Using the High-density WRS logs.

The water team started a rerun test point 1a (2 person, no recycle, small ion exchange beds) at 8 am Nov 20, 2001. The high-density (data every 15 seconds) logs actually start a few minutes after midnight that day and finish at midnight on the 24th. Each subsystem -- the BWP, RO, AES and PPS -- has both a log file and an error file (if any) for each day

This document describes the data columns for each log file, the content of the error files, and points out events that can be looked for in the data. These files should be viewed in MS Excel. A user of these files should keep the skills specs handy to match the labels in the columns with the devices in the subsystem. I will use the schematic in Figure 1 to

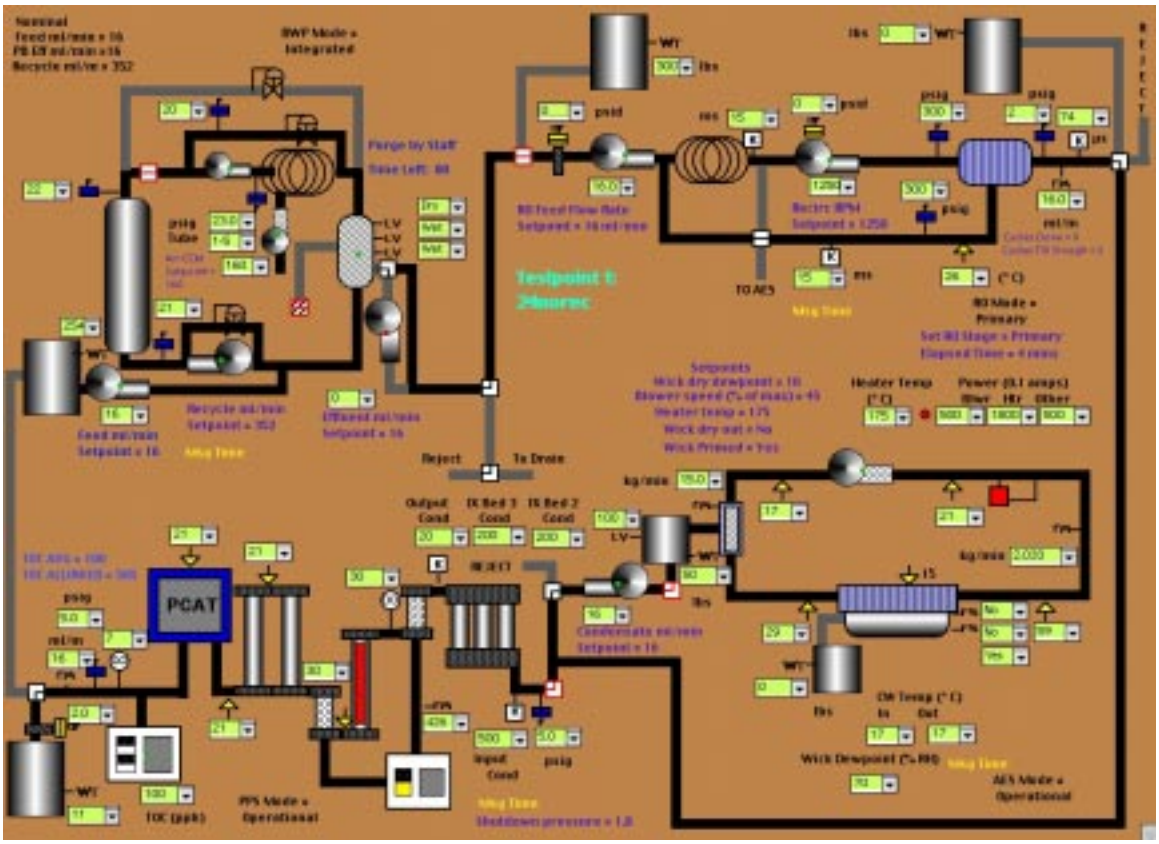

Figure 1 A Schematic Display of the AWRS as seen by 3T. The BWP is in the upper left, the RO in the upper right, the AES in the lower right and the PPS in the lower left. Gray lines indicate flow pipes; black pipes indicate water or air currently flowing. Small boxes with lines at junctures indicate motorized valves**.**

orient the reader during the following discussion.

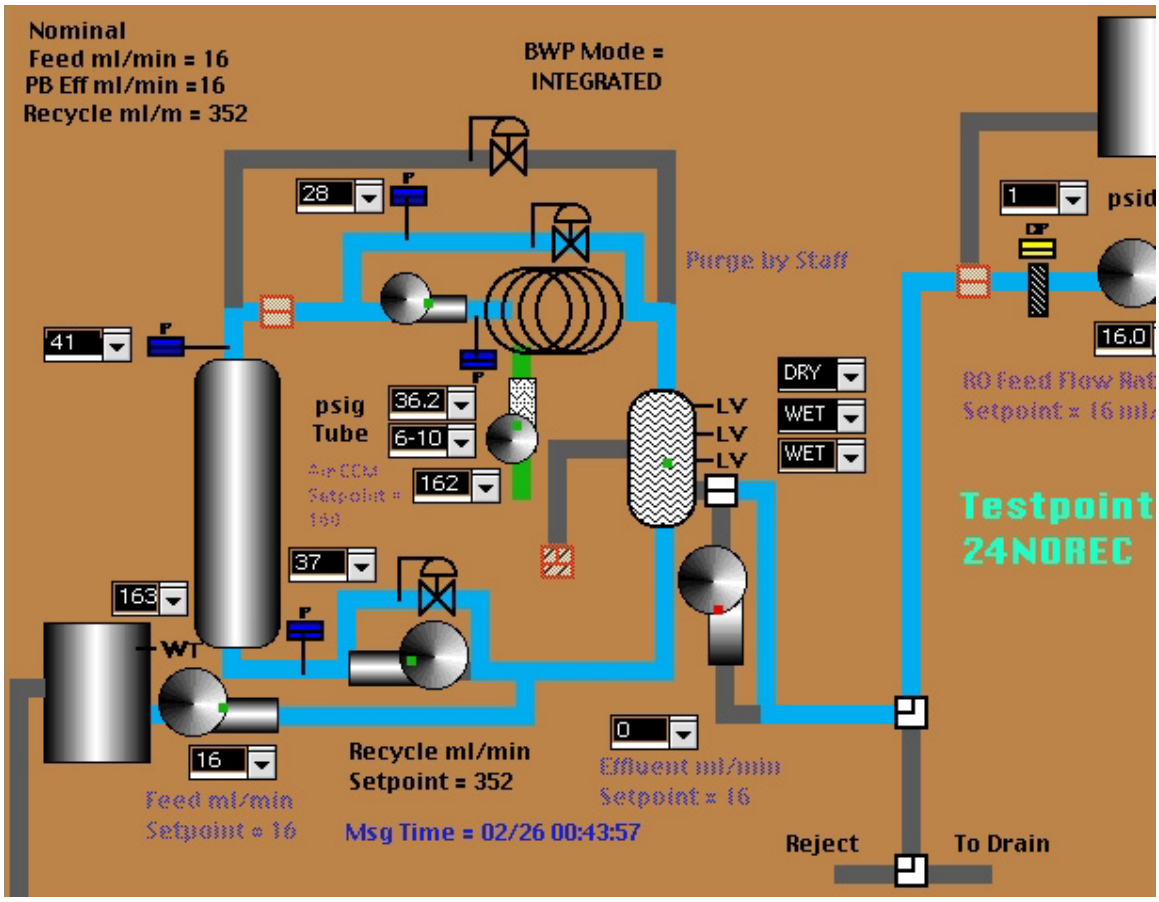

Figure 2 The BWP schematic

The BWP

Water from the main feed tank first passes through the biological water processor (BWP). The main control task for the BWP is to keep the water in the gas-liquid-separator (GLS -- the upright lozenge in Figure 2 with the three level switches) at mid-level. This is accomplished by varying the speed of the feed pump (bottom left of Figure 2) while the draw from the RO main pump (upper right of Figure 2) remains constant. The other requirement is to monitor the pressures in the recycle loop as well as in the nitrifier tubes (spiral coils in Figure 2) and to carry out automatic shutdown procedures (ASDs) in the case of off-nominal values. For example, if one of the nitrifier tubes shows too low a pressure, the water and air pumps associated with that tube are shutdown and a warning is issued.

The BWP Log Files

The BWP log files are prefaced with the letters pbbwpskm (packed bed biological water processor skill manager).

The level switches and pumps

The GLS level switches nominally read as shown below

date	time	ls05	ls06	ls07
11/20/01	4:33:26	0	1	0

Ls05, 06 and 07 are the top, middle and bottom switches respectively, and 1 = wet, 0 = dry. When the switches read as above, the BWP feed pump runs at the test point speed (16 mls/min):

p01_i1	p01_o1
16	16

In our naming convention, the view is from the control system so p01_i1 means the first input (sensor input to the control) for pump 01, and p01_o1 means the first output (command output to the device) for pump 01. In the pbbwp skills spec we see that the pump 01 is the BWP feed pump whose input and output signals are both 4-20 milliamps giving a pump speed of 0 to 100 mls/min.

sensor/device	**wrs name**	**3t Name**	**signal**	**from/to**	**units**
BWP Feed Pump	PU-BWP-017	po1_i1 (waste_water)4-20 ma/		0-100	ml/min
		po1_o1 (waste_water)/4-20 ma		0-100	ml/min

Pump 02 is the effluent pump which is not used in integrated testing; pump 03 is the recirculation pump (runs nominally at 352 rpm) which has no feedback even though a controls channel was made available for it.

p02_i1	p02_o1	p03_i1	p03_o1
0	0	68	352

When the feed pump runs a bit faster than the RO syringe pump the level in the GLS rises and we see the switches as below.

date	time	ls05	ls06	ls07
11/20/01	9:23:24	1	1	0

The 3T controls will slow the feed pump by half to compensate.

p01_i1	p01_o1

8 8

If after twenty minutes, the level has not returned to nominal,

11/20/01 14:28:17 1 1 0

the controls cuts the feed pump speed by half. This is below the resolution of the pump actuator so we see a commanded speed of 4 mls/min but a returned speed of zero.

p01_i1 p01_o1
0 4

Air flow controllers

The nitrifier consists of 8 tubes (coils in Figure 2) through which air and water flow. There are 8 nitrifier air flow controllers each with a commanded and sensed value. Four are shown below (nominal speed is 160 cubic centimeters per minute (CCM)).

p06_o1 p06_o2 p06_o3 p06_o4
160 160 160 160

p06_i1 p06_i2 p06_i3 p06_i4
162 161 162 161

Figure 2 above shows only one air pump icon representing all 8 flow controllers and the displayed air speed is an average of all 8 pumps.

When a tube of the nitrifier is under auto-slough, the air is force to a high value for several minutes and can be seen in the command (or sensed) values, e,g.:

p06_o1 p06_o2 p06_o3 p06_o4
160 160 160 1000

The two columns below are computed from the air speeds and will show off (all 0), on (all at 160) or partially_on (some are off). They tell us if two of the flow controllers have been commanded off because of a high or low-pressure incident (the shutdown will turn off one water pump and two flow controllers because each water pump drives two tubes).

nit_w_pump_cmd nit_w_pump_sens
on on

Nitrifier pressures

There is one pressure transducer that records the psig pressure in each tube (via an eight-way valve) every five minutes. The logs show an average pressure and a max difference pressure from the average as well as the individual pressures.

nit_w_pres_av	nit_w_pres_dif
22.6	4

nit_w_pres(1)	nit_w_pres(2)	nit_w_pres(3)	nit_w_pres(4)
22.1	24.7	22.7	27

Nitrifier pumps

There are four nitrifier water pumps, each with two pump heads, thus driving water through the eight tubes. They are commanded by relays (1 = closed = power, and 0 = open = no power), which provide power to the pumps, which run at a preset speed manually input on the pump face. There is no speed feed back from these pumps. We use the tube pressures to determine if a pump is on or off.

r08_o	r09_o	r10_o	r11_o
1	1	1	1

The two columns below are computed from the relays and will show off (all off), on (all on) or partially_on (some relays are off). They tell us if one of the pumps has been commanded off because of a high or low-pressure incident.

nit_w_pump_cmd	nit_w_pump_sens
on	on

Loop pressures

There are pressure transducers around the recirculation loop. In psig, they will indicate leaks or a failed recirculation pump. Pt02 is not used (the 8 pressures in the tubes are used instead).

pt01	pt02	pt03	pt09
41	204	29	39

Feed Tank Weight

Column wt04 shows the weight of the feed tank in pounds.

wt04
137

Valves

Valve states are displayed as a single 1 and 0's elsewhere for the given number of positions. For example v06 is the valve that directs the water from the GLS through the effluent pump (effluent) or around it (bypass). The skill spec shows that the effluent position is indicated by a one in the first commanded position, and the bypass position by a one in the second position (the normal position when the effluent pump is not used as shown below). The feedback should reflect the commanded position.

```
v06_i1          v06_i2          v06_o1          v06_o2
              1               0               1               0
```

V07, the 8-way valve, is a different kind of device. Its commanded items shown here

```
v07_o1          v07_o2
              1               0
```

Are "step" if the first value is 1 -- moves the valve to the next position, and "home" if the second value is 1 -- moves the valve around to position 1. The feedback consists of 5 values which are decoded using binary coded decimal notation.

```
v07_i1          v07_i2          v07_i3          v07_i4          v07_i5
              0               1               0               0               1
```

The positions represent "1's", "2's", "4's", "8's" and "10's" from v07_i1 to v07_i5 respectively. So the above reading is 0x1 + 1x2 +0x4 + 0x8 + 0x10 = position 2.

The BWP Error Files

Since there were no failures of the bwp during this time period, the pbbwperr files in the high density set only contain information on slough events, e.g.,

```
====== new log, starting 20 Nov 01 00:45:01 ===========

lookForNitSlough: ***** found a nitrifier Slough *****
        tube: 4
        air flow: 988
        nit pres(4): 26.3
                20 Nov 01 00:45:01
lookForNitSlough: ***** found a nitrifier Slough *****
        tube: 4
        air flow: 988
        nit pres(4): 27.4
                20 Nov 01 04:39:51
```

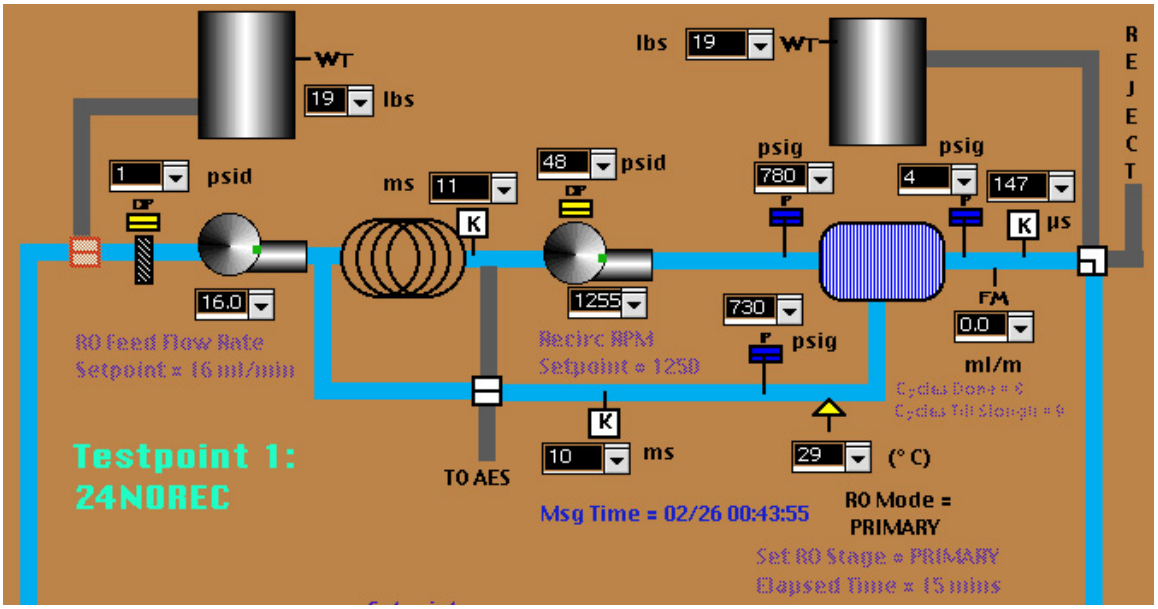

Figure 3 The RO Schematic

The RO

The reverse osmosis (RO) system is the lynchpin subsystem since it pulls water from the GLS of the BWP, and delivers permeate to the PPS and brine to the AES. The RO removes inorganic compounds by pushing the input water at high pressure through tubular membranes (the cross-hatched rectangular icon in Figure 3) that act like molecular sieves with clean water (permeate) passing through to the PPS, and dirty water (reject or retentate) continuing around an internal water loop. The RO must go through up to four distinct phases in each cycle. The primary phase draws water into a coiled section of pipe that acts like a reservoir, while processing permeate in the outer loop of pipes. In the secondary phase, the rejected water is concentrated into brine in the inner loop of pipes. The usual third phase is to purge the brine to the AES. But periodically the membrane needs to be cleaned of particulates that collect on its surface by running the water counterclockwise in the inner loop during what is known as the slough phase.

Additionally there are a number of ASDs associated with backpressure on the membranes, permeate conductivity and loss of pressure in the recirculation loops.

The RO Log Files

The RO log files are prefaced with the letters roskm (reverse osmosis skill manager). The fifteen second logging did not start for the RO until 5:20p on 11/20/01.

<u>RO Syringe (feed) Pump</u>

The RO main feed pump (p06) -- called the syringe pump since it uses two pistons that work in tandem to supply water at a constant pressure -- actually runs from its own

software called Pumpwerks, on its own computer. Rather than going through a skill manager, an IPC client runs on the syringe pump computer and RAPs send pump speed commands (in mls/min) to it via IPC broadcast. The client posts the speed to Pumpwerks, which in turn sends the speed to the firmware running on the pump. RAPs also queries the client for pump data that consists of the pressure in each cylinder and the speed (rate) in each cylinder.

p06_i1	p06_o1	p06_pt1	p06_pt2	p06_rti1	p06_rti2	p06_rto1
16	16	0.7	446.6	-28.8	16	16

The log file records the commanded speed (p06_o1), pressures (p06_pt1 and p06_pt2 in psig) and the speeds (p06_rt1 and p06_rt2). P06_o1 and p06_rto1 are the same and reflect the commanded speed from RAPs (the same speed is sent to both cylinders). Column p06_i1 reflects either p06_rti1 or p06_rti2 depending on which rate is greater, e.g.,

p06_i1	p06_o1	p06_pt1	p06_pt2	p06_rti1	p06_rti2	p06_rto1
15.9	16	451.2	451.2	15.9	0.1	16

The action of the two cylinders -- one extending and the other retracting and then holding until the other is finished extending -- is reflected in the changing rate and pressure fields, e.g.,

p06_i1	p06_o1	p06_pt1	p06_pt2	p06_rti1	p06_rti2	p06_rto1
16	16	1	444.8	-28.8	16	16
16	16	1	445.4	-28.8	16	16
16	16	1	445.6	-28.8	16	16
16	16	1	445.6	-28.8	16	16
16	16	1	446.2	-28.8	16	16
16	16	1	446.4	-28.8	16	16
16	16	441.3	446.7	0.1	16	16
16	16	447.1	447	0	16	16
16	16	447.4	447.4	0	16	16
16	16	447.5	15.1	16	-28.8	16
16	16	447.5	15.1	16	-28.8	16
16	16	448.4	1.1	16	-28.8	16
16	16	449.1	1.1	16	-28.8	16
16	16	449.8	1.1	16	-28.8	16
16	16	450.2	1.1	16	-28.8	16

Column p06_pid (not shown) reflects the status of the pump as sent from Pumpwerks: a value of 17 means everything is nominal; 16 means Pumpwerks is not receiving from the pump firmware; 15 means Pumpwerks is failing to send data to the firmware.

RO Recirculation Pump

The RO recirculation pump (the pump in the middle of Figure 3) runs continuously except during the purge mode and the slough mode. Its nominal speed is 1250 rpm. There is one feedback data item but besides the speed (p07_o1) there are two additional commanded values sent via relays -- the commanded speed, an on/off command (p07_o2, where 0 is on and 1 is off), and a direction (p07_03, where 1 is forward and 0 is reverse).

p07_i1	p07_o1	p07_o2	p07_o3
1253	1250	0	1

In the membrane slough mode, the pump runs at 400 rpm in reverse for two minutes (a small ball rolls back through the membrane, shearing the waste material) and then forward for two minutes (the ball rolls back helping to push the sheared material through the membrane). The data below shows the three fifteen second lines when the pump is changing from running in reverse to running forward during the slough.

p07_i1	p07_o1	p07_o2	p07_o3
429	400	1	1
0	0	0	0
424	400	0	1

The slough-reporting column will show a 1 if within the log interval, the recirculation pump speed has been 400 rpm and a 0 otherwise. This column was used to detect sloughs when the logging interval was greater than the 4-minute slough time.

slough(report)
0

RO Valves

There are two multi-position valves in the RO, a five-way process valve (only three of the positions are used), and a three-way output select valve. Sample valves of the process valve are shown below.

v02_i1	v02_i2	v02_i3	v02_o1	v02_o2	v02_o3
1	0	0	0	1	0

As with the valves in the BWP, one of the positions is "hot" or "on" with the rest "off". When all are "off" the valve state is said to be "unknown". V02_o1, o2, and o3 are purge, secondary and primary positions respectively. Because of a flaw in the wiring, the input signals are not the same, but are secondary, purge and primary for v02i1, _i2, and i3 respectively. The values above therefore show the valve in the purge position.

The data below shows the valve transitioning from secondary to purge.

v02_i1	v02_i2	v02_i3	v02_o1	v02_o2	v02_o3
1	0	0	0	1	0
0	0	0	1	0	0
0	1	0	1	0	0

The data below shows the valve transitioning from purge to primary.

v02_i1	v02_i2	v02_i3	v02_o1	v02_o2	v02_o3
0	1	0	1	0	0
0	0	1	0	0	1

The output select valve can direct the permeate to the PPS, to the BWP feed tank (reject) or to a collection tank (tank). Thus, v03_o1, o2, and o3 are tank, bwp_select, and pps_select respectively; the feedback values are the same. The data below shows the output select valve in the pps_select position.

v03_i1	v03_i2	v03_i3	v03_o1	v03_o2	v03_o3
0	0	1	0	0	1

<u>Conductivity, differential pressures and the flow meter</u>

The three conductivity sensors (in millisemens) reflect the water quality of the input water (cd01), the rejected water in the processing loop (cd02) and the permeate (cd03). The higher the value, the dirtier the water. The permeate water should be cleaner by two orders of magnitude than the feed, and the reject water will gradually get dirtier as brine is concentrated in the secondary loop.

cd01	cd02	cd03	dp03	dp04	fm09
13941	14272	384	0	37	0

DP03 is a differential pressure sensor across the filter in the input line; a value of more than 4 or 5 psid indicates the filter must be changed. DP04 measures the pressure drop across the recirculation pump; values above 60 psid indicate pump trouble.

The flow meter, fm09 should read a value similar to the input flow (16 mls/min), but it was highly unreliable and rarely used.

Loop pressures, power and temperature

Like the conductivity sensors, there are three pressure sensors around the loop (in psig), pt05 upstream of the membrane, pt06 in the reject portion of the loop and pt07 on the permeate side. During normal operation, the two loop pressures should be within 50 psig of each other and the permeate pressure should never be greater than 4 or 5 psig.

pt05	pt06	pt07	pw07	pw08	pw09	tc07
441	413	4	0.45	0.9	1.05	32

The three power sensors measure the power (in amps) in the three legs of the RO three phase power supply. Tc07 measures the temperature across the recirculation pump in degrees C. Temperatures higher than 40 C^{o} indicate a pump problem.

Weight scales

Wt05 and wt06 shown below measure the weight (lbs) in the RO feed tank and in the collection tank respectively (used in stand alone operations).

wt05	wt06
143	18

The RO Error Files

The RO error files just record sloughs that were detected during the given day, e.g.,

====== new log, starting 21 Nov 01 01:28:40 ==========

lookForRoSlough: ***** found a slough ***** 21 Nov 01 01:28:40
lookForRoSlough: ***** found a slough ***** 21 Nov 01 19:13:32

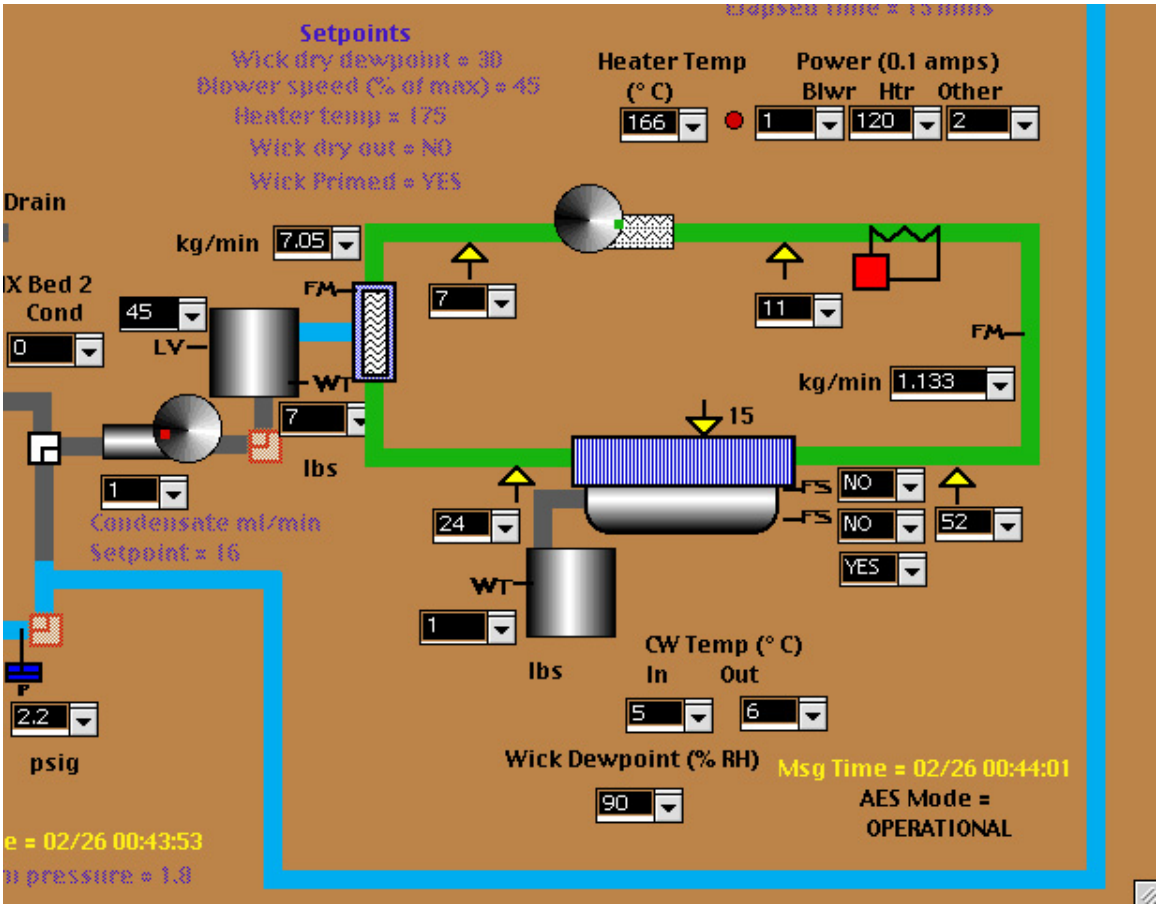

Figure 4 The Air Evaporation System (AES) Schematic

The AES

The AES wick absorbs RO brine as it fills the AES reservoir (tank with three flow switches Figure 4) during the RO purge cycle. During operation, hot air blows across the wick taking up evaporated water and leaving solid waste on the wick. The moisture-laden air then passes through a heat exchanger where water is condensed into an output tank. The AES processes the brine in batches. When the brine fills the reservoir to the second level switch, the AES starts up, processing the brine until the lowest switch reads dry, at which point it goes to standby awaiting another load. ASDs concern overheating and loss of coolant fluid in the heat exchanger.

Additionally, the AES pumps condensate to the PPS when the condensate tank reaches a certain level or when the RO is not sending its condensate to the PPS to keep a steady flow of water to the PPS).

The AES Log Files

The AES log files are prefaced by the letters aesskm (air evaporation system skill manager).

AES Relays

The AES blower (top pump in Figure 4), the heaters (W icon to the right of the blower), and the subsystem power (dot icon next to the power readings) are actuated by relays r01 through r03 respectively. The heater relay is toggled on and off by the heater skill to maintain a steady heater temperature, so it's rare to find a 1 in the r02 column.

r01o	r02o	r03o
1	0	1

When the blower relay is triggered, the blower commanded speed is given by sp01. The speed is commanded by RAPs as a percent of max speed (normally 45%) and the blower skill translates that into an integer number of counts for the A/D board.

sp01
916

AES Condensate Pump

The AES condensate pump is used to send condensate water (at 16 mls/min) to one of three locations determined by the AES output select valve.

p08_i1	p08_o1
18	16

AES Valves

There are two valves in the AES, a two-way valve (v01) for allowing condensate coolant water to flow through the heat exchanger (upright shaded rectangle on the left part of Figure 4), and an output select valve (v04). V01 has no feedback; v04_o1,_i1 and v04_o2,_i2 mean the output goes to the PPS or back to the BWP feed tank, respectively. The data below shows the coolant water is flowing and the output from the condensate tank will go to the PPS whenever the condensate pump (p08) turns on.

v01_o1	v04_i1	v04_i2	v04_o1	v04_o2
1	1	0	1	0

AES level Sensors

Ls01-ls03 are optical level switches at the low, high and midpoint of the AES reservoir (oblong center tank in Figure 4) respectively. They read 1 when they are covered with water and 0 otherwise. Ls04 is a variable valued float sensor in the condensate tank that slides up and down a metal rod, thus varying an output current. It reads percent of "full", where "full" is the top of the sensor, (normally positioned lower in the tank than the top of the tank to provide an overflow safety margin). When the low and midpoint switches are wet (as shown in the data below -- the condensate tank is 31% full), the AES begins operations.

ls01	ls02	ls03	ls04
1	0	1	31

AES Dew point, RH and Flow Sensors

Dw01 measures percent humidity in the air flowing through the wick (shaded rectangle above the AES reservoir in Figure 4). Fm07 measures the air flow from the blower in kg/min, and fm08 measures the flow rate of the coolant water in the heat exchanger also in kg/min.

dw01	fm07	fm08
90	1.244	7.02

AES Pressure and Power Sensors

The AES has a differential pressure sensor (dp01) across the blower and one (dp02) across the wick. These have never read anything but 0. Pt04 is a channel that is not used.

There are three power sensors, measuring blower power (pw01), heater power (pw02) and the power to the instruments (pw03) in amps. The data below shows how the heater power essentially dwarfs the other power readings.

pw01	pw02	pw03
0.1	12.7	0.2

AES Temperature Sensors

As one would expect, the AES has a number of temperature sensors. Tc12-26 measure temperatures (in C^{o}) along the length of the wick and are used for wick analysis purposes.

Tc08 through TC11 measure the temperatures around the air evaporation loop -- the air leaving the heat exchanger, the air leaving the blower, and the air at the wick inlet and the wick outlet respectively.

tc08	tc09	tc10	tc11
7	11	42	22

Tc27 and tc28 measure the temperature of the water flowing into and out of the heat exchanger respectively, while tc29 measures the temperature of the heater. As shown by the data below, tc28 did not seem to be connected during this test point.

tc27	tc28	tc29
5	-250	124

Tc31 (there is no tc30) is a special sensor designed to measure the temperature of the air going through fm07.

tc31
43

Finally, besides the dew point sensor (dw01), the blower has a relative humidity temperature sensor that was never very reliable.

rh01
10

AES Weight Sensors

Wt02 measures the weight in the condensate tank in hundredths of pounds, while wt01 measures the weight of the overflow tank (the tank below the reservoir in Figure 4).

wt01	wt02
0	5.47

The AES Error Files

There is only one AES error file for this test period. It contains a notice of some delays of communications.

====== new log, starting 20 Nov 01 17:07:02 ==========

heartAlarm: "skills" hasn't reported for 55 seconds 20 Nov 01 17:07:02
heartAlarm: "ipc" hasn't reported for 55 seconds 20 Nov 01 17:07:02

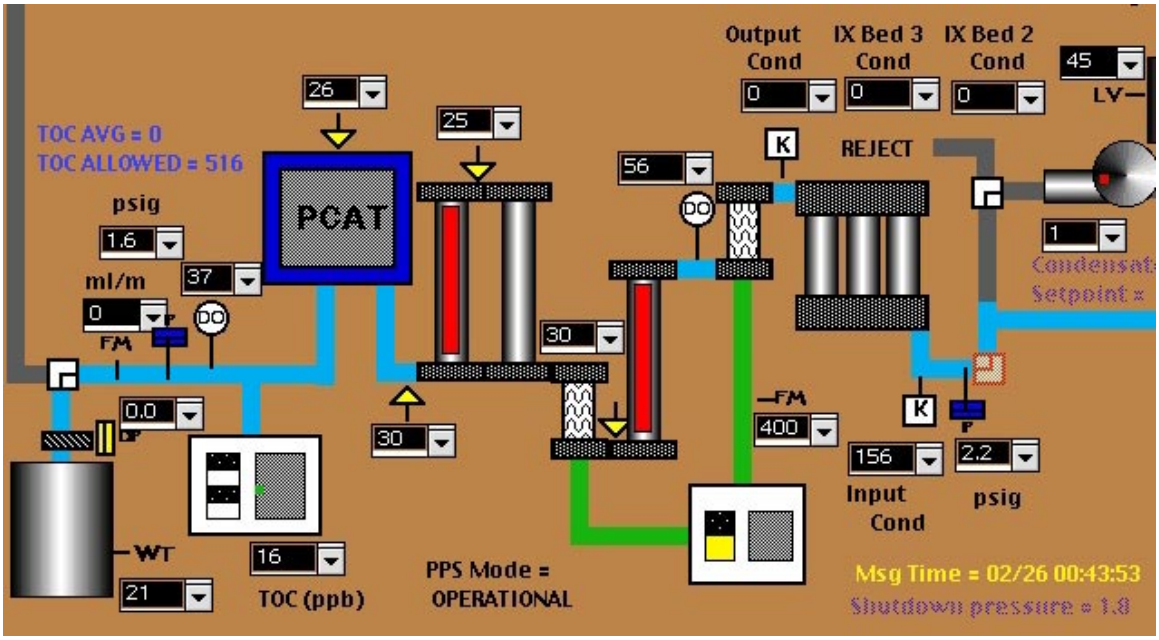

Figure 5 PPS Schematic

The PPS

The PPS "polishes" the water from the RO and the AES by removing trace inorganic material via ion exchange beds (the trio of cylinders at the left end of Figure 5), and trace organics by oxidizing them with ultra-violet (UV) radiation (the three tall cylinders in the middle of Figure 5). When the input water pressure goes above a threshold that indicates water flow from either the AES or the RO, the O_2 concentrator is started and a number of UV lamps are turned on commensurate with the measured total organic carbons (TOC). When the pressure falls below the threshold, the concentrator (white box in the lower right of Figure 5) and lamps are turned off. An average TOC is calculated based on the instantaneous TOC (measured by the Ultra-TOC analyzer -- the white box in the lower left of Figure 5) and the water accumulated in the product tank to determine whether the PPS output should be rejected to the BWP feed tank. ASDs concern overheating of the lamps and high output conductivity, indicating that the resin in the ion exchange beds has been used up.

The PPS Log Files

The PPS log files are prefixed by ppsskm (post processing system skill manager).

PPS Relays

The PPS actuation of the O2 concentrator and the UV lamps is carried out by relays: r04 starts/stops the concentrator, and r05 through r07 activate UV lamps 1 through 3

respectively. The data below shows the nominal configuration with the concentrator and the first UV lamp turned on.

r04o	r05o	r06o	r07o
1	1	0	0

PPS Output Select Valve

V05_o1 (feedback is _i1) and V05_o2 (feedback is _i2) position the PPS output_select valve to the BWP feed tank (reject) and the PPS product tank respectively. The data below shows the valve open to the product tank.

v05_i1	v05_i2	v05_o1	v05_o2
0	1	0	1

PPS Flow, Pressure and Power Sensors

Fm09 measures the O2 concentrator air flow in mls/min while fm10 was supposed to measure the output water flow. But at the low flow rates of the test point, fm10 was completely unreliable as was the flow switch, fs01.

Pt08 measured output pressure in psig. Pt09 measured input pressure and was used as the key indicator for water flow. There were two set points associated with the input pressure: the first when the output valve (far right in Figure 5) was open to the tank (shown as 1.8 psig in Figure 5) and the other 1.0 psig less than the first (i.e., 0.8) when the valve was open to the BWP feed tank. Dp03 measured the pressure drop across the output filter, but it never read other than 0.

Pw05 through pw06 measured the power in amps for the UV lamps, the instruments and the photo catalytic converter (box labeled PCAT in Figure 5). The PCAT was not used during this test run.

fm09	pt08	pt09	pw04	pw05	pw06
304	1.4	2.1	0.8	1.5	-2.4

PPS Conductivity Sensors and TOC Analyzer

Just as the temperature sensors are critical to the operation of the AES, the conductivity sensors in the PPS dictate its operation. The TOC analyzer is used to measure the final output quality of the water and as such is a measure of the output of the whole iWRS.

Cd04 through cd05 measure the conductivity in micro-semens at the inlet to each ion exchange bed and at the output of the last bed respectively. The data below shows the conductivity readings early in the test when none of the beds have been "loaded" with inorganic salts.

cd04	cd05	cd06	cd07
237	-1	0	0

The data below show the case where the first bed has "broken through" because it is fully loaded; the water quality is not changed significantly through the first bed.

cd04	cd05	cd06	cd07
337	324	25	0

The data below show the case where the all beds have broken though (the third bed is significantly smaller than the first two). This condition (output conductivity greater than 100 µsemens) marks the end of the test point.

cd04	cd05	cd06	cd07
512	982	1994	103

The TOC analyzer gives an instantaneous TOC reading (parts per billion) but the PPS skills also compute a TOC average based on integrating the TOC over the volume of water processed. If the instantaneous TOC went very high (usually greater than 1000 µsemens) the second UV lamp is turned on.

toc	xtoc_avg
30	26.27

PPS Dissolved O2 and Weight Sensors

Dp01 and dp02 measure the dissolved O2 as a percentage of water volume at the output of the first membrane contactor (short cylinder just left of the last ion exchange bed in **Figure 5**) and at the output of the TOC analyzer respectively.

do01	do02
4.2	2.3

Wt07 measures the weight of the product tank in hundredths of pounds.

wt07
35.65

PPS Temperature Sensors

Tc32 through tc34 measure the temperature in C^{o} of UV lamps 1 through 3 respectively. Tc35 measures the temperature of the PCAT when the PCAT is operating. The nominal temperature of a hot lamp is greater than 35 C^{o}; thus the data below show two lamps on corroborating the relay data shown above.

tc32	tc33	tc34	tc35
39	31	29	27

The PPS Error Files

There were no pps error logs for this test point.

Events to Watch For

• Early morning of the 20th, the GLS level goes low and has to be balanced by the feed pump (otherwise the BWP is in "recycle" mode, that is only the recirculation and nitrifier pumps are on).

• When the test begins around 8:30a, the BWP is commanded to start in an integrated mode (feed pump goes on), the RO is started up in primary (pumps on, process valve in primary state), the AES and PPS are started in standby. A few minutes after the RO starts the PPS senses water flow and turns its lamps and concentrator on, cycles the output valve to the product tank.

• During the test watch for
  - BWP nitrifier sloughs (use the pbbwperr logs as a check)
  - RO changing from primary to secondary to purge
  - RO sloughs (use the error logs as a check)
  - AES condensate pump going on whenever the RO is in purge or whenever the condensate tank is at 100%
  - PPS turning on a second lamp (based on high instantaneous TOC) (don't know if this ever happened)
  - Really dirty water going to the PPS from the AES condensate tank toward the end of the test (it used up the ion exchange beds faster than ever before, which is why the test point lasted five days instead of a month)
  - PPS cycling the output valve to the BWP feed tank (don't know if this ever happened)

• AES reservoir middle switch gets wet around 7:45p 11/21/01. AES starts operations, blower on, coolant flowing, output valve to product, then heaters on. When

the low reservoir switch goes dry, the AES will go into standby -- heaters off, cool down, then blower and coolant flow off.

- PPS shuts down, as do the AES and RO when the last ion exchange bed breaks through on 11/24/01. The GLS will then go high causing the BWP feed pump to ratchet back slowly until its at 0 rpm, which is its standby state.

- Watch for any of the indicators mentioned in the text of the description of the data items in the logs