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(NASA-CR-166238-Vol-3) ADVANCED TECHNOLOGY DISPLAY HOUSE. VOLUME 3: WATER AND SEWER DESIGN CONCEPTS (University of Southern California) 58 p HC A04/MF A01 CSCL 13B N81-31037

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ADVANCED TECHNOLOGY DISPLAY HOUSE

VOLUME 3

WATER & SEWER DESIGN CONCEPTS

Advanced Technology Display House
Vol. 3
Waste & Sewer Desing Concepts.

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A. Preliminary Design Concept: Water & Sewer System

(1/11/80)

ATH PROJECT

PRELIMINARY DESIGN CONCEPT

WATER & SEWER SYSTEMS

January 11, 1980

Introduction

In the post World War II era water has come to be widely regarded as a cheap, infinitely available resource. This presumption is going to come under pressure in the near future as costs of water and related services increase, availability is reduced and quality is degraded. Therefore, it is particularly appropriate to examine technological options for conserving water usage in the ATH.

Urban domestic water usage is a link in a chain consisting of:

.collection and storage of fresh water

.treatment & quality control

.distribution

.waste water collection

.sewage treatment

.waste disposal

Every one of these steps is capital and energy intensive which guarantees escalating cost to the consumer. The cost increases will be magnified because the marginal costs of additional plant and operations will be orders of magnitude higher than the cost of in-place facilities which were built in an era of much lower capital and energy costs. For Southern California water production & distribution costs may rise at least 1000% by 1985 (as reported in California Business, Sept. 1979 p.29.)

Also post-Proposition 13 fees and surcharges for water and sewage services are revealing. A sample compilation of recent increases in California areas made by the governor's Office of Planning & Research reported;

sewer connections, + 93%

water & drain connections, + 72%

sewer capacity surcharges, + 403%

(Source: California Business, October 79)

Furthermore, maintenance of public water quality is threatened by contamination of regional ground water sources which will demand expensive control and treatment procedures in the near future. ("Pure drinking water no longer a safe assumption". LA Times, Jan 2 1980. Copies of this and the above articles are available if interested.) However, there are a couple of bright spots in the outlook for water as compared to future energy supplies

1) Though the use of energy in the US has been wasteful, and corrective measures will be expensive and will take time to implement, the domestic usage of water has been absolutely profligate. Therefore, there is great potential for substantial reduction in domestic water demand by simply adopting less wasteful practices. For instance, some surveys indicate that where there are strong incentives to conserve water, domestic usage is cut upto 50%. Such comparative results are cited for metered systems vs. unmetered, and volume usage charges vs. flat rate fees. Also, concerns about overloading a septic tank will often induce lower water usage (and related sewage outflows) compared with houses connected to community sewer lines. Obviously extended drought conditions enforce a greater respect for water conservations as was observed in Northern California in 1975-77.
2) Another encouraging point is that, compared to the energy situation, the solutions to water problems are under our own (ie. local) control and can be instituted fairly rapidly. There is, after all, plenty of water available in most areas if it is used sensibly. Technology is available to solve domestic water and sewage problems. The crucial need is for innovative engineering effort to apply the technology to meet present & future residential needs. The ATH will play an important role in displaying the range of possibilities.

Current demands

Water is a "process" commodity and is not physically consumed. So for a house unit,inflows equal outflows. (Vapor losses due to sweat, breath, surface evaporation, etc are negligible.) A flow chart for a typical single family dwelling (4 people) is shown in Figure 1. These data reflect national daily averages for the interior flows and are used as a basis for concept development. Detailed engineering design will have to consider the extreme variations encountered due to diurnal and seasonal demand profiles. Most analyses consider only internal demand flows and leave out leakage losses and exterior usage (primarily lawn irrigation) and data on the latter items are very sparse. The leakage loss shown is a guess based on what comments were available in the literature. (If 50 gallons per day seems high consider that a slow leak of one drop per second equals about 7 gallon per day. A faulty toilet valve can easily waste 100 gallons per day.)

The interior demand data assume normal appliances are installed and used according to current practices.

Modified demand

Figure 2 indicates the combined results of;

1) exercising reasonable restraint in water use (ie. shutting off faucet while brushing teeth, etc.)
2) implementing conservation measures to reduce excessive line flow rates as indicated in Figure 2,
3) Incorporating basic water recycling systems for non-potable reuse.

We do not catalog all of these options & mechanisms here because (a) they are extensively covered in the literature, (b) do not involve any dramatic new technology and (c) are proven applications.

However, it needs to be emphasized that the water recycling systems are not to be taken lightly. Greywater has to be treated every bit as carefully as blackwater (toilet waste) to inactivate pathogenic organisms. Also, waste content of grey and black water is essentially the same, as indicated by the data shown in Table 1. The major difference is that greywater has a higher content of phosphorous (from detergents) and grease, while blackwater has higher amounts of nitrogen.

Any recycling system requires a reasonable attitude on the part of all users so as not to overstress filters and equipment capacities. Reasonable common sense may be assumed for the ATH residents. (In contrast, designs of public and transport based facilities have to assume a high degree of irresponsibility on the part of users which accounts for their high cost and elaborate engineering.)

With due regard for the above observations, basic recycling systems can be engineered from reliable off-the-shelf components and the design of relevant ATH modules should not be constrained by them. One area where new technology inputs are required is in automatic control & monitoring of equipment and process fluids. At the present time bacterial activity is effectively controlled by chlorination, at least to the standards required for uses not involving direct body contact, but continuous monitoring of bacterial content is not an available option as far as can be determined. Also controls and instrumentation should be investigated for indicating simple maintenance needs such as filter cartridge replacement. (For instance, automatic notification of an excessive pressure drop across a filter unit.)

The net result of the measures indicated in Figure 2 is that fresh water demand drops from 530 gallons per day (GPD) to 176. Average outputs to the sewer lines drop from 280 GPD to 76. These are very dramatic results for nominal inputs of essentially low level technology. Clearly, there are benefits in reduced hot water energy usage as well. We have not formally calculated energy savings since this requires more detail on hourly flow profiles and physical layout, plus performance estimates of heat exchangers which could be used to recover waste heat etc. However, energy savings can be expected to be substantial.

It is the system and usage level indicated in Figure 2 which is used as a baseline standard for reviewing what further developments may be included in defining the initial system concept for the ATH.

The ATH concept

It is evident from Figure 2 that any high technology applications aimed at further reduction in water demand would have relatively small effect. A more significant advantage would be to eliminate the need for sewer line connections altogether. This is very much in the spirit of the ATH project in that it offers significant new flexibility in site location, modular design and layout as well as community advantages in reducing sewage treatment needs. On-site sewage treatment is technically feasible and an interesting variety of tested options are available. Current initial costs for these systems can run to several thousand dollars but they are substantially balanced by the elimination of sewer line laterals, connection fees and annual user rates and surcharges.

<u>On site sewage treatment</u>

The sewage treatment system can be broken down into 3 major subsystems,

A) Fixtures and devices for depositing human wastes.

B) Waste transport mechanisms.

C) Treatment and disposal of wastes.

With regard to the ATH;

A. The toilet equipment must be convenient to use, reliable, require minimal servicing, easy to keep clean, and be of aesthetic design. It's operation should be odor free and permit safe use by people of all ages and physical condition.

B. Options for the waste transport mechanism are fluid flow (water or air), air pressure, vacuum, or mechanical means.

C. On-site treatment methods include the following;

* Anaerobic or aerobic digestion tanks emptying into a subsurface leach field or seepage pit.
* Evapo - transpiration beds
* Composting tanks
* Inactivation of waste for sanitary offsite disposal (packaging systems or chemical holding tanks)
* Incineration

There are some other exotic methods devised for manned space vehicles, but designed as they are for difficult conditions in deep space (eg, no gravity) they tend to be far too complex for direct application to terrestrial needs. However the space programs are of enormous value in stimulating research and knowledge of bacteriological processes, waste treatment, instrumentation, and fluids engineering which will benefit future sanitary system development. On going design effort will determine the extent to which some of this technology can be included in the ATH.

Many combinations of the above A, B, C subsystems were reviewed and either of the following systems appear to be most appropriate for the initial ATH design concept.

1) A recirculating oil flush toilet system which transports wastes to a central incinerator unit for disposal. A general description of this type of system is attached (see Article 1). Principle advantages of the system are;
   - Aesthetic, odor free operation since waste rapidly settles through the light weight mineral oil. Separation of waste and oil is efficient.
   - No water required
   - No sewer line connection required
   - Incineration is completely sanitary with small ash residue.
   - No holding tanks or leach fields required.
2) A higher degree of modular design flexibility is offered by individual, self-contained incinerator toilet units which need only connections to power sources (low DC voltage) and ventilation outlets. Further investigation is necessary to confirm the suitability of the available hardware, or to determine what design modifications should be undertaken to ensure conformity with the final ATH concept. (See Article 2)

With the waterless toilet system, and retaining the recycling mechanism introduced in Figure 2, the preliminary ATH concept is shown in Figure 3. Fresh water demand is reduced from 176 GPD to 128 GPD. But most significant is the elimination of the sewer connection.

Potable water supply

An obvious next step would be to consider recovery of waste water and treating it to potable quality for a complete recycling system. A review of the literature suggests that this may not be immediately feasible for the following reasons:

1) Reclamation of potable water requires a foolproof system to guarantee removal of potentially harmful substances and inactivation of bacteria and virus populations. While it is technically feasible

to devise equipment to do this it is difficult to provide the necessary instrumentation to continuously monitor for adequate performance. This is especially the case for virus detection and control. Existing techniques are only economic at a scale well beyond the needs of the single family dwelling and generally their operation requires some degree of technical competence.

2) There are special problems with closed cycle water systems which are inadequately understood. For instance, if medication or drugs are temporarily being taken by a resident, what residues and by-products may accumulate in the recycled water which are detrimental to the health of others? Another question under investigation is the build up and effects of endocrin secretions in a closed water cycle used jointly by males and females. Such concerns are of importance in small scale systems for space vehicles (and ATH's) but assume less significance in the highly aggregated and diluted flows within high volume community systems.

3) Psychological surveys to date indicate that there are generally favorable public reactions to recycling greywater for lower quality reuse. But there are strong negative feelings toward recycling any waste water for potable or bathing purposes. These are, of course, emotional and irrational responses reflecting cultural prejudices of a generally fastidious society. However, it would be advisable to treat the whole subject of water recycling with care to avoid arousing any undercurrent of hostile sentiment toward the ATH as a whole.

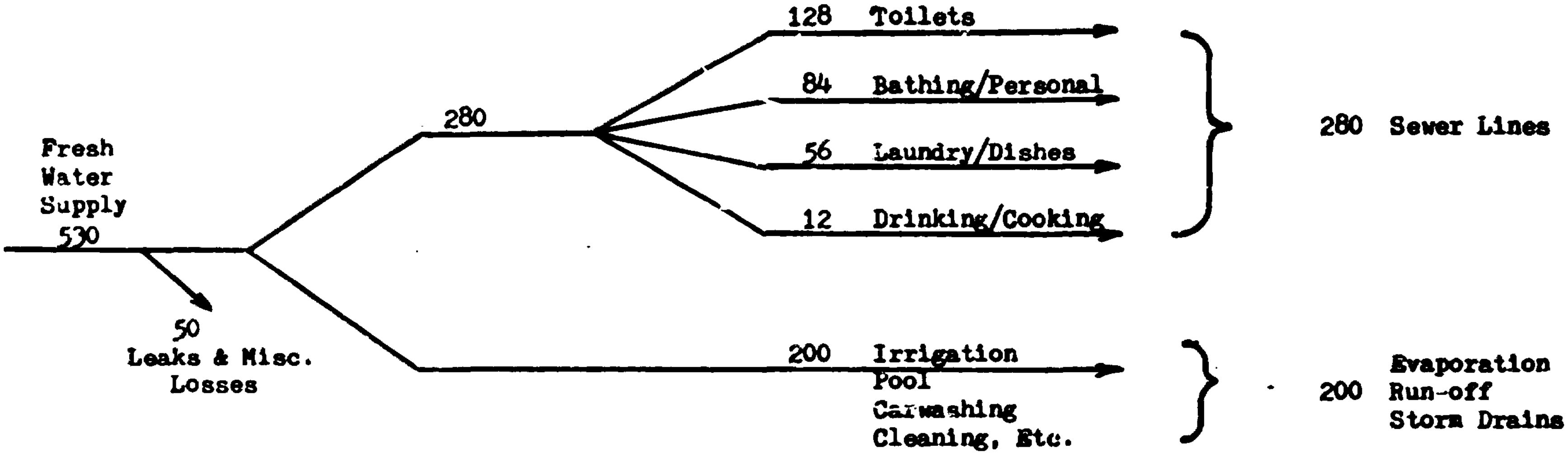
Having made the above points it is of interest to consider some advanced technology methods for refining fresh water as delivered to the house from a well or mains connection. Possibilities include the techniques of vapor compression distillation, air evaporation, and vacuum distillation devised for use on long term space missions and on ships. (Interestingly, the Apollo spacecraft did not include special water provisions for the crew since the hydrogen/oxygen fuel cells produced more than adequate quantities of pure water as a by-product.) With increasing publicity about deteriorating public water supplies, the ability of the ATH to provide pristine, polished water at the tap is bound to generate favorable impressions.

ATH plumbing systems

A single line plumbing system should be used for distributing water throughout the house, with automatic temperature adjustment made via solenoid valves located at the hot and cold water sources. This type of plumbing allows smaller diameter pipes, push button selector control and is alleged to save up to 75% of water and heat losses due to purging water lines and adjusting temperatures at the faucet as in conventional layouts. Many other advantages are claimed. If proven to be valid, this type of system would fit very well into the ATH and possibly enable additional opportunities for development in conjunction with the central computer system. A general description is contained in Article 3.

FIGURE 1

Average daily water use (gallons) for typical single family dwelling of 4 persons.



Assumptions:

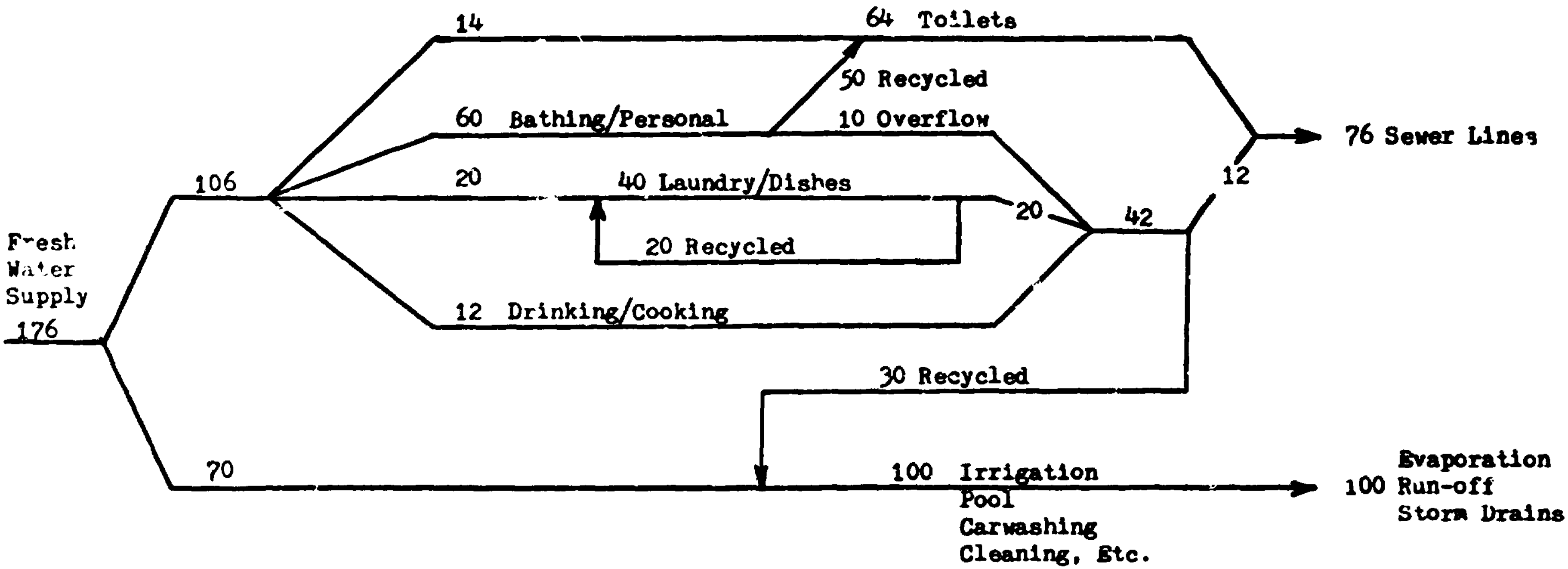
1) Standard appliances and toilet fixtures. Current normal usage.

2) Interior flows are based on nationwide annual averages. There is some seasonal variation but not extreme.

3) Exterior flows are a "best guess" for a mid-California location based on annual demand. What little data exists suggests that annual interior and exterior usage are about equal, therefore figure shown may be conservative. Average seasonal variation may push summer usage to 2 or 3 times the winter demand.

FIGURE 2

Modified average daily demand with reasonable conservation measures & off-the-shelf hardware.

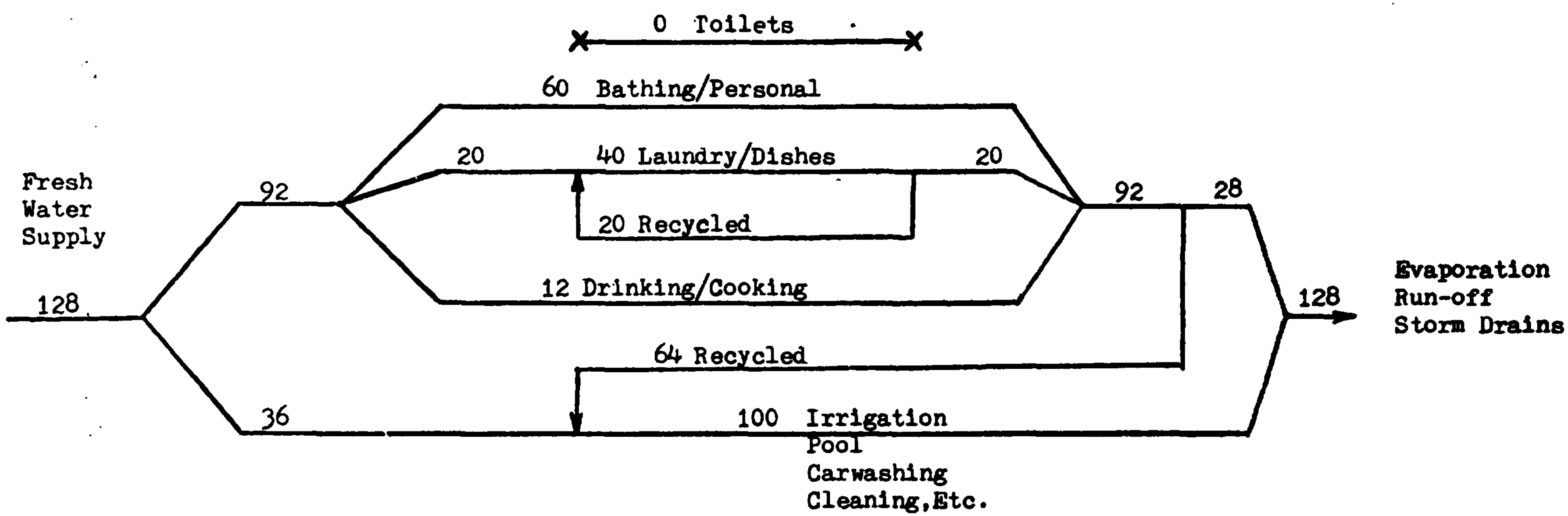


Assumptions:

1) All leaks repaired and equipment well maintained.
2) Low flush toilets (50% demand reduction)
3) Low flow devices on faucets and showers plus non-wasteful practices,(30% saving).
4) Recover bath water and treat for toilet flushing (allow 20% overflow loss due to diurnal demand schedule mismatch).
5) Recover rinse water from washers for next wash cycle (50% reduction).
6) Recover all non-toilet waste & treat for exterior use (30% overflow loss).
7) Improved irrigation methods and less wasteful exterior use practices(50% saving).

FIGURE 3

The sewerless house.



Assumptions:

1) No water required for toilets. Install oil flush, incinerating type. Only residue is small quantity of sanitary ash.

2) All interior water wastes are collected and treated for exterior use. No sanitary sewer line connections required.

TABLE 1

Average Pollution Loads from Rural Households

Source of Wastewater	BOD$_5$[a] (grams/person/day)	SS[b] (grams/person/day)	N[c] (grams/person/day)	P[d] (grams/person/day)
Greywater:				
Kitchen sink	8.3	4.1	0.4	0.4
Automatic dishwasher	12.6	5.3	0.5	0.8
Bath/shower	3.1	2.3	0.3	<0.1
Laundry	14.8	10.9	0.7	2.1
Greywater subtotal	38.8	22.6	1.9	3.4
Garbage disposal	10.9	15.8	0.6	0.1
Toilet	20-28	27	10.5-17.7	0.7-1.9
TOTAL	69.7-77.7	65.4	13.0-20.2	4.2-5.4

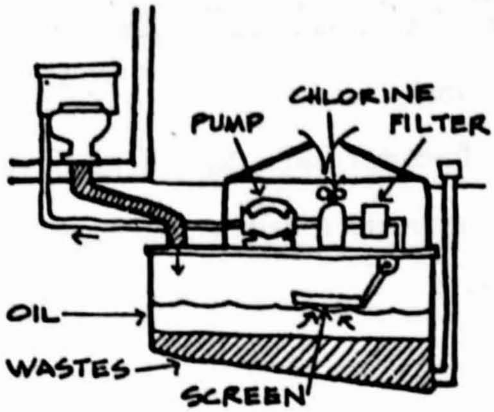
Source: All data except for toilet wastes are from R. Siegrist, "Segregation and Treatment of Black and Gray Waters" (Small Scale Waste Management Project, University of Wisconsin, Madison, WI, 1976; see R. Siegrist, M. Witt, and W. C. Boyle, J. Environmental Engineering Division, ASCE, *102,* No. EE3, June 1976). Data for toilet wastewater is from Rein Laak, University of Connecticut, Storrs, CT, 1977.

a. BOD$_5$ (Five-day Biochemical Oxygen Demand) is, technically, the quantity of oxygen used in the biochemical oxidation of organic matter for five days at 20°C. It is a general indicator of how much organic pollution is in the wastewater.

b. SS (Suspended Solids) is the amount of solid material suspended, as different from dissolved, in the wastewaters.

c. N (Nitrogen) is the total amount of nitrogen, in all forms, in the wastewater.

d. P (Phosphorus), usually present as phosphates, is the amount in the wastewater. Nitrogen and phosphates is the amount in the wastewater. Nitrogen and phosphorus are nutrients for aquatic organisms and contribute to water pollution.



OIL FLUSH TOILET

Operational Characteristics

Description: Instead of water, the oil flush toilet uses a clear, odorless mineral oil not easily distinguishable from water. The toilet can use off-the-shelf hardware with slight modifications. Since the oil does not have the same scouring effect as water, a teflon coating is applied to the interior of the bowl. The main reason for introducing oil as the waste carrier is the need for easy and fast separation of the carrying media from the waste. The separation takes place in two steps: (1) The separation and storage tank is designed to minimize agitation to allow the wastes to settle to the bottom. The partially separated oil is then pumped up through a screen to prevent particulate matter from passing on. (2) In the oil line to the flush tank is an additional filter similar to one found in an automobile. This filter removes the remaining particulate material and color bodies which have been absorbed by the oil. Chlorine is also added to insure no bacteria build-up will occur. The oil should never need replacement as long as incompatible foreign materials (i.e., crankcase oil) are not thrown into the toilet. One typical home system employs 20 to 30 gallons of fluid with five percent or less evaporation per year.

There are two commercially available alternatives for the final disposal of the resulting wastes. The wastes may be stored, quiescent, being pumped out once annually by a transport vehicle. In this case the storage (and separation) tank is sized to hold approximately half the annual waste product of the occupants -- the other half being deposited at work, school, etc. A family of four needs about a 350 gallon storage tank for a once-yearly service cycle. The other alternative employs an incinerator to burn the wastes, reducing the volume to about three percent sterile ash. The wastes are held in a storage and transfer tank until there

* RESIDENTIAL WATER CONSERVATION : MURRAY MILNE. MARCH 1976
CALIF. WATER RESOURCES CENTER, UC DAVIS, CALIF.

is sufficient waste for incineration. The manufacturers* claim both systems to be fail safe since they automatically shut off if either the storage tank is full or the system has a leak.

Water Consumption: The oil flush toilet does not require water for the conveyance of fecal matter, thus saving the water commonly consumed by conventional toilets. Indoor home water consumption is thereby reduced by 45 percent. The oil flush toilet also allows for the separate treatment of grey and black water.

Feasibility

Cost Considerations: The oil flush system is significantly more expensive than conventional equipment. One home model without incinerator costs $2500, not installed. Other costs include electricity, chemicals, and maintenance. The amount of electricity used should be low since the pump operates only during the flush cycle. The toilet is generally sold with a service contract which covers repairs, chemicals, and servicing. The once-yearly service cycle includes pumping the tank, replacing the filters, adding chlorine, and checking the oil level. While the oil flush toilet is mechanically more sophisticated than the conventional toilet, the manufacturers have attempted to maintain simplicity which offers fault-free operation. The manufacturers are continuing to review the maintenance and operational requirements of the system.

Public Acceptance: Since the oil flush toilet is outwardly similar in operation and appearance to conventional toilets, public acceptance should be positive. Also oil exceeds certain properties of water. Lighter in density, the oil allows human waste to quickly sink to the bottom of the bowl, thus providing a better odor trap than water. The manufacturer also claims that there will be no mineral or fecal matter build-up on the inside of the bowl because of the teflon coating, thereby reducing routine cleaning. The service contract should remove most of the inconvenience associated with such a unit. Cost remains the limiting factor.

Stage of Development: The oil flush toilet is fully developed and has been in use in the United States since 1970. As production increases, further modifications will likely be made. Although most municipal codes do not allow for the use of oil flush toilets, it is presently finding acceptance in rural detached settings where central sewage and/or central water do not exist, and where high water table or poor soil percolation characteristics limit the feasibility of conventional septic systems.

* Chrysler
Monogram (Magic Flush)

ARTICLE 2

INCINERATOR TOILET

Operational Characteristics

Description: The incinerator toilet is a self-contained electrically and gas operated sanitary system. It destroys all liquids, reduces solids and eliminates bacteria by burning. The timer which controls the incineration cycle is set by lifting the toilet seat cover before use. When the seat cover is lowered after use the burn cycle begins. The fuel used is natural gas or propane and is ignited by means of a replaceable automobile spark plug. A blower unit removes odors, vapors, and heat out a four inch flue. The incineration cycle is timed for about fourteen minutes. The blower continues for an additional six minutes to help cool the combustion chamber. The cycle may be interrupted at any time for further use; when this is done, the burning cycle is automatically reset for a longer period. An individual toilet is designed for use by a family of four to six persons. In case of emergency, or for normal maintenance, it is recommended that a gas shut-off valve be placed outside of the toilet.

Water Consumption: The incinerator toilet requires almost no water. No water is used for the disposal or transport of wastes; they are moved mechanically (by a device similar to a conveyor belt) from the hopper to the combustion chamber. An eight ounce glass of water is required for its weekly cleaning. This toilet thereby saves the 45 percent of the fresh water conventionally used in the home by toilets.

Feasibility

Cost Considerations: The suggested list price of the incinerator toilet in 1972 was $395. Installation, costing about $75 in 1972, includes piping a gas line to the toilet location, an electrical connection, and the construction of an exhaust duct with natural draft. Not required are the conventionally installed water line and sewer connection. Operation and maintenance costs include the cost of electricity and gas, estimated at two dollars per week for a family of three, and the weekly cleaning. The cleaning consists of vacuuming the ashes, cleaning the bowl and incinerator with eight ounces of water. The manufacturer guarantees the overall quality of the system for one year and the combustion chamber (free of defects in workmanship and materials) for five years. It is also recommended that a qualified dealer perform the installation.

Public Acceptance: Because of its comparatively high initial and operating costs, its unconventional nature of operation, and need for regular cleaning, the public acceptance of the incinerator toilet will likely be limited. There will be many who will consider these characteristics an inconvenience. In case of electricity or gas failure the system will not operate. Also, though it is sanitary, its cleanliness is not as great as conventional water flushing toilets. Minor noise and odors are created during incineration. The odors vent through the exhaust duct except in rare circumstances where a downdraft is present. Despite these limitations it is the only toilet found in this study that is designed for permanent installation and use which is self-contained. In case of water shortages and in situations where central sewer systems are not available and the excavation for tanks and other equipment is unreasonable, the incinerator toilet remains a very desirable system.

Implementation: The incinerator toilet is reasonable for any scale project. Models are available which operate on a simple 12 volt circuit and propane or butane gas which makes the toilet adaptable to very remote locations. Its environmental impact is positive for its reduction of water consumption and its complete, sanitary elimination of toilet wastes. Unlike some other systems there is no need for further "final" disposition of stored wastes. Its environmental impact is negative for its energy consumption not common in conventional toilets.

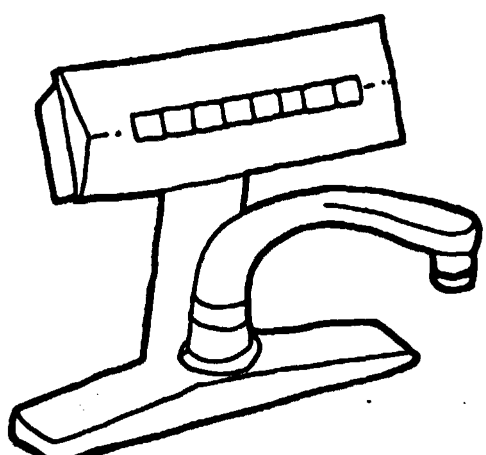
Stage of Development: Though the unit is fully developed, increased production will likely reduce its high cost. It is necessary to check for local code compliance before installation.

ELECTRICALLY CONTROLLED PLUMBING SYSTEM

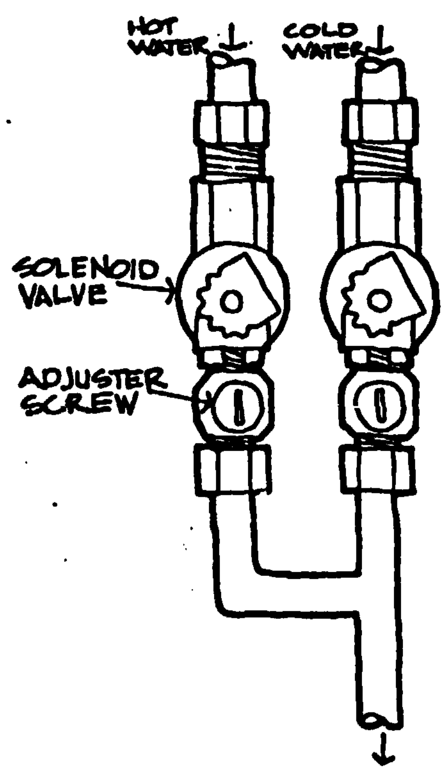
Operational Characteristics

Description: Conventional home plumbing employs a two line system, one line for hot water and one for cold. The plumbing lines begin at the source, the water heater for the hot water line and the entry point into the home for the cold water line, and connect to a series of uses ending at the farthest appliance. The hot water line can be designed into a continuous loop (see Hot Water Recirculating Systems). An alternate plumbing system uses a single line connecting from the source to each fixture individually. Because each fixture is serviced separately the diameter of the line can be smaller; either 1/4 or 3/8 inch, depending on the fixture, instead of the conventional 1/2 and 3/4 inch diameter plumbing line. The source for the single line plumbing system is a series of electrically controlled solenoid valves located within three feet of the water heater.

Whereas in a two-line system the temperature selection is determined at the faucet, in a one-line system the water temperature is preset. Instead of a faucet, a spout is located at each fixture along with push-button control panel. By means of a 12 volt electrical circuit the push buttons direct the operation of the solenoid valves. The hot and cold water is mixed by solenoid valves to the preset temperature upon demand. The selections offered at the control panels consist of:



KITCHEN PUSH-BUTTON CONTROL PANEL



TYPICAL VALVE UNIT

Kitchen Switch

Select Button	Result Provided
Hot	- Water directly from the hot water supply
Warm	- Hot and cold water blended to the preset temperature desired by user
Cold	- Water directly from the cold water supply
Drink	- Water directly from the cold water supply but bypassing the water softener (when applicable) to provide more palatable drinking water.
Disposal	- Simultaneous operation of the disposal unit and cold water flow
High flow	- Maximum preset water flow desired by user
Low flow	- Provides reduced water flow when desired
Off	- Halts all activity generated by the switch

Lavatory Switch

Select Button	
Hot	- Water directly from the hot water supply
Warm	- Water blended to the preset temperature desired by the user
Cold	- Water directly from the cold water supply
Off	- Stops all flow of water to the fixture

Shower/Tub Switch

Select Button	Result Provided
Warm	- Water blended to the preset temperature desired by the user
Warm 2	- Water blended to a higher temperature then the warm setting
Warm 3	- Water blended to a higher temperature than the warm 2 setting
Off	- Stop all flow of water to fixture

In case of a power failure, there is no built-in backup system, but a battery may be connected. When the system is installed the warm selections are preset, but these may be further adjusted later by use of a screwdriver. An additional convenience is that any outside water fixtures may also be operated indoors at a central control panel (i.e., swimming pool filler, lawn sprinklers, etc.). Some appliances need not be connected into the system, as clothes washers and dishwashers, which already use solenoid valves in their operation.

Water Consumption: The manufacturer claims that its system will save the homeowner 75% of the water now being wasted by conventional systems. The 75% water savings referred to is the percent savings in the amount of cooled water that normally must be drained out of the hot water line before it is used. The following chart shows the reduced volume of the smaller diameter line.

Nominal Size (in inches)	Gallons per 100 ft. of tubing
1/4	.405
3/8	.753
1/2	1.210
3/4	2.514

The manufacturer thus finds that "a 30 foot tube run of 3/4 inch pipe from water heater to faucet, with the regular plumbing, costs the user 620 gallons per fixture per month. With [their system], only 68 gallons are lost. With one shower used once daily [their system] will save the home owner a fantastic 6,388 gallons of water a year."

The manufacturers feel the solenoid valves (gate valves) to be more dependable than conventional faucets (globe valves) against leaks. They also eliminate changing washers and other routine maintenance associated with conventional faucets. Since the water temperature is preset, no water need be wasted in adjusting the temperature at the tap. And finally, the smaller diameter line acts as a "built-in" flow control reducing the water consumption but not below that necessary for the uses contemplated. A water consuming feature of the system is that each time the water temperature is changed during operation the line must be drained before the new temperature is achieved. This also takes from three to five seconds.

Feasibility

Cost Considerations: The cost of the equipment installed of this one line plumbing system is highly dependent on the floor plan and place of installation (home, apartment building, institution, etc.). The manufacturer has found that the system costs between 15% under and 5% over conventional plumbing in comparable installations. These general savings are mainly the result of easier installation. The smaller diameter copper or plastic tubing used for this system is flexible and may be bent around corners and past obstructions, eliminating the need for rigid piping and joints found in conventional plumbing. The manufacturer also claims that the potential water and fuel savings generated by the system should be significant. The solenoid valve has been found to be very dependable and over the last ten years of its installation in the system has had a very good service record. Though the system can be installed to replace conventional plumbing when major home remodeling is undertaken, it has its greatest cost efficiency when installed as original equipment.

Public Acceptance: Convenience is one of the fundamental features of this system. By offering water at preset temperatures and at the push of a button, much of the fuss associated with conventional faucets is eliminated. The water temperature is maintained as long as the hot water lasts. Also, small children are better able to operate the control panel than conventional faucets. Many outside watering chores can also be handled from indoors. For these conveniences one does lose a degree of selectivity. For those few situations when other than the preset flow rates or water temperatures are needed, other sources would have to be found.

Implementation: Because the distance from solenoid valve to fixture must be minimized, this system is best suited for four or fewer dwelling units. The environmental impact is positive because the system provides significant water savings and should also use considerably less pipe. While the system does consume some electricity for operation, this should be more than offset by the energy saved through heating a lower volume of hot water.

State of Development: The alternate one line plumbing system described here has been produced and installed in homes for over ten years. It has the approval of the Underwriters Laboratory (UL) and is commercially available.

References*:

- Ultraflow

B. Concepts for On-Site Waste Disposal

(3/21/80)

ATH PROJECT

CONCEPTS FOR ON-SITE WASTE DISPOSAL

(3/21/80)

Introduction

A key objective of the ATH is to reduce interaction of the house system with external (community) systems in order to demonstrate maximum utilization of on-site resources. One of the supporting concepts is to eliminate the need for connection to a community sewage system. But to achieve this goal it is necessary to provide for on-site disposal of greywater residues & food wastes as well as the toilet waste. The Conventional on-site treatment method using a septic tank and seepage field can be quite adequate for the purpose with proper care and maintenance. Unfortunately, the conventional systems require large subsurface areas for leach fields and are highly constrained by local soil conditions.

Therefore, it is appropriate to investigate advanced technology options for organic waste disposal which are not dependent on local site conditions and do not impose any detrimental loads on the environment.

In keeping with the systems engineering approach used in developing integrated concepts for the ATH, consideration of waste disposal options should include all types of wastes and residues emanating from all sources. This memo focuses on the overall ATH waste disposal problems and their resolution.

Daily Waste Generation Model

In order to analyse the general problem of waste disposal for the ATH a typical daily flow rate for each type of waste product was derived. Details are displayed in Table 1.

The toilet waste is raw sewage unadulterated with any water, oil or other transport medium used to transfer the waste to a central collection point. It is assumed that perfect separation of raw sewage and the transport medium is feasible.

Garbage waste consists only of food residues and scraps from daily meal preparation. A conventional water flushed garbage disposal unit is not used in order to prevent contaminating large quantities of water with biological matter and to avoid subsequent energy penalties fo separation. Instead, we assume a convenient means of accumulating food wastes in a bagging mechanism. A simple, automatic sealing device in a receptacle near the sink is a sensible alternative.

Grey water is assumed to be collected from kitchen, bath, lavatories and utility sources. The inclusion of the kitchen water in the grey water category is unconventional but is necessary due to the assumption of a sewerless house.

The kitchen waste water will require pretreatment with a grease tray and filtering devices prior to delivery to the grey water processing unit. A total of 115 gallons of grey water is presumed to be treated by the Lockheed pasturization and reverse osmosis (R.O.) equipment which provides 104 gallons of clean water for recycling to utility systems, irrigation or simply runoff in storm drains. The 11 gallons of concentrated brine from the R.O. unit remains to be disposed of.

The household generates 7 lbs. of dry trash per day of which 5 lbs. is combustible material such as paper, plastic, wood, etc. We assume it's no great imposition to separate out the 2 lbs. of metal and glass at the source. Incentive for this effort is that the metal and glass may be considered a useful resource and community pick up and disposal may be arranged free of charge. Therefore, with on-site disposal of other materials all costs related to garbage services would be eliminated.

The yard residue is a highly variant quantity depending on occassional clean up activities. This material (all organic) will be shredded and stored for eventual disposal on or off site.

The only other waste materials not included above are spent filter elements and grease trap residues. These may be bagged and treated with one of the other sources as appropriate. They would be generated only every 6 months or so and do not impose a heavy load on any of the disposal procedures.

The waste generated from each source has the approximate dry solid and mosture contents shown in Table 1, along with estimated combustion energy values. The relatively high value for the food matter (11918 BTU per lb.) is primarily due to fat and oil content.

Ideal net energy input to or output from each source is shown on the bottom line of Table 1. These figures include neither the substantial energy inputs for heating the moisture content to evaporation temperatures nor the parasitic losses in processing machinery. Obviously, the actual net energy input and output levels depend heavily on the disposal method ultimately chosen.

Disposal Method Alternatives

Disposal methods for each type of waste are summarized in Table 2. Details follow. Methods to be discussed all relate to the sewerless house assumption.

Incineration

Three types of incineration may be considered:

- advanced multichamber furnace devices
- pyrolysis
- wet oxidation

Advanced technology furnaces can burn many types of material with minimal emission of gases, fumes or smoke. Ideally, a multi-use furnace could be built to handle slurries, liquids and solids. Such equipment is available in moderate to large sizes designed for more or less continuous operation. Small capacity units with intermittent operation present a more challenging problem to keep energy demands within reasonable levels. Otherwise, they ought to be fairly conventional, reliable, low maintenance equipment items.

Pyrolysis involves reducing waste materials to ash, gas and vapor products within a heated, enclosed chamber (somewhat similar to self - cleaning oven as compared with flame burning of grease deposits). The process is less developed than conventional furnace incineration with consequent reliablity and operational unknowns. It is not yet known whether small units are avialable for an ATH scale operation.

Wet oxidation is a relatively new combustion process which subjects waste material to relatively low temperatures and high pressure air (or oxygen) in a sealed reaction chamber. It appears to be particularly suitable for disposal of dilute organic material. There is interesting potential for significant reduction of net energy input but this advantage may be outweighed by complex control mechanisms and safety hazards.

Investigation is underway to determine feasibility and availability of each of the above incineration processes for the ATH.

Stabilization and Hold

This method refers to mechanisms for disinfecting organic wastes and accumulating them in a quiescent state for periodic pump out and removal. Considering toilet wastes only, one manufacturer claims a 350 gallon capacity unit is adequate for a four person family and requires pumping out once a year. Though such a system may avoid a sewer line connection; it is not, strictly speaking, a "sewerless" method since it imposes a servicing load on some other sewage disposal facility plus the costs of transport. Therefore, this alternative is of less interest for the ATH.

Aerobic tanks

Aerobic tanks are essentially similar to conventional septic systems with the addition of mixing and aeration mechanisms to promote the aerobic (oxygen breathing) bacterial activity for digestion of organic matter. In contrast, conventional septic tanks are an aerobic (non-oxygen using) system. The advantage of the aerobic action is that it can be a considerably faster, more efficient process if set up and used properly. Therefore, smaller tank capacities and leach fields are required. There has been a great deal of research into aerobic processes in recent decades and they are included here as a possible option for the ATH, for selected site conditions, since they do represent a relatively new technology.

Composters

This method of organic waste utilization is included as an option for ATH residents who would be active gardeners. It provides a old, proven method for cheap, efficient conversion of food and yard wastes into a valuable soil supplement.

There has been strong development of composting toiletsin Europe and elsewhere which is now starting to gain some attention in some areas of the U.S. Properly maintained and used, they can be a perfectly acceptable, sanitary method of disposal for toilet waste. However, on reviewing the literature on the subject it appears that use of these systems require the highly motivated attitudes usually found in people deeply involved in ecological issues. It is felt that general acceptance of composting toilets by a large proportion of the population is not imminent. Also more research and analysis is needed on the bacteria and virus content of compost residues. In the meantime, it is advisable to exercise the same precaution with compost residue as with normal septic tank wastes.

Therefore for the ATH we consider simple composting of kitchen and yard organic matter as an interesting option for residents so situated and so inclined to use it. But on-site disposal of toilet wastes by composting methods will not be considered further.

Evaporation

There are some interesting possibilities in concentrating the waste from the greywater treatment unit by evaporation. This is an ideal use of low grade solar heat energy. Essentially, warm air from a separate solar panel,or directed from a PV array cooling channel,flows through an evaporator chamber which simultaneously cools the air and vaporizes the greywater. The evaporator may use either a wick or disc mechanism. For instance, a single 8' x 12' solar panel and fractional horsepower air blower could generate 100,000 BTU's on a reasonably sunny day which is sufficient to evaporate upto 12 gallons of water.

Compact and Hold

In the absence of an incineration system it will be necessary to use conventional means of dry trash disposal. If this is the case then high ratio, energy efficient compaction units would be required to effectively store trash on-site prior to pick up. The reduction in volume would at least reduce the frequency (and presumably the cost) of community trash services.

Disposal Systems Synthesis

The utlimate waste disposal system for the ATH would be a multi-purpose incineration device that would burn sludge, solids and liquid materials. Referring to Figure 2 this may be termed the A1-B1-C1-D1-E1 system. The final waste products generated by the ATH would be limited to sterile ash, glass/metal trash and benign gases and vapors. The ash can be buried or disposed of off-site with minimal demands on external systems. The glass/metal trash should have economic value and be readily accepted for recycling. The gas and vapor wastes would be air dispersed with no discernable impact on the immediate environment.

As mentioned previously, if the ATH residents were so disposed they could compost the kitchen and yard waste for gardening purposes and eliminate some of the demand on the incinerator. (System A1-C1-D1 & B4-E3).

For a moderate investment in equipment a solar evaporator could be included to concentrate greywater wastes. If this is achieved the incinerator could conceivably become a net energy generator due to the high BTU content of household trash. (refer to Table 1). The obvious use of excess energy would be to recapture heat via heat exchangers tied to the hot water system. This would supply a substantial portion of hot water heat which is assumed to demand a total input of some 36,000 BTU's per day.

For any system which includes an incineration option, net energy inputs would be reduced by using heat recovery devices in the flues and vents. Detailed energy flow and balance analysis will be conducted as equipment data is obtained and specific system configurations are composed.

TABLE I

AVERAGE DAILY WASTE FLOWS & DISPOSAL REQUIREMENTS FOR SINGLE FAMILY DWELLING

SOURCE	TOILET	GARBAGE DISPOSAL	KITCH., BATH, LAVS, UTILS.	HOUSEHOLD TRASH	YARD
Product	1.1 Gal. Urine 1.3 lb Feces	1.5 lbs of Food Matter	115 Gal Grey Water	5 lb Combustible Materials; plus 2 lb Metal & Glass	1.5 lb Grass Leaves, Etc.
Process	Oil Flush Transport System	Bagging System (No Water)	Reverse Osmosis Treatment unit. 104 Gal. Clean Water for Reuse. 11 Gal. Concentrated Waste Water for Disposal.	Combustibles to Compactor, Non-combustibles to storage for collection	Shredded & Compacted
Equiv. Dry Solids (lbs).	0.4	0.5	-	4.5	0.9
Energy Potential (Avg. BTU/LB)	7668	11918	-	8059	7391
Total Energy Potential (BTU)	3067	5959	-	36266	6652
Moisture Content (LBS)	10.1	0.9	96.0	0.5	0.8
Energy to Evap. Moisture (@ 1040 BTU/LB)	10504	936	99840	520	832
Net Energy Input (Output) in BTU's	7437	(5023)	99840	(35746)	(5820)

TABLE 2

ALTERNATE METHODS OF WASTE DISPOSAL

A. TOILET SLUDGE	B. GARBAGE	C. GREY WATER CONCENTRATE	D. TRASH	E. YARD WASTE
1. Incineration	1. Incineration	1. Incineration	1. Incineration	1. Incineration
2. Stabilize & Hold	2. Stabilize & Hold	2. Evaporation	2. Compact & Hold	2. Compact & Hold
3. Aerobic Tank	3. Aerobic Tank	3. Aerobic Tank		3. Composter
	4. Composter			

C. Concept Development for Water System

(5/12/80)

ADVANCED TECHNOLOGY DISPLAY HOUSE

CONCEPT DEVELOPMENT FOR WATER SYSTEM

CONTENTS

5/12/80

Submitted By

Don Maund

INTRODUCTION

The following material presents a baseline concept for the ATDH water system consistent with previous memoranda. It is intended to identify major components which need to be engineered or selected for inclusion in the project. Actual layouts displayed may be changed as specific equipment is analysed for the water and/or interface systems.

WATER SYSTEM DESCRIPTION

A diagram of the proposed water system for the ATDH is shown in Figure 1. The overall system is composed of the four major subsystems outlined in Figure 2 and identified as:

Conventional Supply
Rain Collection
Distribution
Greywater Recycling

Conventional Supply System

Both utility mains and wells are indicated as possible sources of freshwater supply. In practice only one or the other will be used. The obvious advantage of well supply, where practicable, is the greater degree of independence of the ATDH from the external (communicty services which provides more physical and economic flexibility.

Another consideration is that an on-site well is the ultimate water recycling process whereby local surface runoff percolates to the ground water table and is naturally purified prior to being pumped for reuse.

Filtration and conditioning requirements depend on local water supply quality ranging from nothing to fairly elaborate treatment to remove or reduce rust particles, turbidity, chlorine, etc. For the ATDH it will probably be necessary to provide some treatment in order to attain the highest quality for potable water in terms of taste and clarity.

Rain Collection System

Increasing awareness and concern about the critical problems facing public water supplies will undoubtly reawaken interest in rain collection and storage. Therefore, it is an appropriate consideration for the ATDH even though no advanced technology is involved.

Rainfall at Moffett Field averages 13.3 inches per year with a monthly distribution as shown in Table 1 below.

TABLE I

Month	Rainfall (inches)	Gallons Collectable(1)	Percentage of ATDH Demand(2)
Jan	2.9	3625	121%
Feb	1.9	2375	79%
Mar	1.9	2375	61%
Apr	1.1	1375	35%
May	0.4	500	13%
Jun	0.1	125	3%
Jul	-	-	-
Aug	-	-	-
Sept	0.2	250	6%
Oct	0.6	750	19%
Nov	1.7	2125	71%
Dec	2.5	3125	104%
	13.3		

1. 2500 sq. ft. roof area and 20% loss due to evaporation, etc.
2. Assume 3000 gal/month usage (net of extensive recycling) in Nov., Dec., Jan., Feb., and 3900 gal/month rest of year.

The actual amount of rainwater which could be collected depends on cistern size and daily rainfall and storm patterns. However, rain is obviously a significant resource. A 1000 gallon (approximately 5X5X5 ft) cistern would probably retain most of the potential catchment. In addition, the cistern would also provide buffer storage for recycled greywater and increase overall utilization of this resource also.

Greywater Recycling System

The system shown allows for maximum recycling of all greywater generated within the ATDH. The major subsystem is a pasturization/reverse osmosis unit originally designed for long term life support in spacecraft. The unit can reclaim and purify to potable standards better than 90% of all greywater.

The pasturization process eliminates the need for chlorine or iodine additives for disinfection by holding the fluids at 165^{o} F. for a suitable length of time to eliminate pathogens. It may be desirable to operate the unit at higher temperatures (200^{o} F.) for greater reliability. At the higher temperatures, holding time is reduced and flow rates through the reverse osmosis units are significantly increased. This and other engineering design tradeoffs will be investigated as specific data on flow rates and component sizes are developed.

Water Distribution System

The distribution of water within the ATDH is designed around the Ultraflow system, (Using direct routed, single line, small bore pipes, which deliver water at preset temperatures via electrically actuated solenoid valves). This system offers the ultimate flexibility in design and greatly simplifies distribution of the three grades of water circulating within the ATDH. In addition the system has the potential for significant water and energy savings by reducing the amount of water normally wasted in purging lines used in conventional dual pipe plumbing.

Referring to Figure 3, there are five inputs to the Ultraflow control unit deriving from three water sources A(fresh), B(recycled), C(rain).

A_H = Heated potable freshwater from mains or well.

A_C = Cold potable freshwater from mains or well.

B_H = Heated recycled water.

B_C = Cold recycled water.

C = Stabilized rain water from cistern

There are many ways to use the various grades of water, only one of which is indicated in Figure 3:

(a) Only A grade potable freshwater is delivered to the kitchen sink and other areas where a potable outlet is required, such as a bathroom.

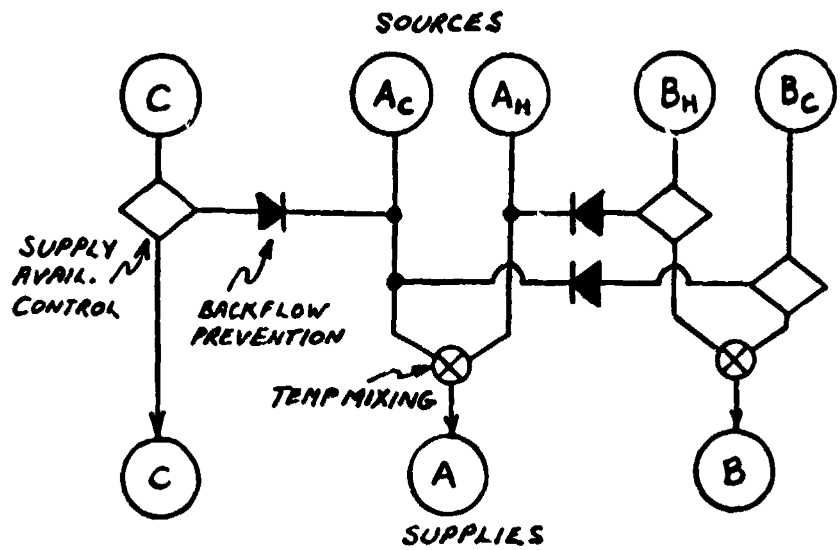
(b) Grade B recycled water would be suitable for any utility and personal hygiene use. (Public attitudes may dictate the optional use of grade A for bathing purposes, however.) In any case grade A would be automatically switched on whenever grade B is not available.

(c) Grade C water will be used for exterior uses as shown. If grade C supply runs out at any time then grade A would come on line automatically.

The only reason that relatively pure, soft rainwater might be graded below the B (recycled) water would be due to the economics of treating all water to the same standard of reliability. Otherwise, grades B and C could be lumped together to enable a simplified distribution system.

The relative ease with which water grades can be switched and distributed according to demand is a powerful feature of the Ultraflow system in the ATDH application.

Control logic for the Ultraflow unit is indicated in the following diagram:



The distribution system indicates the possible tie-in of the garbage disposal and toilet units. Ideally, these functions will not use any water at all, however some connection may be needed depending on the type of units to be installed. Clearly, this would not present a problem as far as water distribution is concerned.

FIGURE 1.

WATER SYSTEM FLOWCHART

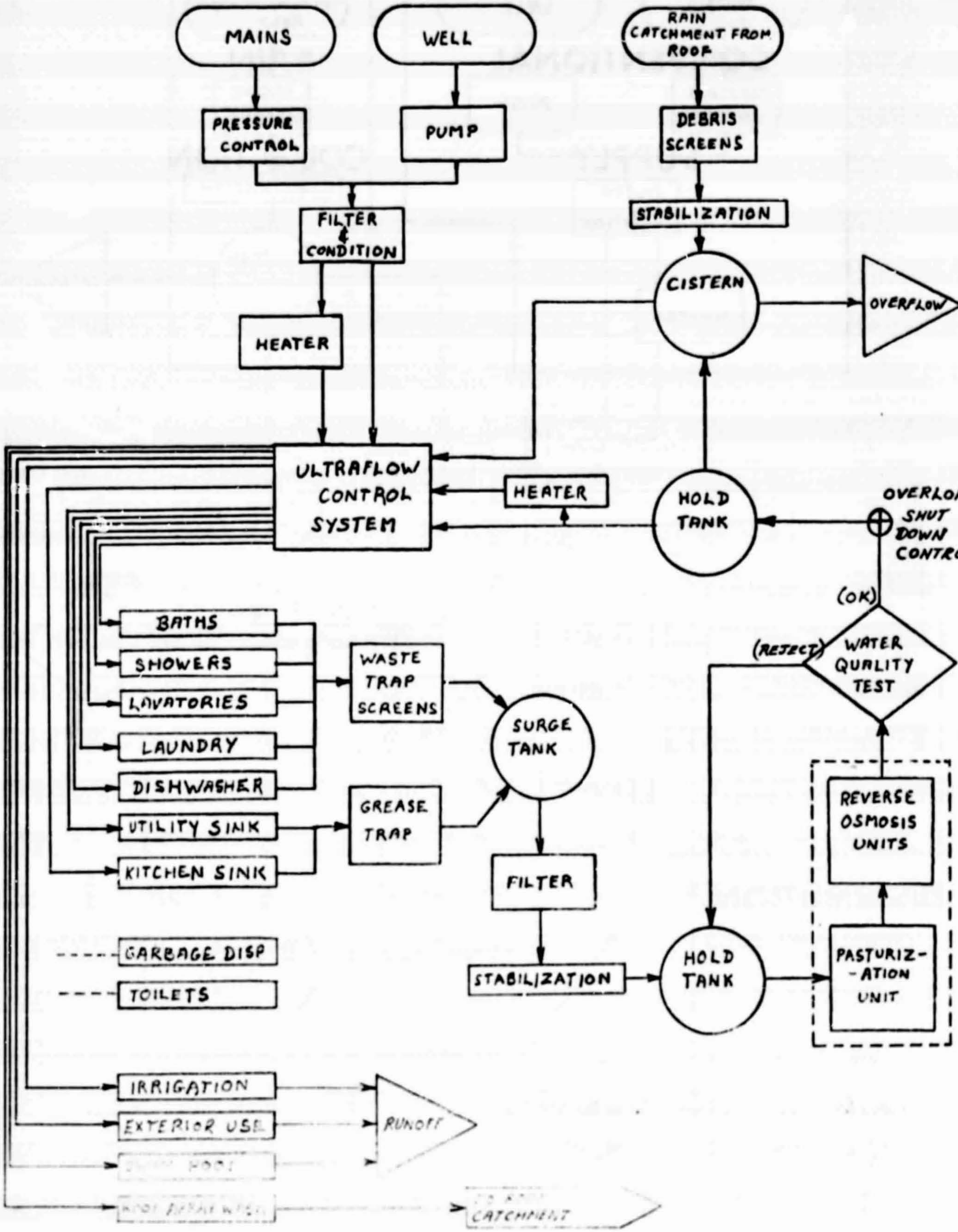


FIGURE 2

MAJOR SUBSYSTEMS

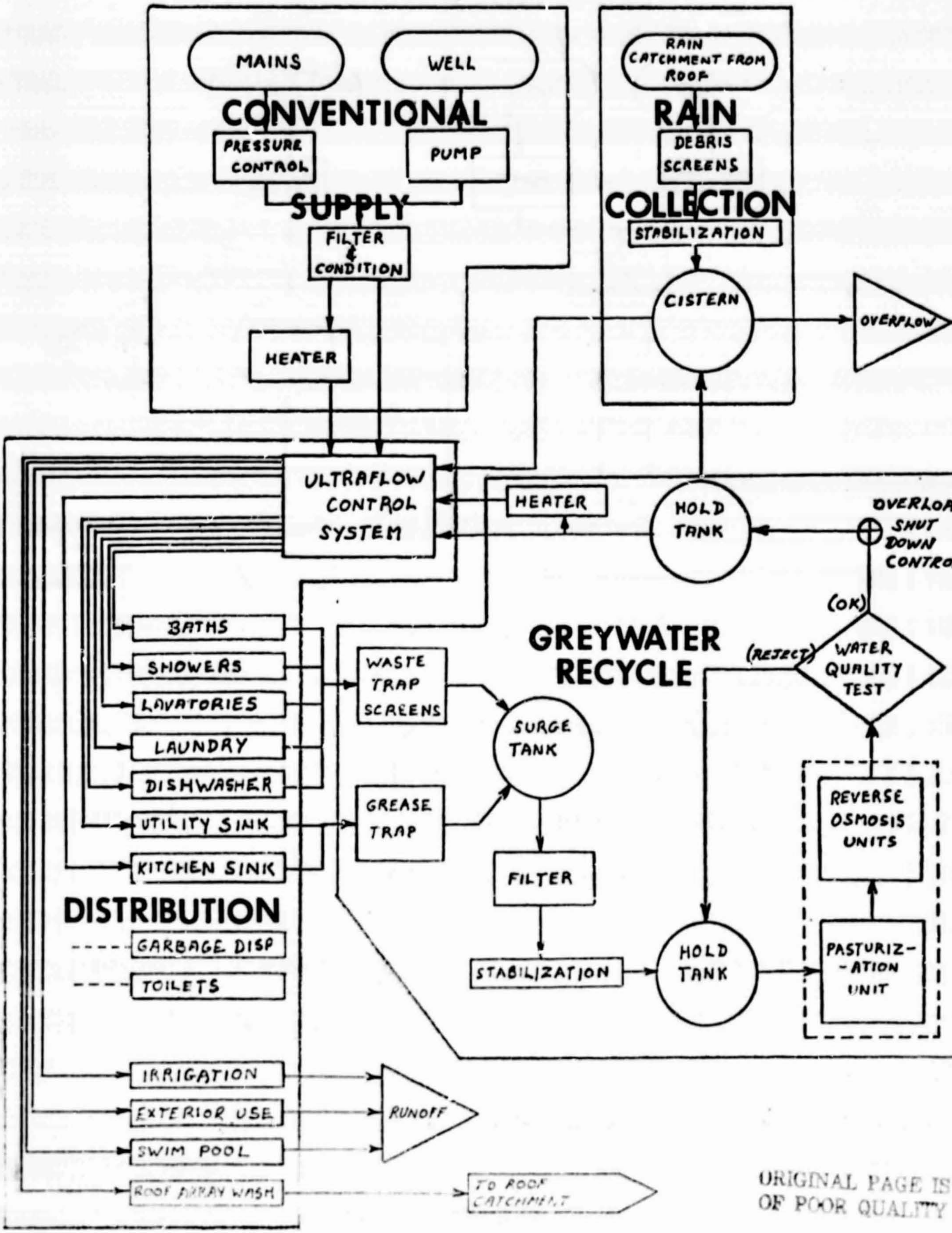


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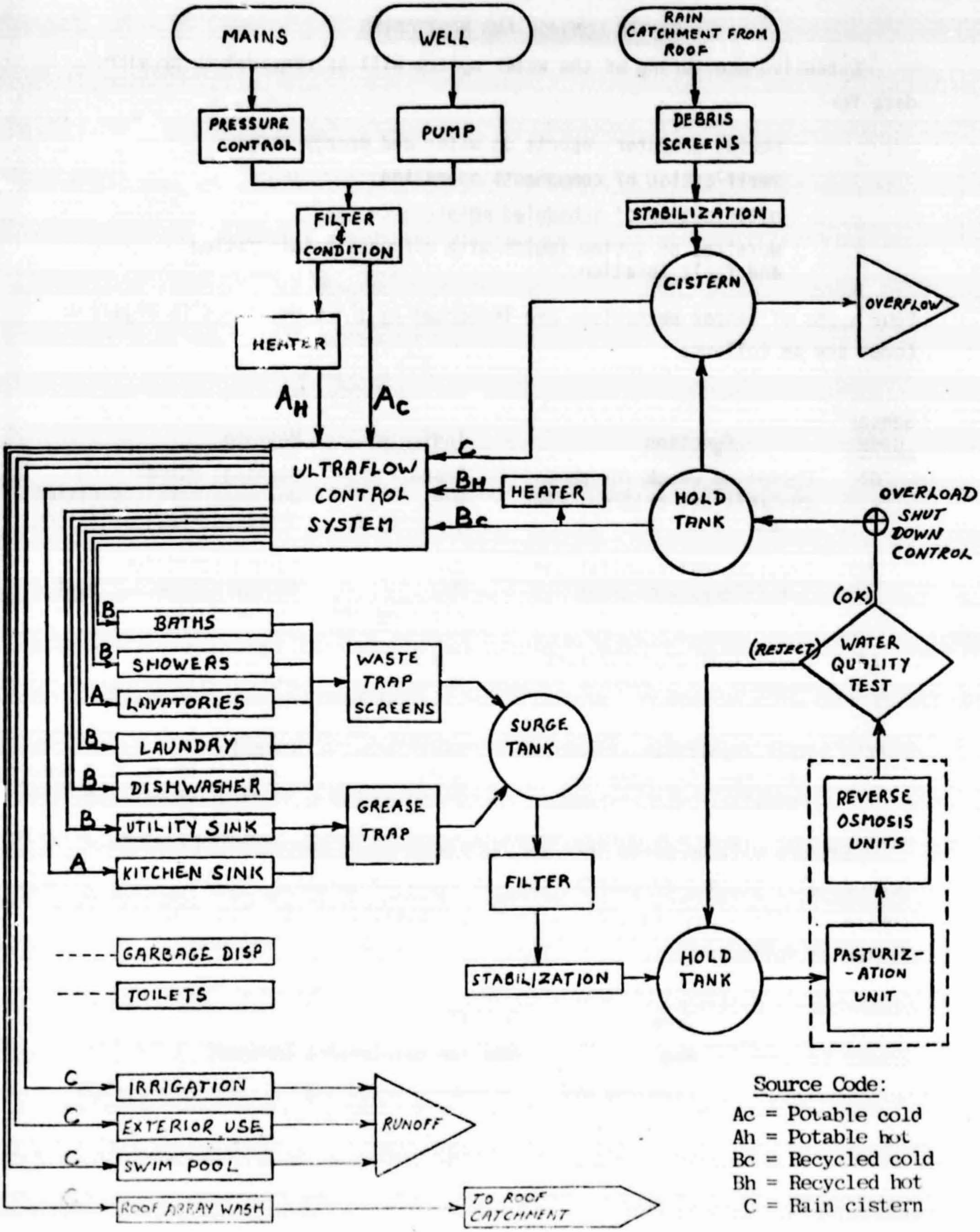
FIGURE 3

Distribution sources and uses.



Source Code:

Ac = Potable cold
Ah = Potable hot
Bc = Recycled cold
Bh = Recycled hot
C = Rain cistern

SYSTEM CONTROL AND MONITORING

Extensive monitoring of the water system will be required to provide data for:

- period computer reports on water and energy usage,
- verification of components operation,
- notification of scheduled maintenance needs,
- warnings on system faults with diagnostic information and fault location.

Four types of sensor mechanisms are indicated by the coded flags in Figure 4. Codes are as follows:

Sensor Code	Function	Indicator	Message
'O'	Operating check for pumps controls and critical flow lines	Green	Running; Normal
		Red	Running; Fault condition
		Flashing Red	Stopped; Fault condition
'P'	Pressure differential check for filters and traps	Green	Normal condition
		Red	Filter change imminent
		Flashing Red	Change filter
'L'	Level indicator for tank units	Green	Normal
		Red	High level
		Flashing Red	Overflow condition
'T'	Test stabilization equipment (eg. Chlorination units)	Green	Normal
		Red	Recharge or service imminent
		Flashing Red	Recharge or service unit

Sensors will be wired into the home management computer and will be periodically scanned for condition. An indicator light located at a convenient central location (eg, kitchen) will continuously indicate status of the water system as follows:

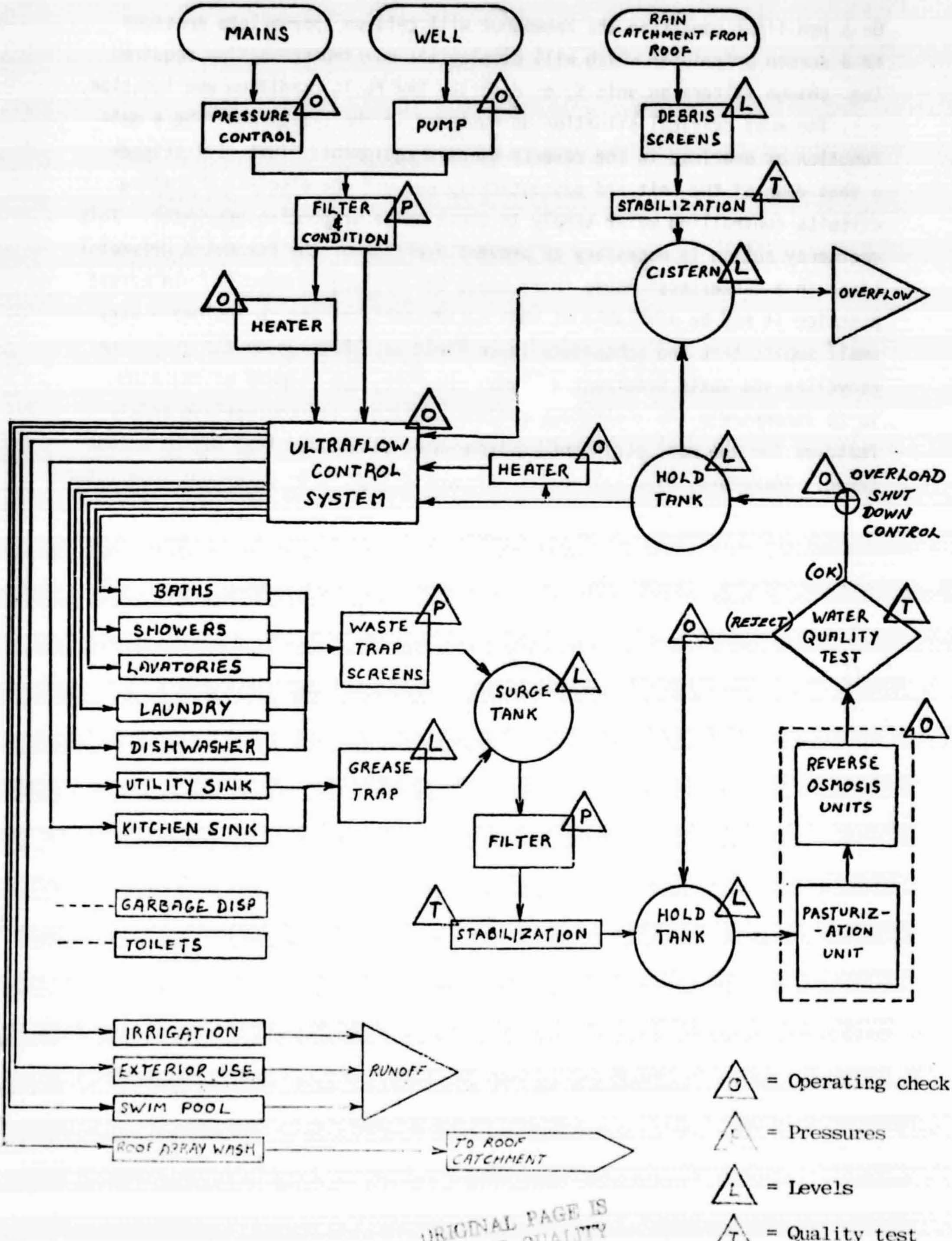
Green	Normal
Red	Routine maintenance imminent
Flashing Red	Maintenance required or fault condition

On a red light condition the homeowner will call up appropriate messages on a screen or printer which will display the maintenance action required (eg. change filters on unit X) or describe the fault condition and location.

The most critical situation encountered in the system would be a malfunction or overload in the reverse osmosis equipment. This will trigger a shut down of the unit and automatically cut off the electric Ultraflow circuits controlling water supply to those units producting greywater. This emergency action is necessary to prevent overflow of the untreated greywater since in a "sewerless" house there would be no place to dump it. In actual practice it may be advisable at some residence locations to include a very small septic tank and subsurface leach field as a back up to the greywater recycling and waste treatment systems. However, the purpose of the ATDH is to demonstrate the technology options available and appropriate safety features for the most stringent environmental situations that may be encountered. Therefore, high reliability systems design is of paramount importance.

FIGURE 4

System Control



WASTE MATERIALS GENERATION

The principal links across the water waste disposal systems interface are shown in Figure 5.

Waste from sources number 1, 2, 3 and 4 will be spent filter cartridges and clogged screens. The types of filters which are renewed by backwashing would not be desirable in the ATDH system due to complications in disposal of the flush water. Therefore, units using replaceable elements will probably be emphasized. The ultimate disposal of the spent materials is a problem to be addressed in the waste treatments systems definition.

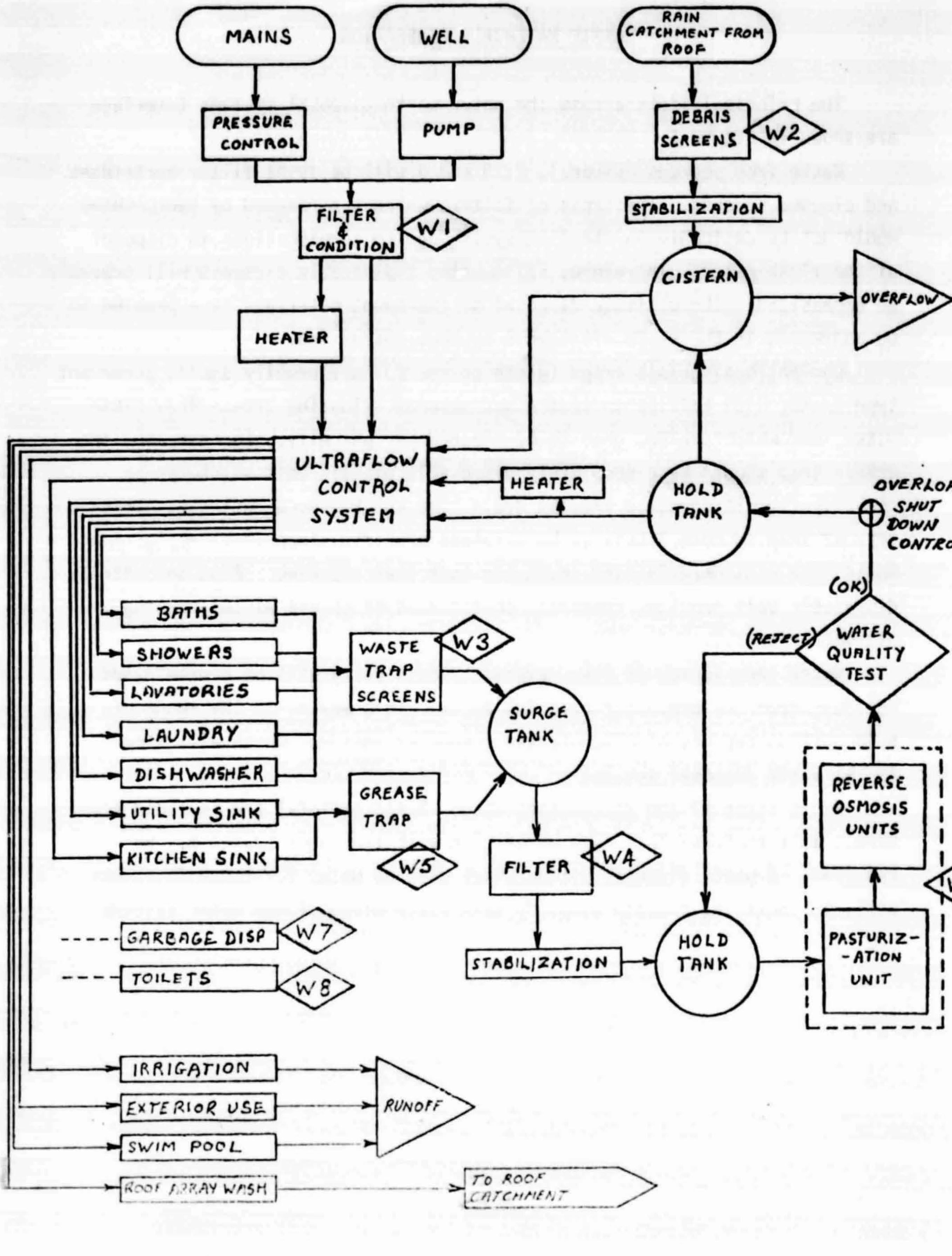
Conventional grease traps (waste source #5) are usually small, permanent type tanks, with baffles to settle and separate floating grease from waste water, and which are designed to be cleaned periodically. For the ATDH the grease trap should be a completely disposable plastic unit which can be conveniently disconnected from the drain line and replaced entirely. This type of trap is more likely to be serviced properly since total replacement would be a considerably more aesthetic task than cleaning. Also an entirely disposable unit provides temporary containment of grease wastes pending ultimate disposal.

Waste from source #6 (the reverse osmosis unit) will be concentrated residues from the greywater cleaning cycle. This may be in the range of 5-10 gallons per day of concentrated greywater residues which will flow to the waste disposal system.

Waste items #7 and #8 (garbage disposal and toilets) are included here merely as a reminder that some connection with the water system may be required. A waste disposal system which uses no water for these functions will, if feasible, greatly simplify both waste disposal and water systems design.

FIGURE 5

Waste Generation (Sources indicated by ⟨W⟩)



SYSTEM DESIGN

The mission of the ATDH project is to demonstrate technological options for future housing construction and operation within a realistic setting. In addition it will provide an invaluable, full scale test bed for a variety of equipment and procedures for implementing future technologies. This objective contrasts with some previous demonstration projects which have attempted to select a particular item, or set of items, to meet set guidelines which pressume to describe typical future personal and community needs for housing. As a result, for the ATDH project, it is not so important to optimize the design of any one system as it is to provide a layout which can accommodate a wide range of equipment and usage scenarios. The water system suggested in the previous sections is intended to meet this provision. Final design must await specific information on components likely to become candidates for inclusion in the project.

In order to size the various parts of the water system on a realistic scale, the following baseline daily needs of for a family of four (two adults, two children) may be used:

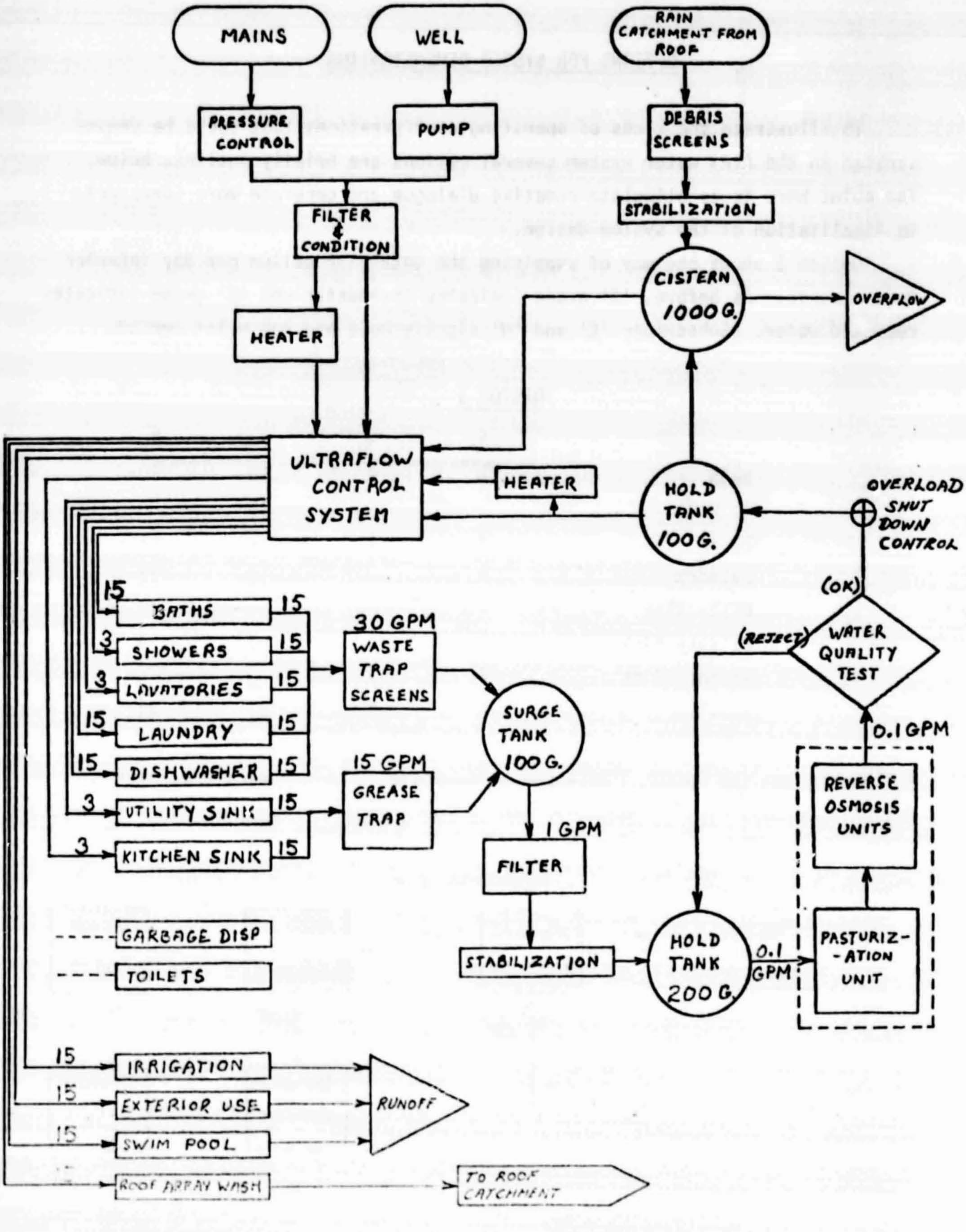
	Average Gallon per Day		
Function	Cold	Hot	Total
Baths	10	20	30
Showers	10	20	30
Lavatories	4	4	8
Laundry	10	25	35
Dishwasher	-	15	15
Utility Sink	1	4	5
Kitchen Sink	4	5	9
Totals	39	93	132

There is very little data to go on for estimating water used for the exterior purposes, and what there is indicates a wide variance in both quantity and time of usage. As a general guideline a household may use an average of 25 gallon per day during the four winter months (Nov., Dec., Jan., Feb.) and an average of about 100 gallon per day the rest of the year. In addition there may be infrequent high demands when flushing and recharging some part of the water system, or refilling a pool, etc.

A possible set-up for the ATDH system is indicated in Figure 6 which would provide some flexibility in demonstrating a number of optional demand and service scenarios.

FIGURE 6

Approximate flow rates and capacities



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OPTIONS FOR SYSTEM DEMONSTRATION

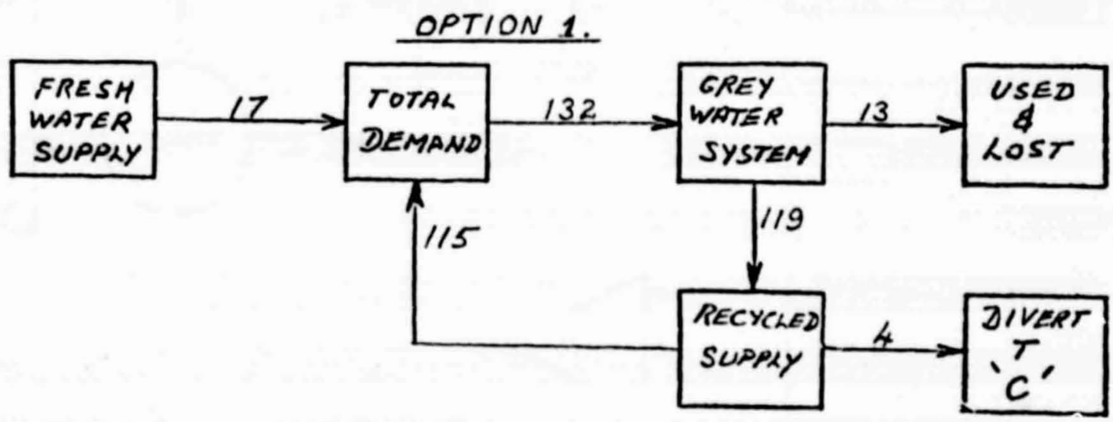
To illustrate the kinds of operating configurations that could be demonstrated in the ATDH water system several options are briefly outlined below. The point here is to stimulate creative dialogue and generate more ideas prior to finalization of the system design.

Option 1 shows one way of supplying the total 132 gallon per day interior requirements. As before, 'A' grade indicates freshwater and 'B' grade indicates recycled water. Subscripts 'C' and 'H' signify cold and hot water demand.

OPTION 1

	A_C	A_H	B_C	B_H
Bath	-	-	10	20
Showers	-	-	10	20
Lavatories	4	4	-	-
Laundry	-	-	10	25
Dishwasher	-	-	-	15
Utility Sink	-	-	1	4
Kitchen Sink	4	5	-	-
Totals	8	9	31	84

A flow diagram for Option 1 is shown below where numbers indicate average gallons per day.



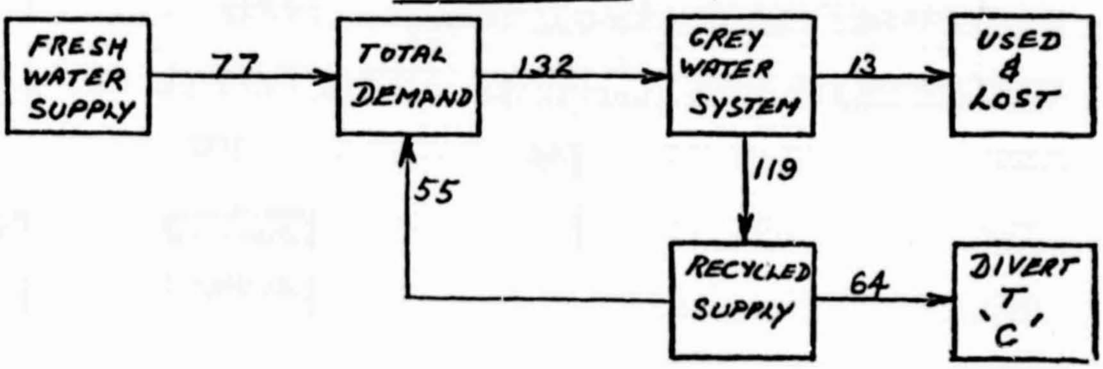
Option 1 represents about the ultimate in recycling potential since it requires a total freshwater input of 17 gallons per day. This input almost exactly compensates the estimated 10% (13 gallon) losses from the water cycle due to non-replaceable usage and greywater processing residues.

The more likely configuration to be adopted by most ATDH "residents" is given in Option 2.

OPTION 2

	A_C	A_H	B_C	B_H
Bath	10	20	-	-
Showers	10	20	-	-
Lavatories	4	4	-	-
Laundry	-	-	10	25
Dishwasher	-	-	-	15
Utility Sink	-	-	1	4
Kitchen Sink	4	5	-	-
Totals	28	49	11	44

OPTION 2.



This configuration requires a daily freshwater input of 77 gallons plus 55 gallons of recycled water. The 64 excess recycled gallons are diverted to grade 'C' storage or runoff drains.

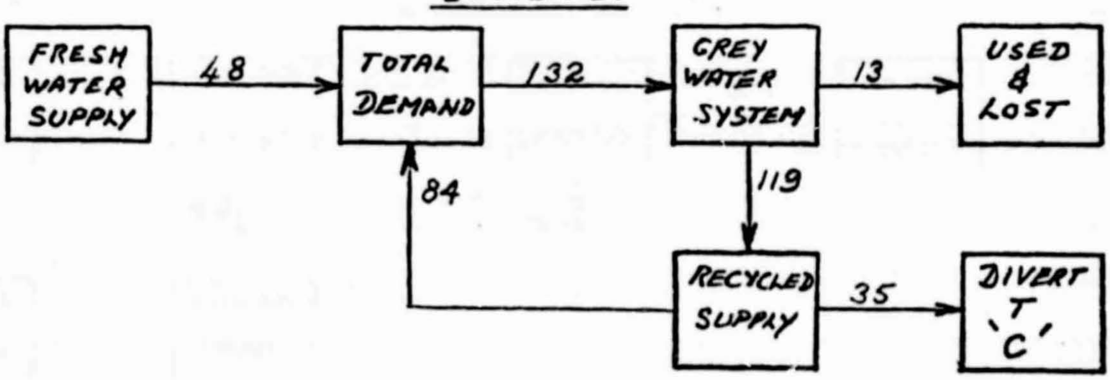
Either of the above configurations is a dramatic improvement over the approximately 300 gallon daily usage in the conventional four person residence.

Another interesting possibility would be to use freshwater for all cold water and potable needs, and recycled water for the non-potable hot water demand. This is displayed in Option 3.

OPTION 3

	A_C	A_H	B_C	B_H
Bath	10	-	-	20
Shower	10	-	-	20
Lavatories	4	4	-	-
Laundry	10	-	-	25
Dishwasher	-	-	-	15
Utility Sink	1	-	-	4
Kitchen Sink	4	5	-	-
Totals	39	9	..	84

OPTION 3.



A number of advantages might accrue from Option 3 including:

(a) The freshwater heating tank could be eliminated. The nominal hot water needs at the kitchen and lavatory sinks would be supplied by instant hot water devices located at the faucets or at the Ultraflow control unit.

(b) All the recycled water would be held, or flow through, a 160°F heating tank which provides added sterilization protection. It would then be diluted with cold freshwater as necessary.

(c) Only 48 gallons of freshwater are needed for average daily system inputs.

In summary, many arrangements are possible with Ultraflow controls which could include any combination of 4-way mixing between the A_C, A_H, B_C, and B_H inputs to provide the desired dilution of recycled water with freshwater.

An interesting further possibility for any of the three optional configurations outlined above is to use a commercially available desalination device to supply the freshwater from S.F. Bay waters. Some information on a unit produced by Allied Water Corperation (South San Francisco) is appended. A unit which produces upto 80 gallons of potable quality water per day currently costs $4000.

Such an input source would isolate the ATDH from all water utility lines and demonstrate the degree of independence possible.

The model shown is also a reverse osmosis (or hyperfiltration) device based on similar principles to the unit for greywater recovery previously discussed as a candidate for the ATDH. However, the commercial model is a "high bypass" mechanism which circulates saline water at high volumes, extracting about 20% of the water in the process and returning some 80% to the source. For the greywater processing unit a "high product ratio" device is required which recovers the maximum amount of greywater and minimizes residues to be further processed for disposal.

SweetWater Series III

Integrated Water Desalting & Purification Systems
By Allied Water Corporation

Allied Water INVENTED the Portable R/O Desalter...

Allied Water understands small-scale, portable R/O water desalting systems because Allied invented them back in 1976. Starting with the concept that the world needed a human-scale sea-water desalting system, one that didn't require heat or chemicals, Allied innovated the energy-efficient, reverse osmosis systems that are now synonomous with the Allied trademark "SweetWater."™

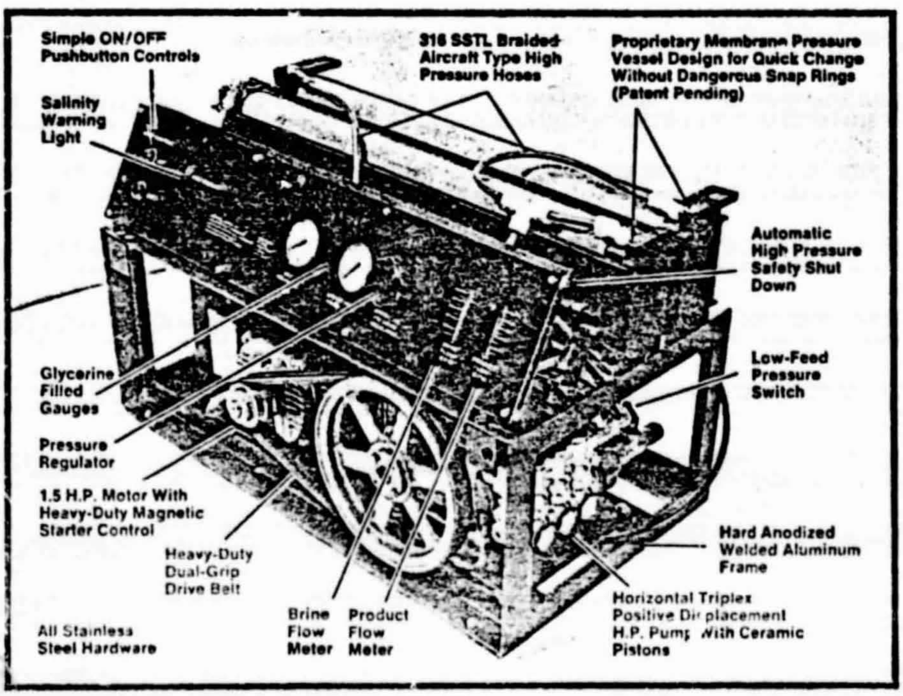
Allied's concept represents a radical departure from traditional thinking in the R/O water desalting establishment—where the emphasis has been primarily on producing ever-larger systems. Allied's initial "water machine" reversed this trend. Smaller than a TV set and drawing less power than a window air conditioner, it produced 200 gallons of fresh water a day from virtually any feed source. At last, a practical, low-cost, low-maintenance desalting system was available for everybody who needed it—for commercial and private boat owners, isolated bad-water communities, crews working in areas where fresh water supplies had to be flown in.

SweetWater units desalt and purify water for only a few dollars per 1,000 gallons, and initial equipment costs are modest. A SweetWater system is also available to operate on virtually any power source and in nearly any environment one may find in any part of the world.

SweetWater Series III represents the third generation "state-of-art" in small-scale reverse osmosis water purification. No other small unit is comparable. Many innovations and modifications have been made since the earlier introduction of the SweetWater systems to reduce maintenance and improve overall reliability.

Allied Water now produces SweetWater systems for a thirsty world at its new manufacturing and research center in South San Francisco, California. Because Allied Water is the leader in human-scale R/O water systems, and is not a part of a multi-product company with other interests, it can maintain and guarantee exacting standards in every unit delivered.

The SweetWater Series III... a BETTER water System



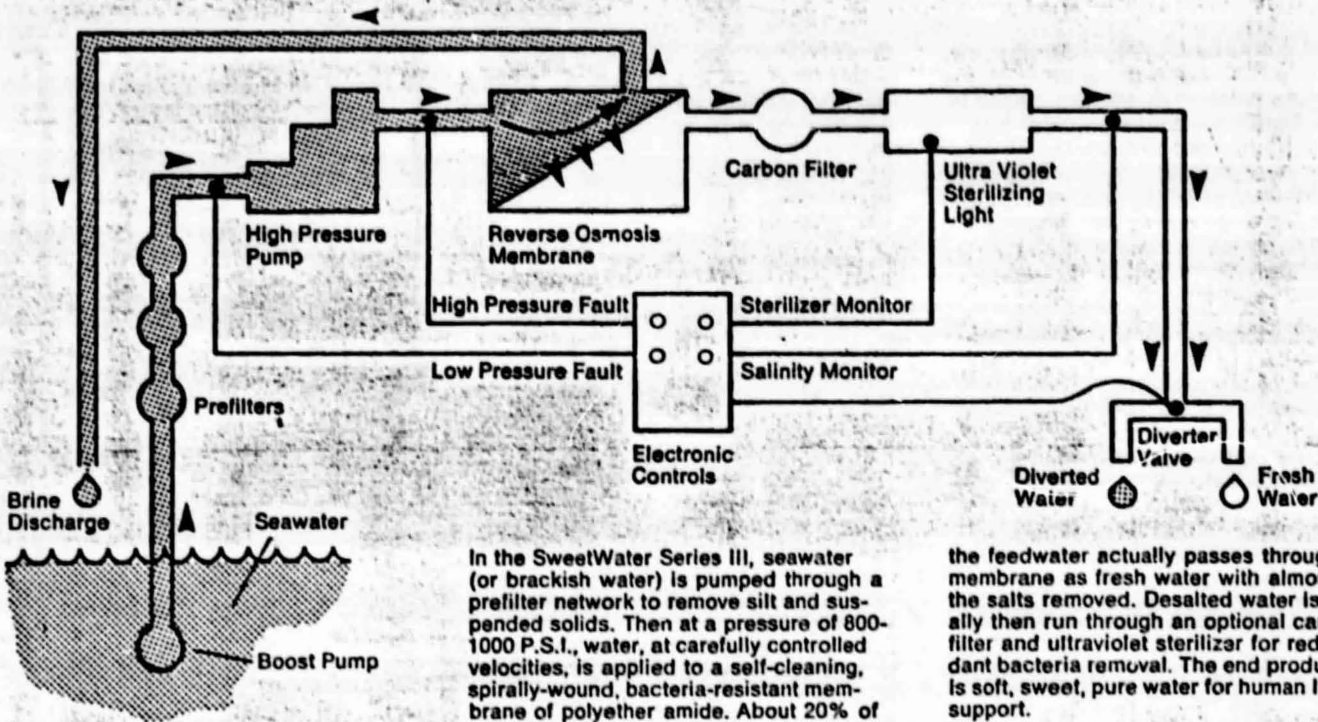
Typical SweetWater system; Model 600SM shown.

The physical demands of a good seawater R/O desalting system are incredibly tough to meet. Not only must components on the high-pressure (800-1000 P.S.I.) side of the system provide long-term integrity—but they must also resist the extremely corrosive effects of the seawater itself. Years of constant testing and research have gone into the SweetWater Series III to make it the most reliable R/O unit on the market today. All components, many specifically made for this application, have been continuously field tested to insure reliability. SweetWater Series III is designed to stand up in the most adverse application.

To make a good thing even better, SweetWater Series III can be equipped with a fail safe electronic monitoring control. If salinity, sterilizer level, high-pressure systems, or prefiltration vary only slightly from preset standards, the unit simply shuts itself down and tells you what is wrong.

And the way the unit is designed, anyone can usually correct a shutdown easily and quickly with simple tools. Unlike many portable R/O desalting systems, the SweetWater Series III has been carefully thought out, designed and tested with long-term reliability and life-support consciousness in mind. It is definitely the BETTER water system.

The SweetWater Desalting Process...



In the SweetWater Series III, seawater (or brackish water) is pumped through a prefilter network to remove silt and suspended solids. Then at a pressure of 800-1000 P.S.I., water, at carefully controlled velocities, is applied to a self-cleaning, spirally-wound, bacteria-resistant membrane of polyether amide. About 20% of the feedwater actually passes through the membrane as fresh water with almost all the salts removed. Desalted water is usually then run through an optional carbon filter and ultraviolet sterilizer for redundant bacteria removal. The end product is soft, sweet, pure water for human life support.

Capacities from 40 to 2,000 gal/day meet any type of application...

SweetWater systems are a complete product line of small-scale seawater desalters producing 40 to 2000 U.S. Gallons per day of drinking water from seawater. Specific capacities are: 40*, 80, 200, 600, 1000, 1500, 1750 and 2000 U.S. Gallons per day. These systems are manufactured in three levels of construction standards as described below.

Standard Marine

Designated by a **SM** suffix to the **1XXXX** series model numbers, Standard Marine systems are the most basic mainframe necessary to produce desalted water from the sea. The basic mainframe design allows selection of various options and accessories to complete an entire systems package for custom installation. The SM models are built for moderate to heavy duty applications such as those typically found in private pleasure marine or land based use. Simplicity and cost effective design, plus freedom of option and accessory selection characterize SM systems.

Commercial Marine

Designated by a **CM** suffix to the **2XXXX** series numbers, Commercial Marine systems are of heavy duty construction exceeding most industrial standards. CM systems are designed for operation in commercial/industrial applications under severe environmental conditions. CM systems include many of the available options and accessories as standard to create a fully integrated system. Integrated design, more conservative engineering approach, and extreme-environmental protection characterizes the CM systems.

The CM systems are ideally suited for the commercial fishing industry, the marine transportation and supply industry or commercial applications.

Offshore/Military

Designated by an **OM** suffix to the **3XXXX** series model numbers, Offshore/Military systems are consistent with PetroChemical industry and most military standards. The design has been based upon the need for critical, failsafe operation under the most extreme environmental conditions. OM units have the most extensive level of instrumentation, monitors and controls. Due to the very conservative engineering approach and multiple safety factors, the level of construction standards for the OM units far exceed the requirements of either the standard or commercial marine systems. These units are therefore ideally suited for the offshore industry for installation aboard the drilling, exploration, and production platforms. Military and critical life-support applications are also typical.

*40 GPD is DC current.

SweetWater Attracts World-Wide Attention

As a result of successful demonstrations in Australia, Sinapore, Saudi Arabia, Hong Kong, Sweden, Denmark, South Africa, Japan, Fiji, Indonesia, Italy, the Philippines and the United States, millions of people have heard of the remarkable, energy-efficient, compact, non-polluting, practical portable SweetWater systems.