision water flow calibration facility as absolutely essential to the improvement of water distribution systems, for without same there can be no truly meaningful ***water audits***, nor the possibility of ***detecting/locating/prioritizing leakage*** at low/remediable levels in water distribution systems. These are key elements of the ***effective management*** of any municipal water distribution system.
>
> Falling back to nomenclature used in military/aerospace programs, the large water flow calibration facility is deemed ***mission essential*** and/or ***mission critical*** to the efficient management of the reliable and accountable supply of water to the population.

Using the California Department of Water Resource's own estimate of the potentially recoverable water, we have calculated that only a 5% savings in California's annual water losses is equivalent to $6,576,113 per year. EPA estimates that up to 75% of losses are recoverable.[20] If, over the course of years, improved measurement and the resulting improved ability to detect leakage results in any water recovery even remotely approaching, say, even 50%, then the argument for the establishment of a large water flow calibration facility becomes absolutely irrefutable.

More precise water measurement provides the ability to detect — and prioritize — smaller leaks sooner, and therewith the ability to make inexpensive repairs before major failures/leaks occur. This prevents long term water loss.

Distribution side reduction and efficient management of water losses is the most efficient and economic way of reducing water losses from distribution systems.

The absolutely most basic necessity / prerequisite for accurate flow measurement is highly accurate, low uncertainty calibration. This is a basic rule of quality management.

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19. See Appendix 5. This is again a much more difficult undertaking that the design of liquid flow calibration systems, due not only to the compressibility of natural gas, but also due to its varying composition, affecting its compressibility factor Z, its speed of sound W, density as a function of pressure and temperature, etc.

20. *Water Audits and Water Loss Control for Public Water Systems*, www.epa.gov/sites/production/files/2015-04/documents/epa816f13002.pdf.

SPECIAL NOTE FOR WATER POLICY MAKERS

Water sustainability rests ultimately on the difference between potentially available water supplies and the water that is actually delivered and consumed. These are matters of quantity measurement that must be eventually addressed. Isn't it time that we finally rigorously address the measurement quantities that are actually within human control? We can't control the weather changes due to global warming and the looming megadrought. However, we can — and must — minimize water infrastructure leakage losses.

A high precision large water flow calibration facility is the first rigorous and rational step towards accurate water accounting and leak detection.

It is universally accepted that the recovery of water that would otherwise be lost to leakage is the most cost effective way of obtaining "new" water sources, while simultaneously insuring the reliablity of the water distribution infrastructure.

A recent study by California's PUC summarized water costs as follows:[21]

- The average cost of water from existing/traditional sources is $793/acre-foot;
- The estimated average cost of water obtained through recycling as $2,869/acre-foot;
- The estimated average cost of water obtained through desalination as $3,889/acre-foot.

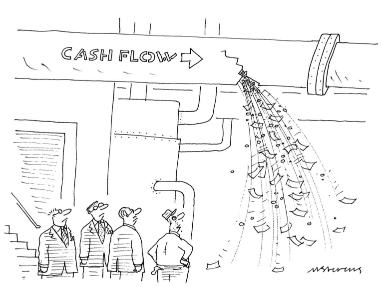
Why put expensive recycled and/or desalinated water into pipes that still leak — and may continue to leak for decades until leakage is detected/noticed?

The fact that no similar efforts have been made thus far towards significantly improved measurement and the consequent rigorous on-line determination of water distribution system leakage appears to indicate a lack of technological and managerial awareness — and possibly lethargy — that many mid-level managers of water distribution display.

California statutes and executive orders — and water scarcity — clearly REQUIRE that accurate water audits be performed, with the goal of quantifying, detecting, prioritizing, and minimizing water loss/leakage — with the ultimate goal of conserving/maximizing our precious water supply.

Especially given the legal, auditing, fiscal, operational, and water and energy saving consequences of the proposed water calibration facility — which economic analysis demonstrates would literally pay for itself within months — it would seem to be the only logical way forward for a responsible water utility.

We are therefore requesting the careful and thoughtful review of this matter by cognizant water policy makers — and that real action finally be taken to insure the water supply necessary for long term societal flourishing and, indeed, existential survival.



"Well, gentlemen, there's your problem."

21. *What Will Be The Cost of Future Sources of Water for California*, California Public Utilities Commission, 1/12/2016, p. 16.

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