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The University of California at Santa Barbara

The George E. Brown Jr. Network for Earthquake Engineering

WLA Instrumentation Guide

Prepared by The Institute for Crustal Studies, UCSB.

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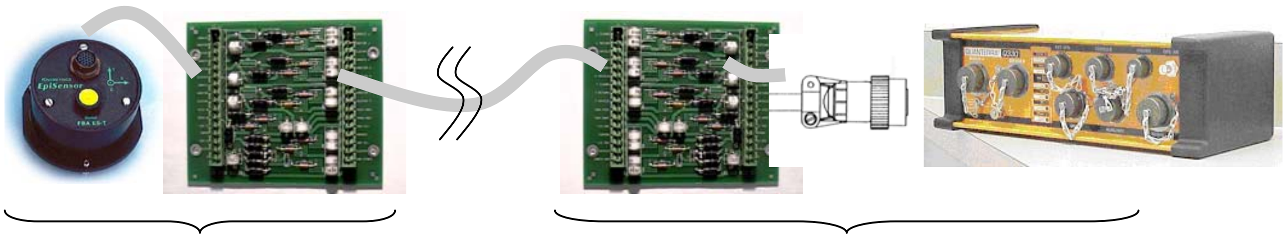
Section I: Overview

The generic hook-up of a field instrument at the Wildlife site is shown in the figure below.



Sensor and LP board are in-ground/in external box

LP board, connector and Q330 are in-the-hut

In the case above, an EpiSensor surface accelerometer with three channels is connected to a local Lightning Protection board in the wellhead box before the signals are passed through an underground cable into the hut.

This cable is terminated at another lightning protection board in the hut and then typically connects to a cable with the Q330 “sensor” connector which plugs directly into either the SensorA or SensorB input of the datalogger.

The Q330 End

Each Sensor input of the Q330 has three differential analog input channels feeding to the devices 24-bit analog to digital converters. Each of these inputs is a true differential input with a full-scale range of +/- 20V.

This means an input potential of -20V between the +ve and –ve inputs is represented by the largest negative value out of the 24-bit ADC while +20V between +ve and –ve gives the largest positive output. One bit of the ADC represents $40/2^{24}$ Volts.

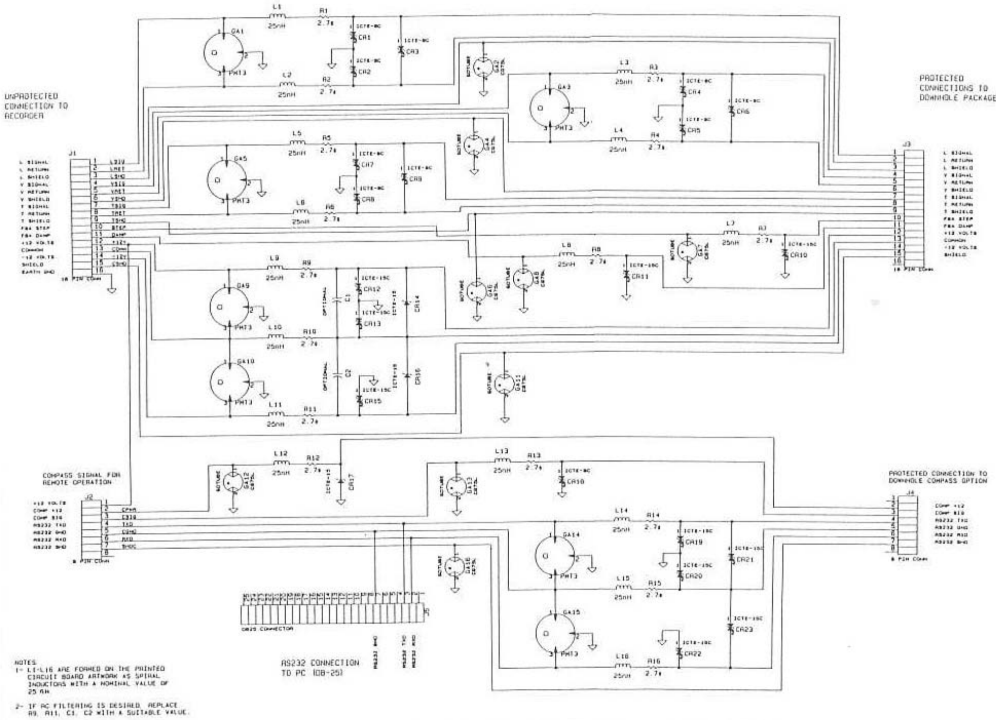
In addition to the analog input channels, the sensor connector also supplies low-current (spec?) 12V supply voltage and calibration control outputs.

There is a color code standard used for the cables from the Q330 sensor connectors to the lightning protection boards (or any other termination).

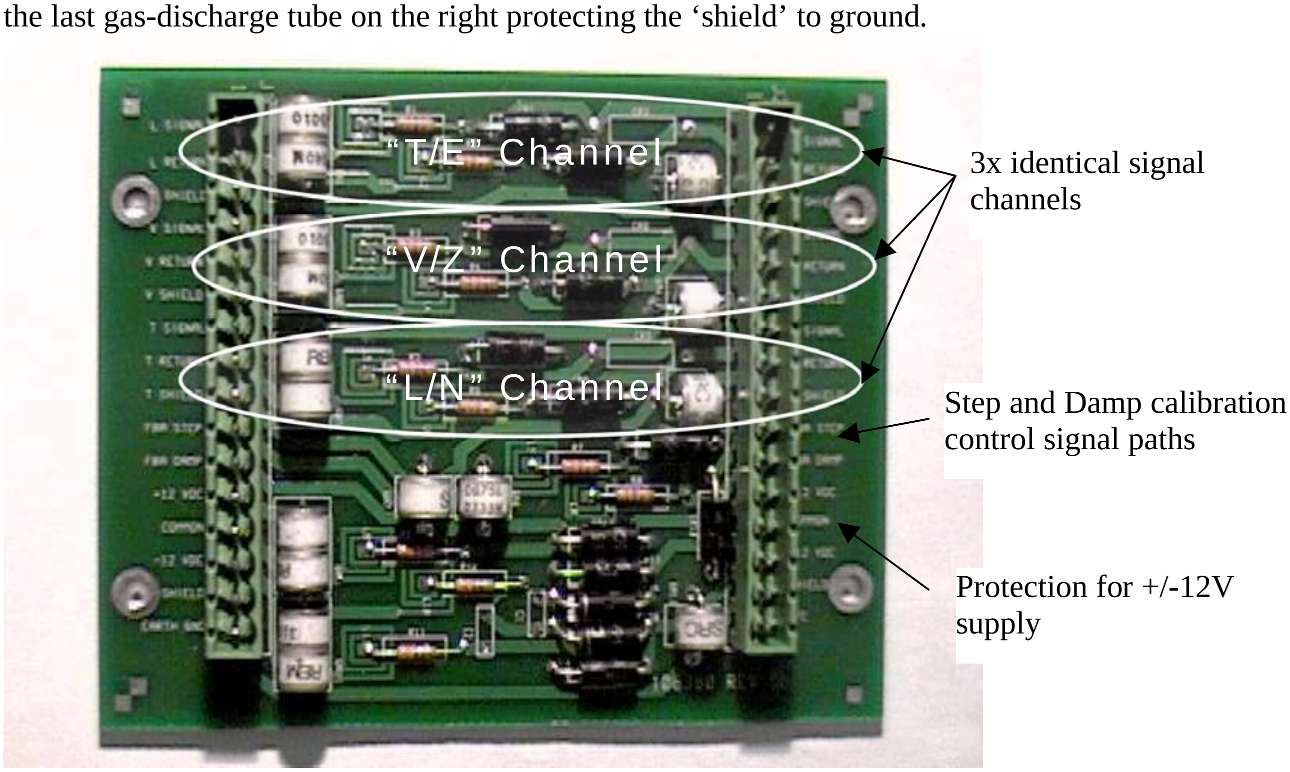
Q330 Sensor A(B)	Cable-color and pairing
+Input 1(4)	Yellow
-Input 1(4)	Black (of Yellow pair)
+Input 2(5)	Green
-Input 2(5)	Black (of Green pair)
+Input 3(6)	White
-Input 3(6)	Black (of White pair)

The Lightning Protection board

The lighting Protection boards were built by consultant based on the design by Kinemetrics.



The board layout pretty much flows as drawn in the schematic, from left to right there is the three-terminal gas-discharge tube, into a series impedance (R+L) followed by the transorbs, with the last gas-discharge tube on the right protecting the ‘shield’ to ground.



Channel Assignments

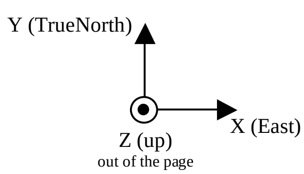
The T, V, L channel naming stems from historical use of Transverse , Vertical and Longitudinal, designations for accelerometer component direction. From a lightning protection perspective these channels are identical, but the mapping of actually sensor orientation to Q330 channels is very important.
For WLA (for reason now not so clear!) the arbitrary sequence of wiring through the LP boards is T-V-L (regardless of silkscreen etc.) as shown in the figure above.

The general rule is:

TVL Mapping	*Ideal Sensor Direction (True)*		*Q330 Channel#*
T (x)	**E-W**	**(east = positive)**	**3 (6) White**
V (z)	**Z**	**(up = positive)**	**1 (4) Yellow**
L (y)	**N-S**	**(north= positive)**	**2 (5) Green**

Wiring from the sensors to the Q330s through the lightning protection etc. should map from sensor-axis to Q330 channel with the assignment of up-down to channel#1, north-south to channel#2, east-west to channel#3 (this sequence is “ZNE” for true-aligned sensors or “VLT” if the y-axis is not pointing to true-north)

The *standard* configuration and channel naming of ZNE should result in positive data for movement in the up, north and east directions. WLA has all accelerometers installed per this standard.



Ideal ‘Standard’ Orientation

Longitudinal (Y) is positive in the direction of true North.

Transverse (X) is positive in the direction 90° clockwise of Y i.e. East

Vertical (Z) is positive for upward components.

Section II : The WLA Hut

The east wall of the hut has the shelves holding the Q330 dataloggers and the networking equipment. Adjacent and in-line with the Q330s are the Lightning Protection boards where the sensor cables terminate in the hut. The photo below shows the basic layout.

The power-supply for the sensors is routed through the +12V channels of the LP boards. IT has been found that noise from the solar charge controllers contaminates the sensor signals when used to power the sensors directly. For this reason, Acopian dc/dc bricks are being used to isolate and filter the power-supply to the sensors.

The Power System

The powering of the instrumentation at WLA is split between two identical 12V solar systems. Each system has three solar panels on the roof, charging (via an Outback MX-60 MPPT controller) a set of four gel-cell 12V batteries which supply power to the connected instruments, sensors and networking equipment.

Additionally, the cooling system has a separate 24V solar system, again 3 roof-panels and four batteries.

Solar Circuit #1: 24V Cooling

Solar Circuit #2: 12V Instrumentation

Solar Circuit #3: 12V Instrumentation

Battery/Load-Breakers

Batteries (2 sets of 2x 12V batteries in series) for 24V cooling (circuit #1)

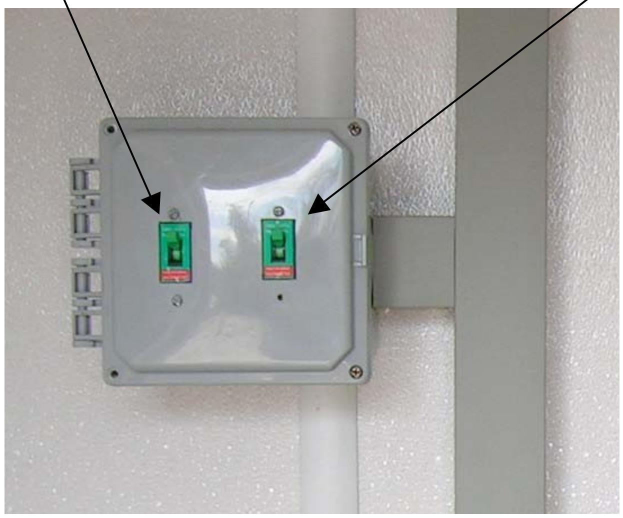
Batteries (4x 12V in parallel) for 12V instrumentation (circuit #2)

Batteries (4x 12V in parallel) for 12V instrumentation (circuit #3)

The power-system has a number of breaker/disconnects which turn-on/off the power from the panels, the connection of the batteries to the charge-controllers and the batteries to the loads.

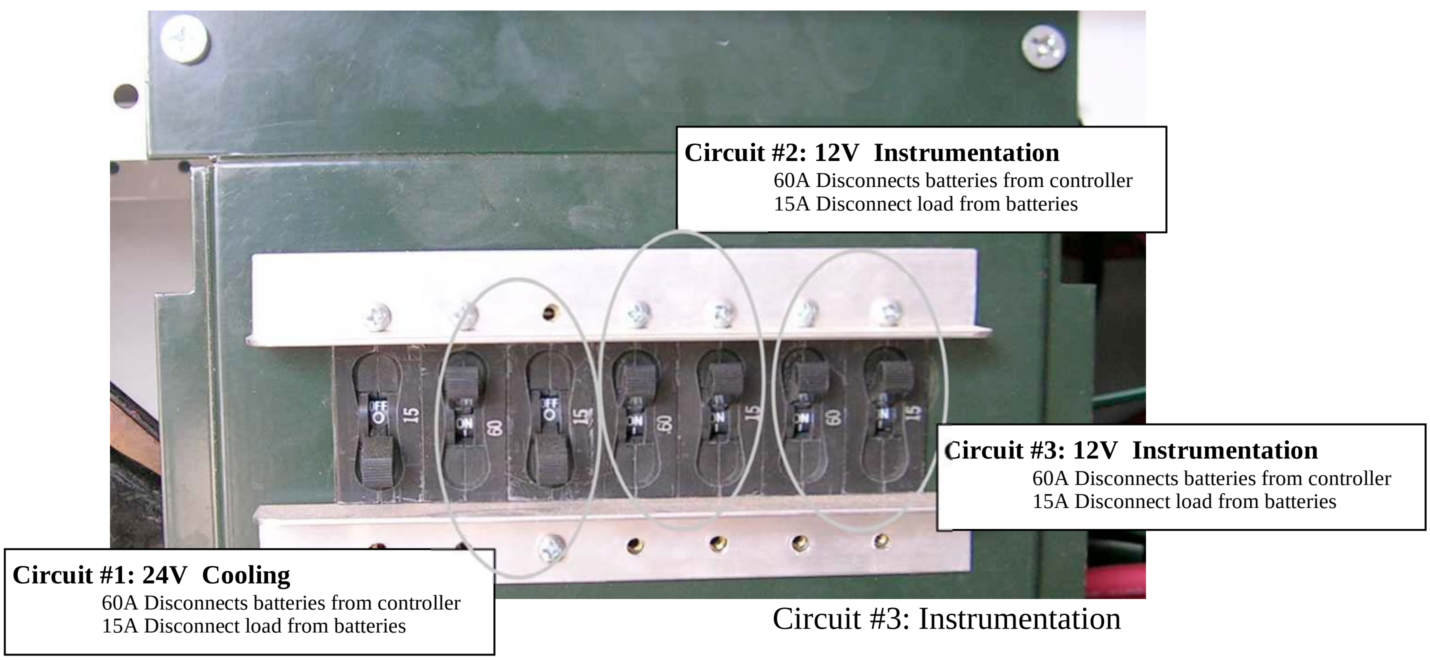
On the wall above and to the left of the battery enclosure, two green-colored breakers allow the roof-panels to be disconnected.

The left-most breaker disconnects panel-sets #1 and #2. The second breaker disconnects panel-set #3.



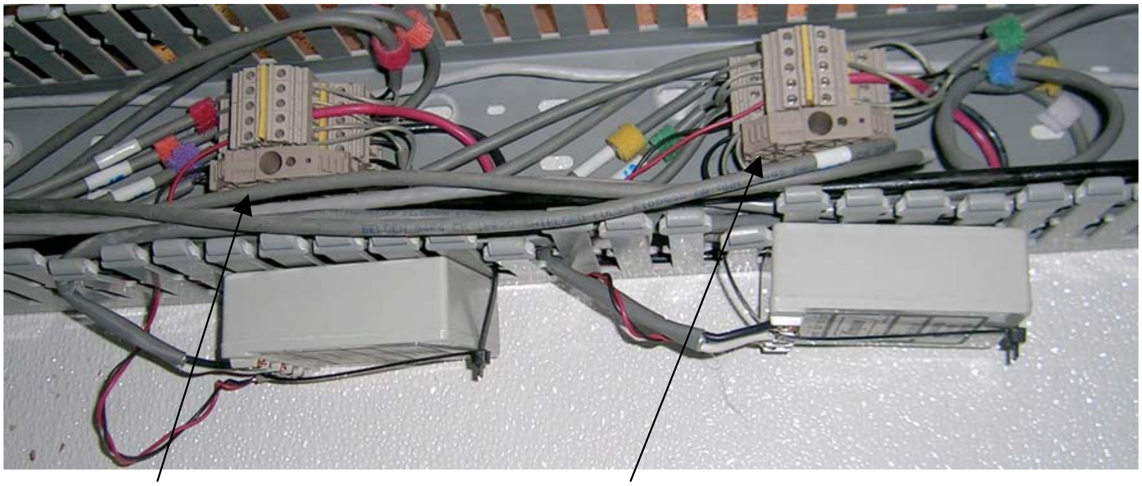
The breaker-panel on the front of the battery enclosure has (from left-to-right) a spare 15A breaker and then three sets of a 60A breaker and a 15A break. These sets, left-to-right, correspond to power circuits #1, #2 and #3.

In each case, the 60A breaker is the charge-controller-to-battery disconnect and the 15A breaker is the battery-to-load disconnect.



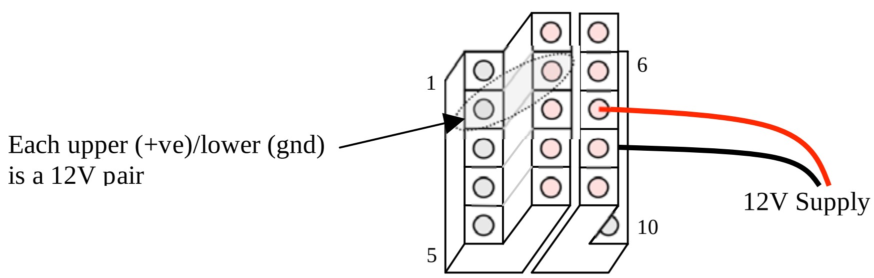
Circuit #3: Instrumentation

Power connections to the individual instruments, sensors (via the LP boards on the wall) and networking gear are made at two sets of DIN-mount terminal blocks in the caterpillar underneath the Q330 shelves.



Terminal-block for 12V circuit #2 **Terminal-block for 12V circuit #3**

Each block has ten sets of power screw-terminals. One set of terminals (middle of the right-hand side) is used to connect power from the breaker-panel in the battery enclosure to the connector assembly (the 12ga red and black connectors in the photo above), then each of the other 9 terminal pairs can be used for power-cables to the equipment.



The power assignments to each circuits is given in the table below:

12V Power circuit #2					12V Power circuit #3			
1	WLA Sensors	6	WLA Q330		1	WLA02 Sensors	6	WLA02 Q330
2	WLA01 Sensors	7	WLA01 Q330		2	WLA03 Sensors	7	WLA03 Q330
3	WLA05 Sensors	8	12V in		3	WLA04 Sensors	8	12V in
4	WLA07 Q330+Sens	9	WLA05 Q330		4	WLA08 Q330+Adam+Sens	9	WLA04 Q330
5	Radio	10	Network#1[1]		5	WLA06	10	Network #2[2]

Most of the power lines to the sensors now go “through” Acopian dcd/dc converters to stablize (and for downholes boost) voltage and add power supply noise isolation (noise from the charge controllers has been found to be well filtered by these converters). In the photo above also note the two Acopian DC/DC converters (these are 12Vin, 13Vout types) for the two power lines running to the remote T-Hut.

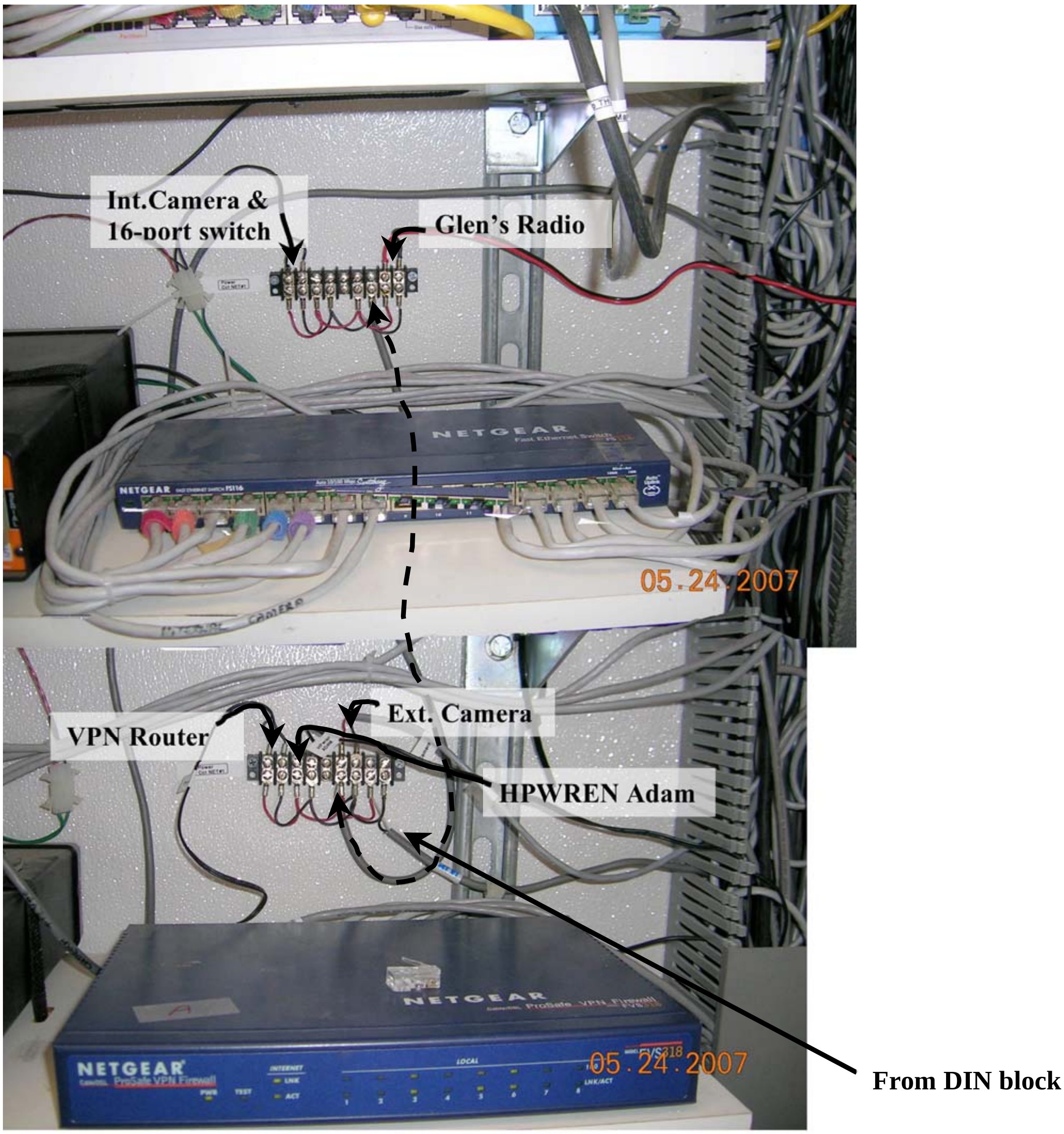
[1] See Section IV for network equipment set-up.

The load circuits labeled as “Network” are the feeds to power the various network and miscellaneous equipment in the hut. These circuits from the DIN-block feed to spade-terminal blocks mounted on the wall above the fourth and fifth shelves.

“Network#1”

The Network#1 circuit supplies the items below by way of two terminal-strips:

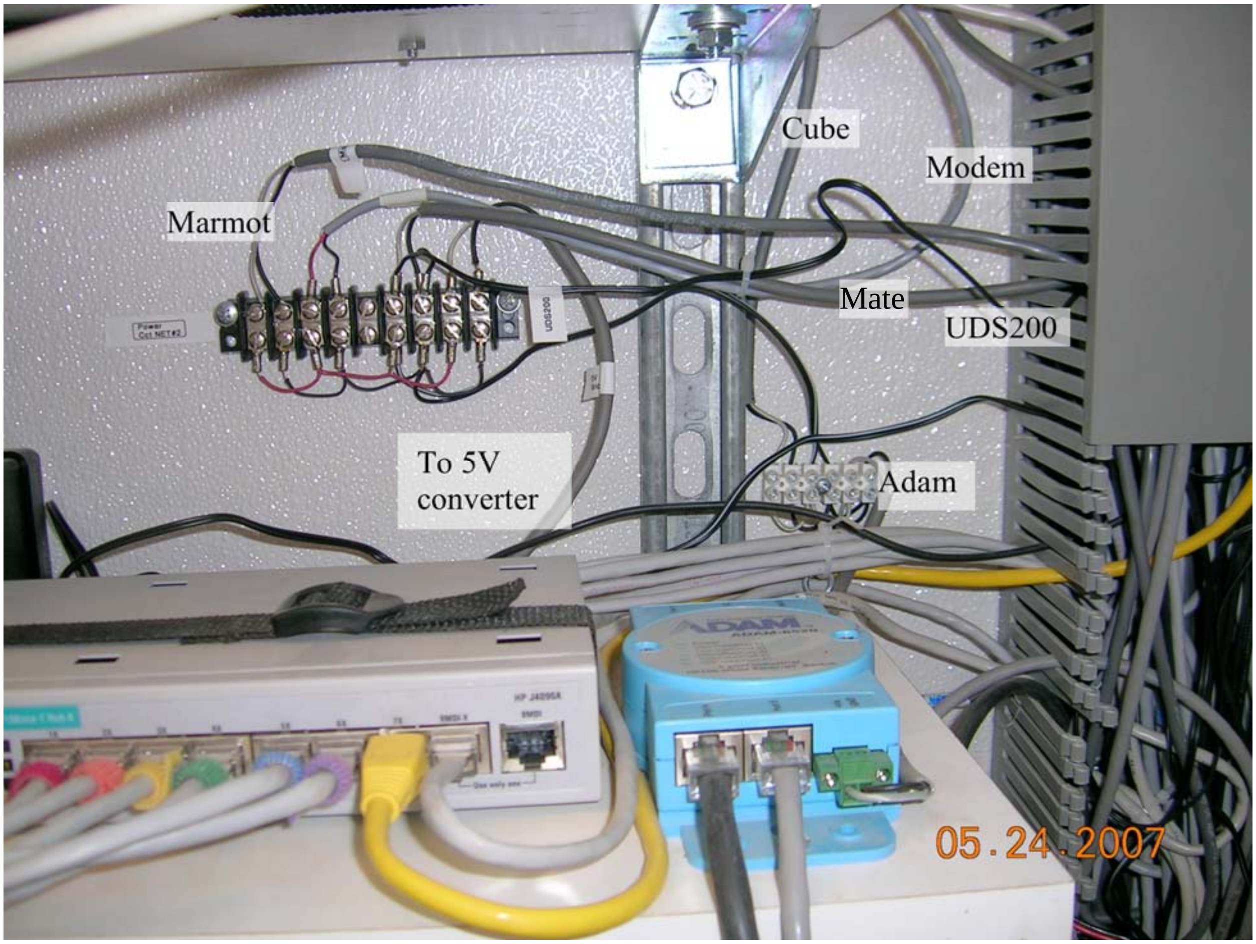
- Netgear VPN router
- External Camera
- Internal Camera (via Q330 opto-out controlled switch)
- ADAM switch on the HPWREN sub-net
- Netgear 16-port switch (via Q330 opto-out controlled switch)
- Extra radio we host for Glen.



"Network#2"

The Network#2 circuit powers all the other bits and pieces from a terminal-block and a terminal-strip:

- Marmot
- Wireless Modem
- Lantronix UDS200
- Outback-Mate RS232
- Via a 12V/5V DC to HP Hub and Davis weather station
- CerfCube
- Adam 6520 on the LAN



The wiring above is not so clear, here is a text descripti:

The power for the circuit comes from the DIN-block into the lower-right terminal block. Reading left-to-right this block then connects to…

the Cube;   a link over to the terminal-strip;   to the ADAM.

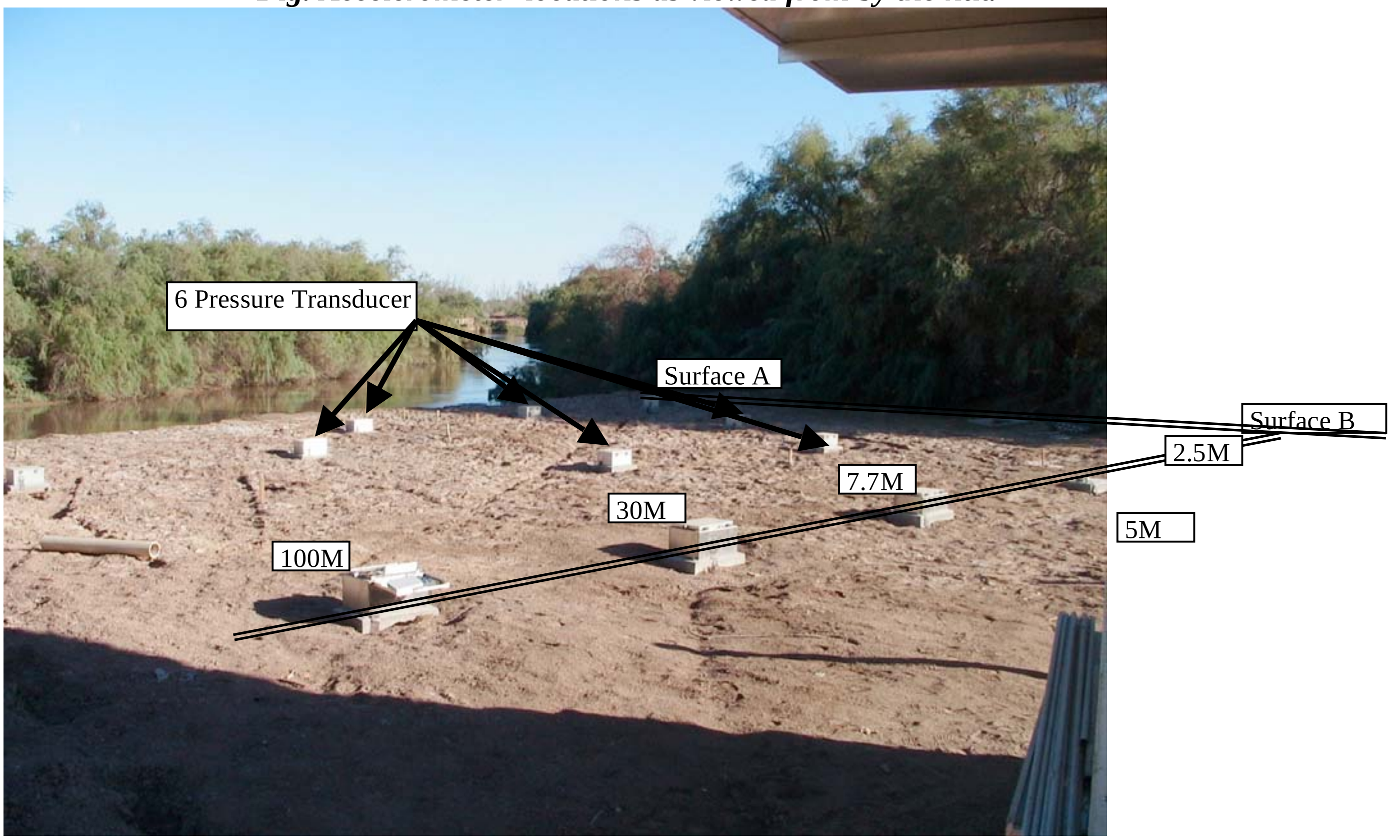
Reading left-to-right for the terminal-strip the connections are…

Marmot: WirelessModem; UDS200&Mate; 12V-to-5V DC/DC for hub and Davis.

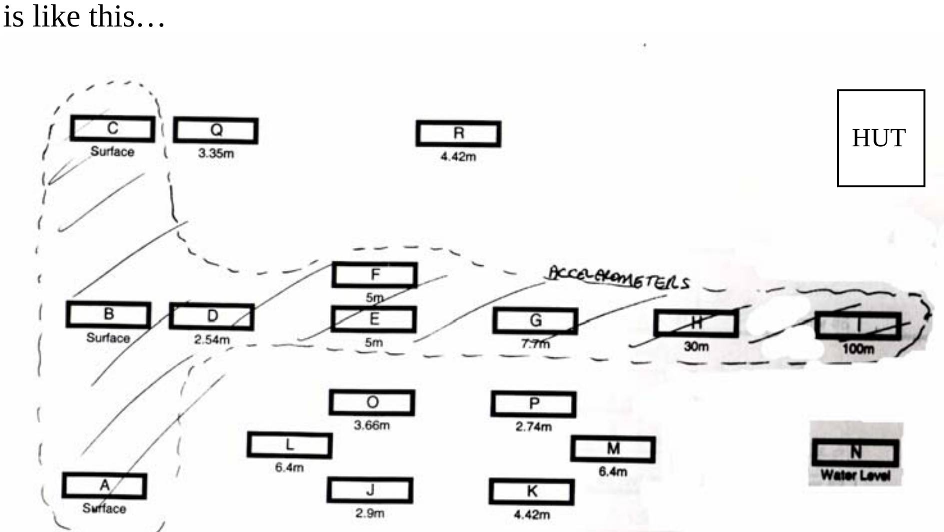
Section III: Sensor Descriptions

This section lists each sensor in turn with pictures and notes about actual cable coloring, actual LP board wiring and any other physical information of relevance.

Fig. Accelerometer locations as viewed from by the hut.



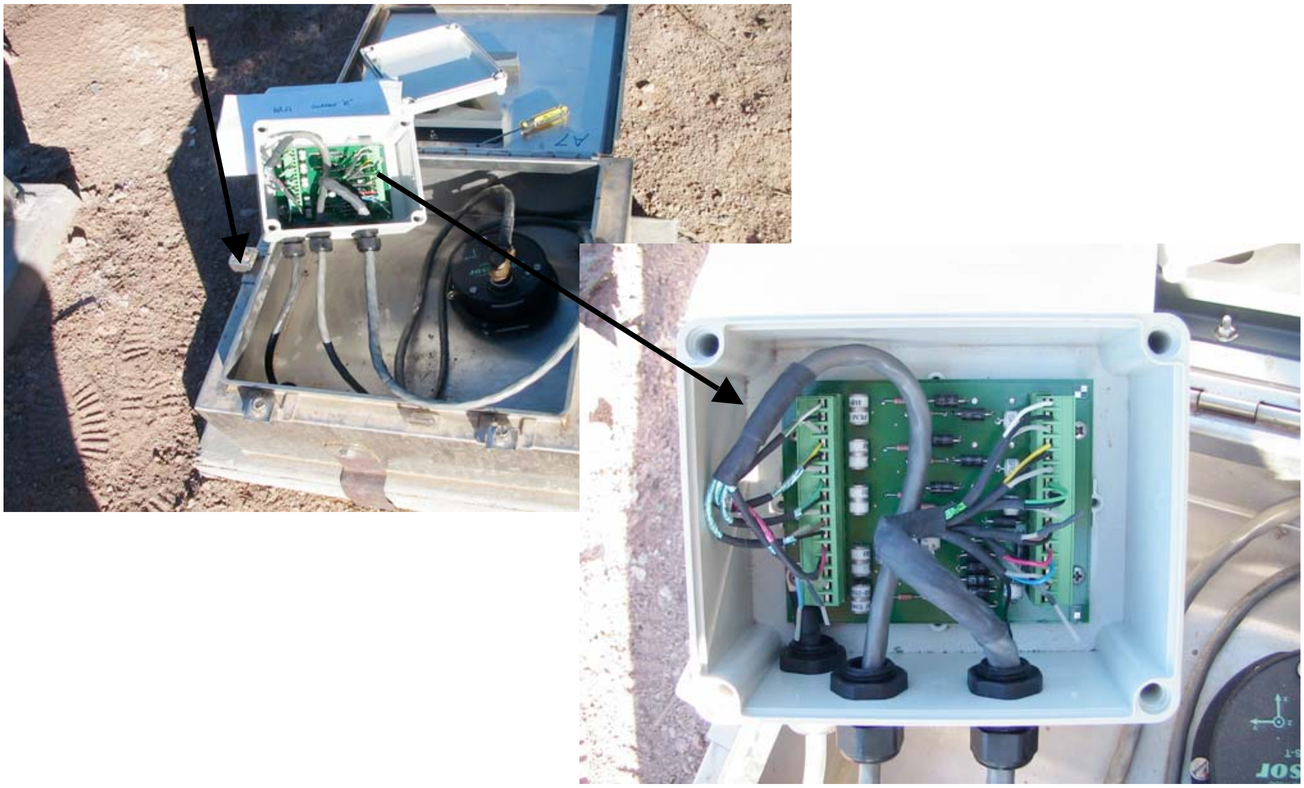
The picture above gives a site idea of the layout, more schematically (and not to scale) the layout is like this…



WLA Sensor layout for cabling conectivity (not-to-scale)

Sensor: Surface "B", Location Code: 00, EpiSensor ES-T

A Surface Accelerometer housed in a stainless-steel Hoffman box.



Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

Sensor details:

Type: Kinematics EpiSensor FBA ES-T Serial #01457
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor: Surface “A”, Location Code: 10, EpiSensor ES-T

A Surface Accelerometer housed in a stainless-steel Hoffman box.

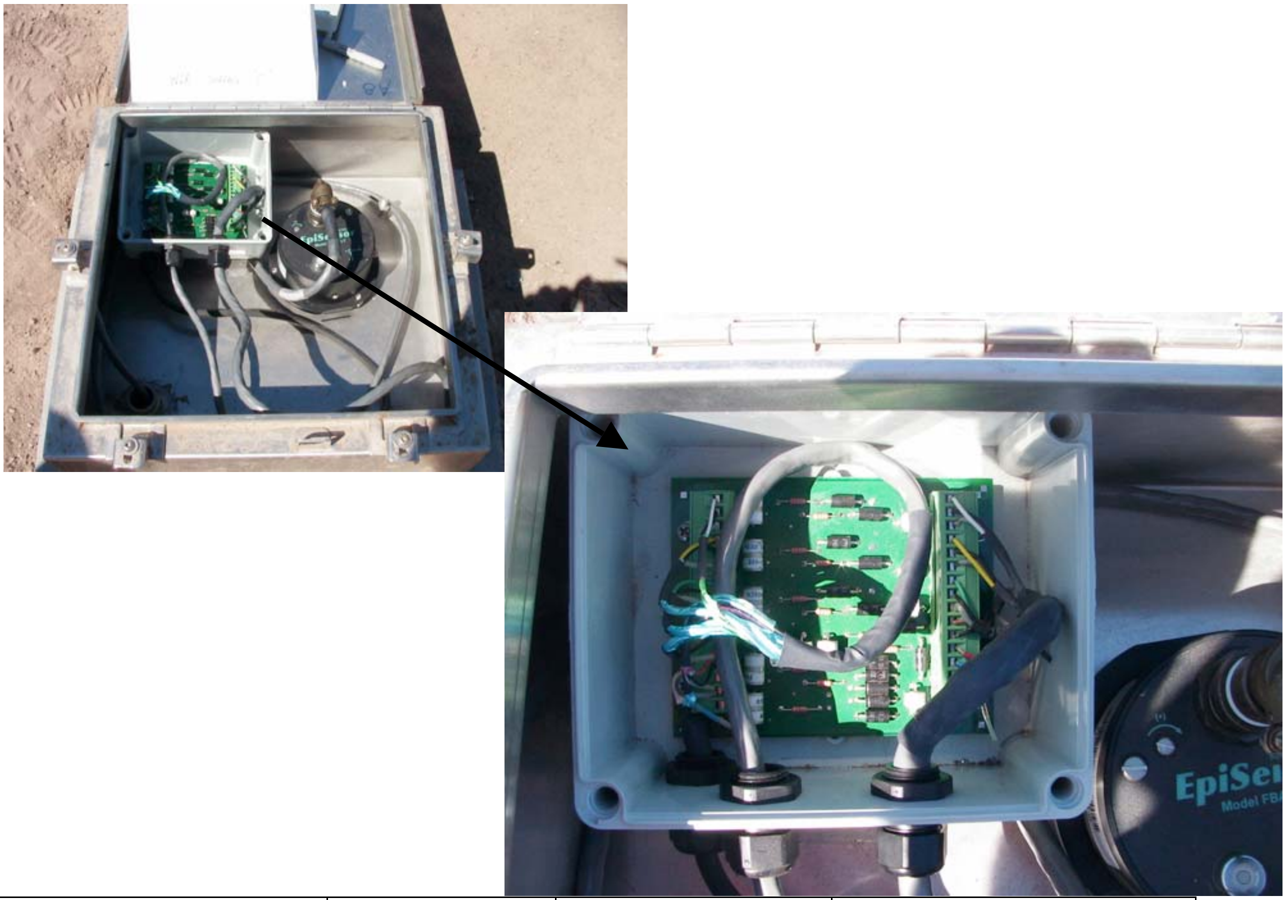
Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

<u>Sensor details:</u>

Type: Kinemetrics EpiSensor FBA ES-T Serial #01456
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor: Surface "C", Location Code: 11, EpiSensor ES-T

A Surface Accelerometer housed in a stainless-steel Hoffman box.



Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

Sensor details:

Type: Kinematrics EpiSensor FBA ES-T Serial #01458
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor: 100M “I”, Location Code: 06, HypoSensor

A Surface Accelerometer housed in a stainless-steel Hoffman box.

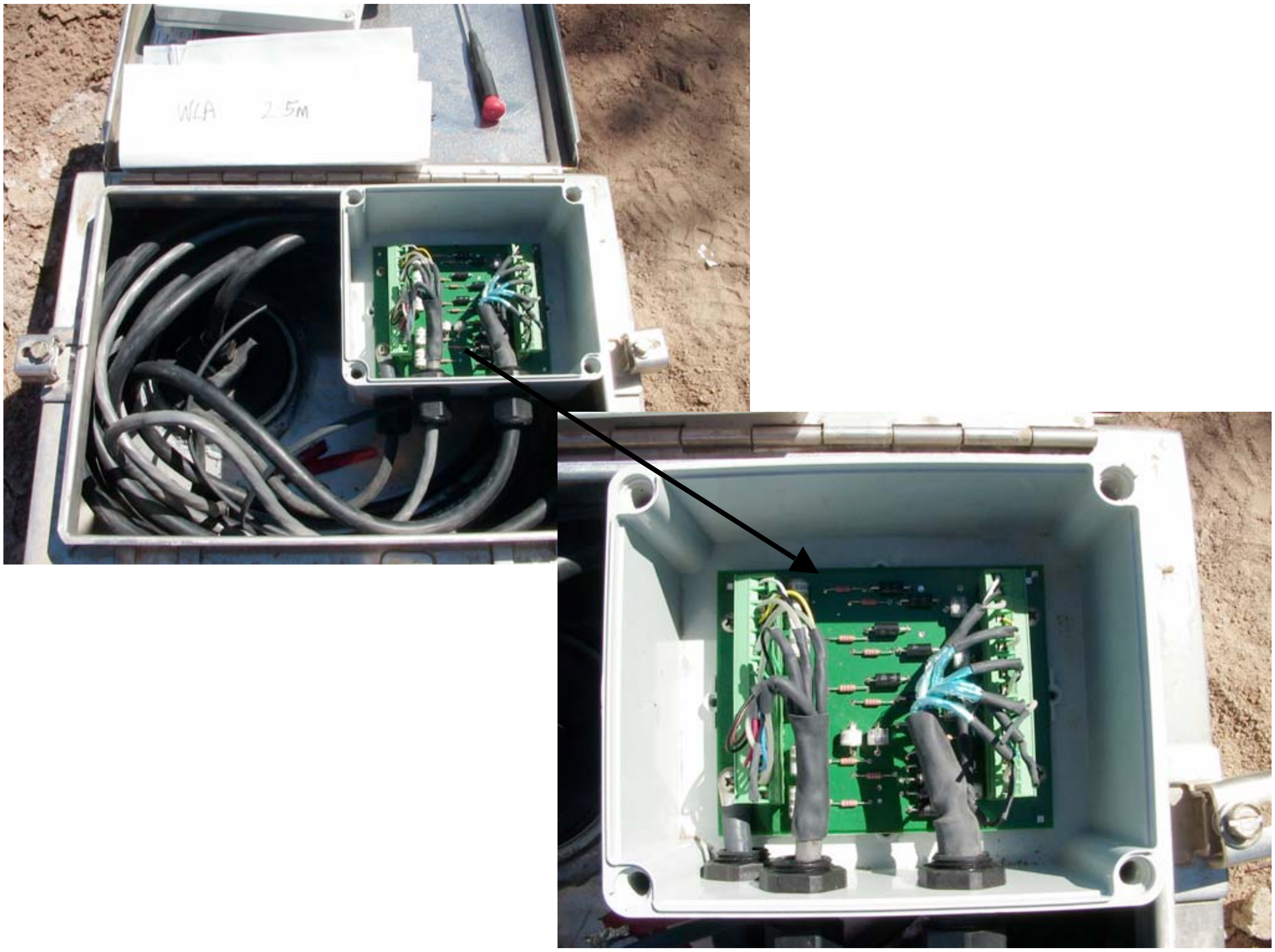
Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
Red/White (#1,2)	White/Black	White/Black	X-axis (E-W)
Yellow/White (#3,4)	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/White (#5,6)	Green/Black	Green/Black	Y-axis (N-S)
Red (#17) +12V Black (#7) Com	Red/Black	Clear/Black to PSU	

Sensor details:

Type: Kinemetrics HypoSensor Serial #182
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor: 2.54m "D", Location Code: 01, Shallow Borehole EpiSensor

A Surface Accelerometer housed in a stainless-steel Hoffman box.



Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

Sensor details:

Type: Kinemetrics SBEPI Serial #186
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor:5m “E”, Location Code: 02, Shallow Borehole EpiSensor

5m “F” Location Code: 03, Shallow Borehole EpiSensor Coex

Both 5M sensors are the same type, with similar wellhead wiring:

Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

<u>Sensor details:</u>

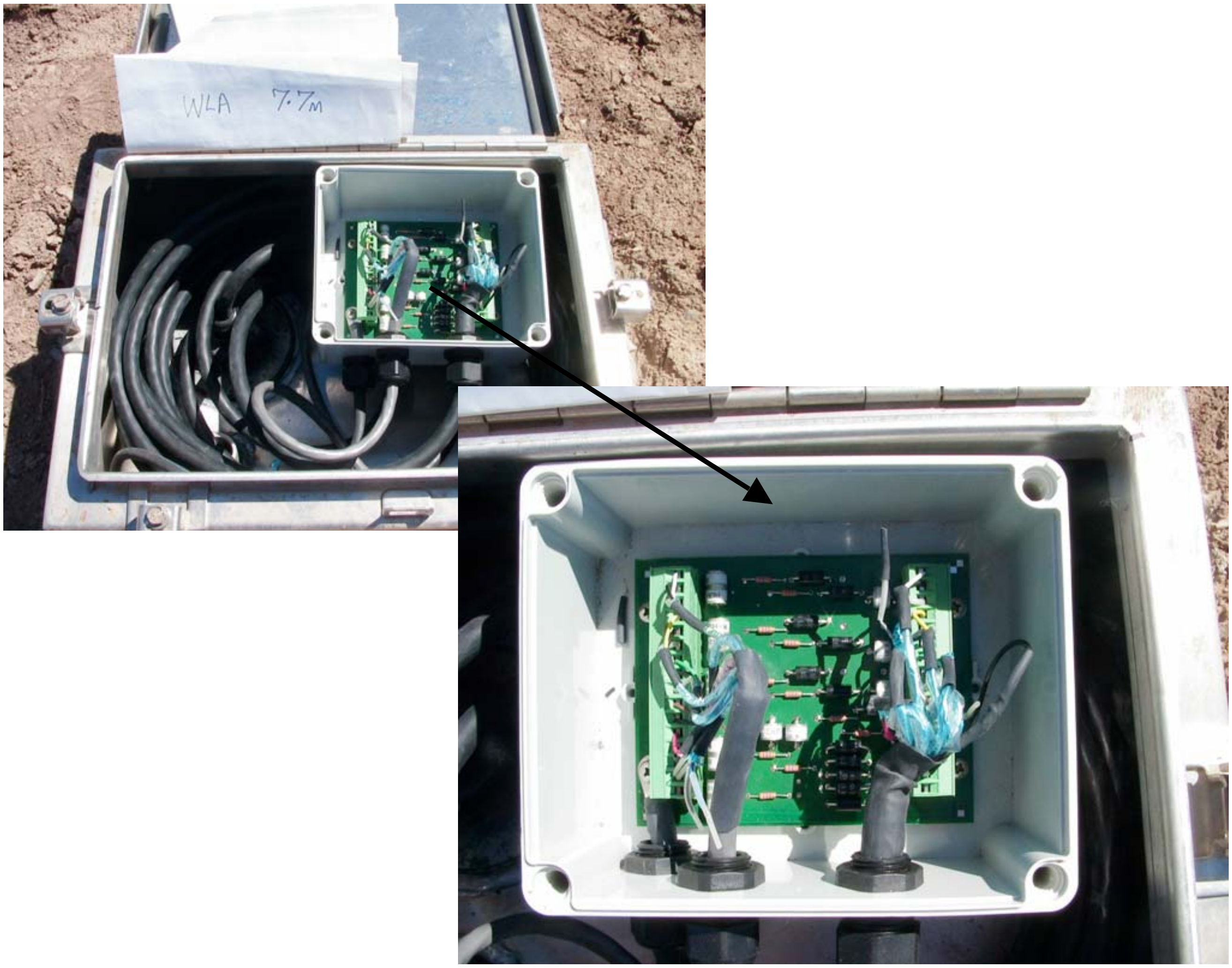
Type: Kinemetrics SBEPI Serial #240 (solid casing, loc #02)
Kinemetrics SBEPI Serial #241 (coex flexible casing, loc #03)

Oriented: L(y)=True North, Vertical=Up

Sensitivity: 10V/g

Sensor: 7.7m “G”, Location Code: 04, Shallow Borehole EpiSensor

A Surface Accelerometer housed in a stainless-steel Hoffman box.



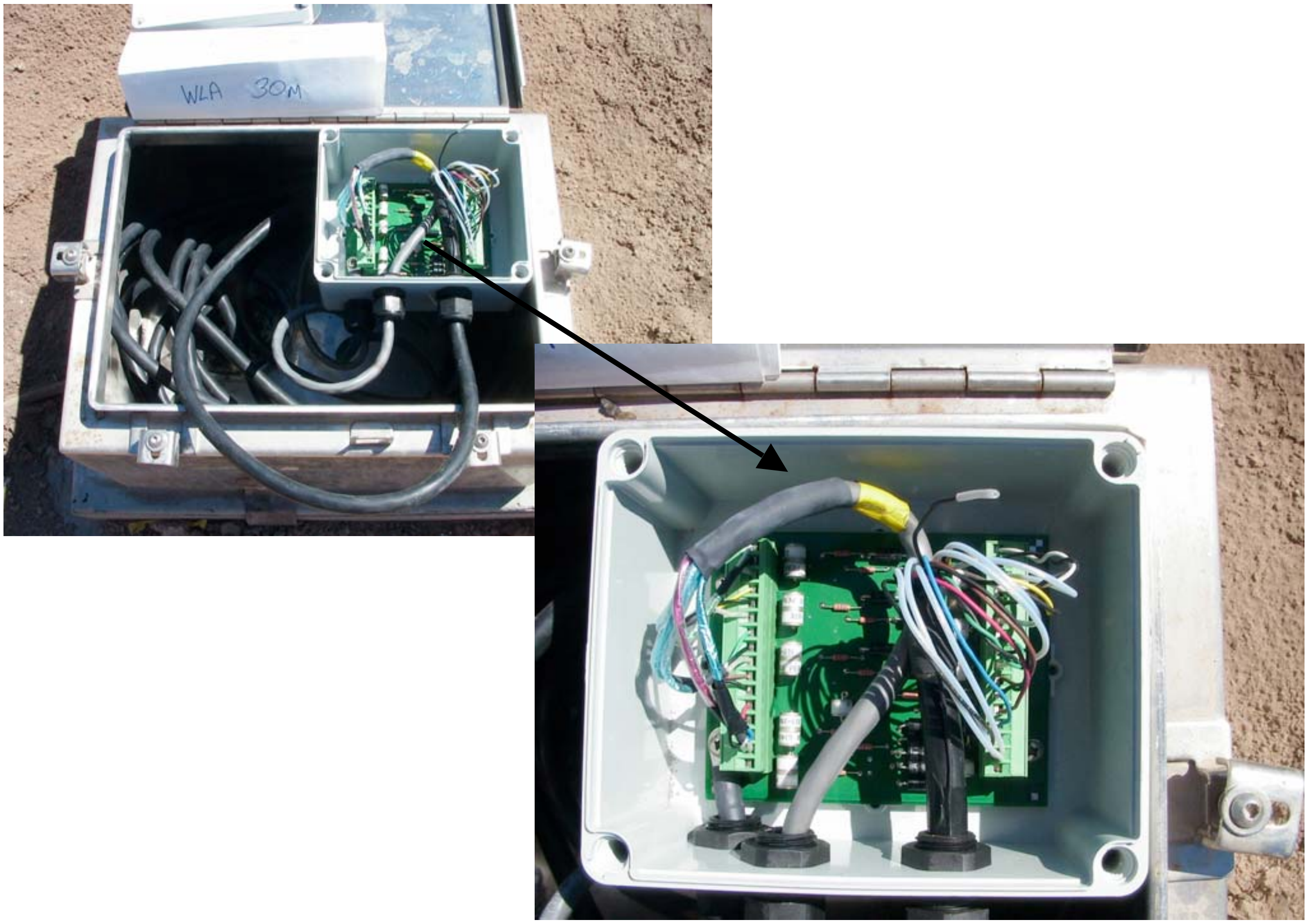
Sensor-to-LP	**BoxLP-to-HutLP**	**LP-to-Q330**	**Notes**
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

<u>Sensor details:</u>

Type: Kinematrics SBEPI Serial #184
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

Sensor: 30m “H”, Location Code: 05, Shallow Borehole EpiSensor

A Surface Accelerometer housed in a stainless-steel Hoffman box.



Sensor-to-LP	BoxLP-to-HutLP	LP-to-Q330	Notes
White/Black	White/Black	White/Black	X-axis (E-W)
Yellow/Black	Yellow/Black	Yellow/Black	Z-axis (Up-Down)
Green/Black	Green/Black	Green/Black	Y-axis (N-S)
Red +12V Blue (of blu/blk pair) Com	Red/Black	Clear/Black to PSU	

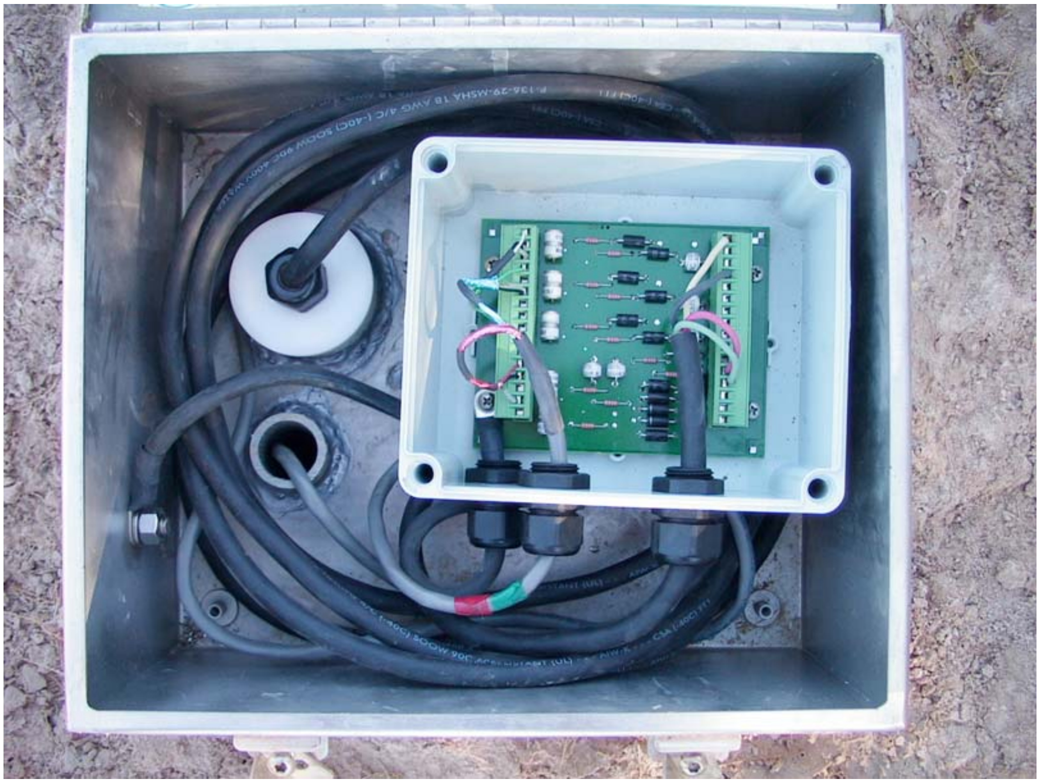
Sensor details:

Type: Kinemetrics SBEPI Serial #185
Oriented: L(y)=True North, Vertical=Up
Sensitivity: 10V/g

The Paroscientific Pressure Transducers, Location Codes: 60-67

The piezometers are controlled and monitored over a serial-interface. Each sensor has a four conductor cable (to the right in the photo below) interface.

Color	**Description**
Red	Positive power-supply
Green	Common
White	Tx (from sensor to converter)
Black	Rx (to sensor from converter)



Sensor-to-LP	BoxLP-to-HutLP	LP-to-PTAC	Notes
White/(blk+shield tied)	White/Black	White	
Black/(blk+shield tied)	Green/Black	Green	
Red +12V Green Com	Red/Black	Clear/Black to PSU	

<u>Sensor details:</u>

Type: Paroscientific, 0-20m (model#8WD020)

Sensitivity/Output: Programmable.

As described in other documentation, these transducers talk via an RS-232 interface. To translate this digital serial interface to an analog signal that can be recorded with the other transducer streams a custom converter (called the PTAC) is used.
Each PTAC unit handles two transducers – one through the “A” channel and one through the “B” channel.

For the eight Paroscientific transducers at WLA, four PTAC units are deployed. These units continuously converter readings from the transducers and can be monitored and controlled via a web-interface accessible on the local network.

The table below maps the physical transducers to their respective PTAC channels

Transducer	Converter	PTAC IP address
LQ1 (2.74m, loc#60 SN#89184)	PTAC #2 Chan B	192.168.1.201
LQ2 (2.90m, loc#61 SN#89186)	PTAC #4 Chan A	192.168.1.203
LQ3 (3.35m, loc#62 SN#93461)	PTAC #1 Chan A	192.168.1.200
LQ4 (3.66m, loc#63 SN#89187)	PTAC #3 Chan A	192.168.1.202
LQ5 (4.42m, loc#64 SN#93459)	PTAC #4 Chan B	192.168.1.203
LQ6 (4.42m, loc#65 SN#89182)	PTAC #1 Chan B	192.168.1.200
LQ7 (6.40m, loc#66 SN#93447)	PTAC #3 Chan B	192.168.1.202
LQ8 (6.40m, loc#67 SN#85854)	PTAC #2 Chan A	192.168.1.201

The KPSI Barometric Pressure Transducers, Location Codes: 69

A KPSI Model 30 barometric pressure transducer with a 0 to 20 PSIA for a 0 to 5V analog output is used to record outside atmospheric pressure.

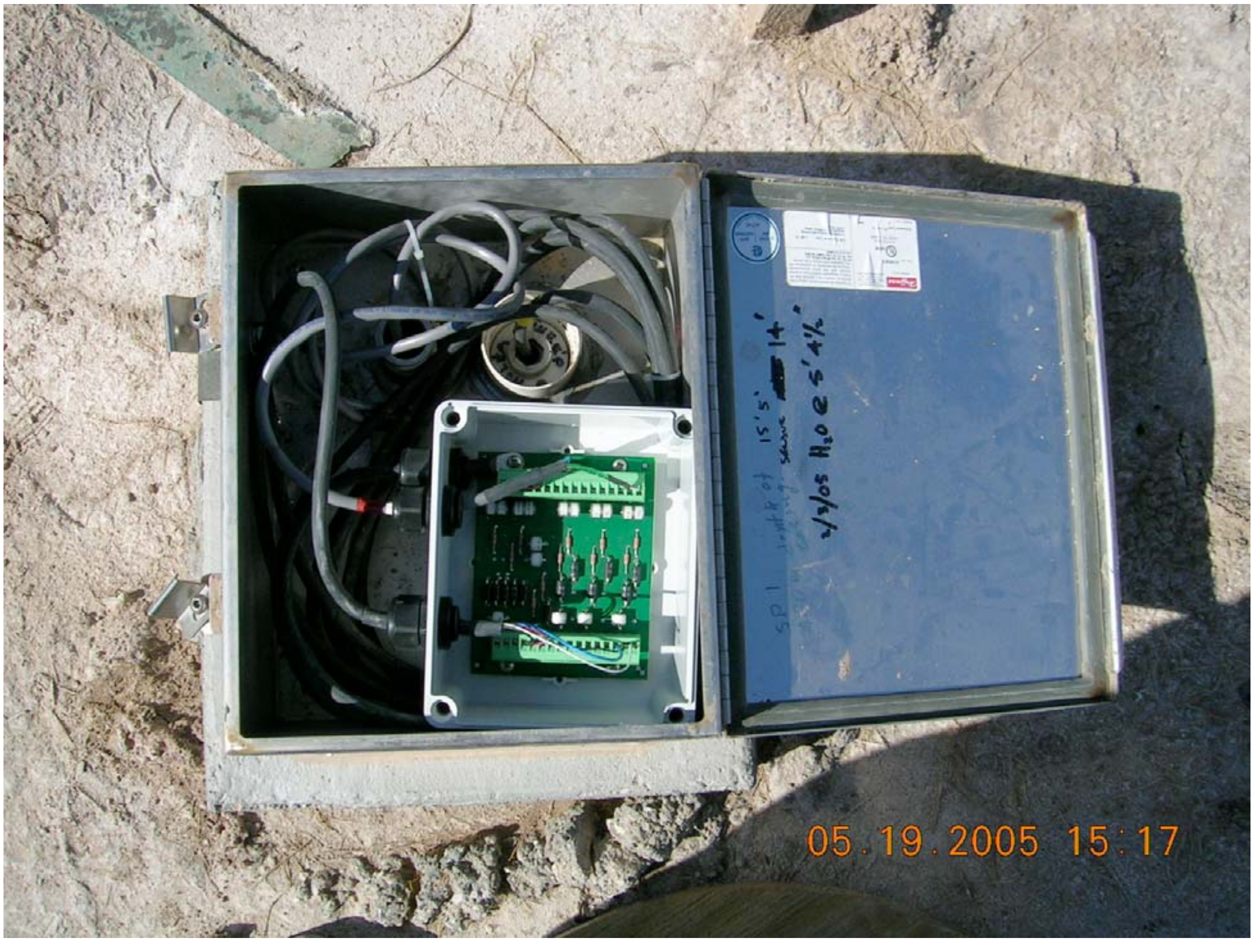
The transducer is located in the cable-caterpillar inside the hut with a reinforced tube running to outside the building to ensure local pressure effects of the hut do not distort the readings.

Sensor details:

Type: KPSI, 0-20PSIA (model#30-432-1020) S/N#0307155
Sensitivity: 4PSI / V

KPSI Pressure Transducer for water level, Location Code: 70

A KPSI Model 730-430-0045 is used in a borehole at 14ft as a water level monitor. This is an analog transducer with a 0 to 45 PSIA for a 0 to 5V output.



Sensor-to-LP	BoxLP-to-HutLP	Notes
White	White	Analog output relative to Gnd
Red	Red	+12V
Black	Black	Gnd
Blue	Shield or Wht/Blk pair	Cable Shield

Sensor details:

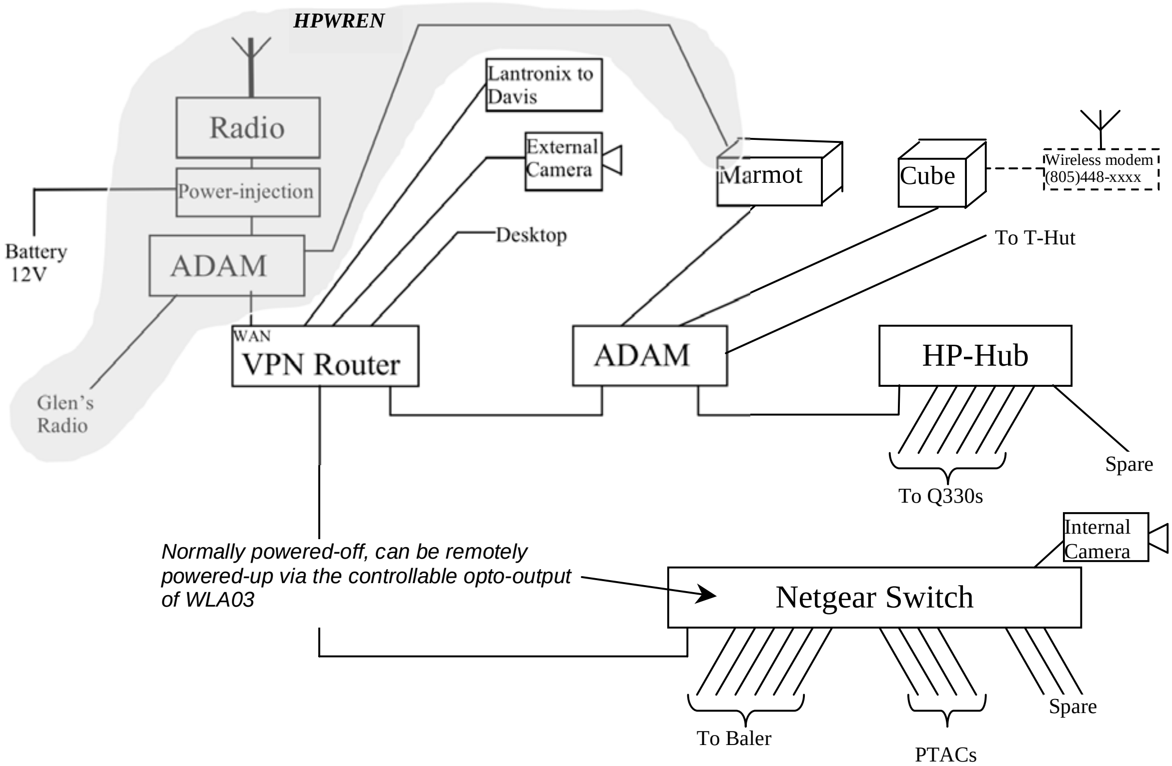
Type: KPSI, 730-430-045 0-45PSIA S/N#0307157

Sensitivity/Output: 9PSI/V

Section IV: Network Setup

The diagram below shows the physical networking setup in the WLA hut. The details of address allocation etc. are covered in a separate document.

In summary, the access out of the hut is via HPWREN, with the internal network operation on a private LAN 192.168.1.x controlled by a Netgear VPN/NAT router.



The equipment is powered from the same two battery circuits as the instrumentation (see section II above).

Equipment	Conditioning	Network #1	Network #2
Radio	Direct to battery	√	
Glen's Radio	Direct to battery	√	
VPN Router	Direct to battery	√	
ADAM Hub (lan)	Direct to battery		√
ADAM Hub (hpwren)	Direct to battery	√	
HP Hub	Via DC/DC converter[2]		√
Davis Weather Sta.	Via DC/DC conerter		√
Lantronix	Direct to battery		√
Netgear Switch	Direct to battery via Q330 (wla03) controlled switch	√	
Marmot	Direct to battery		√
CerfCube	Via DC/DC converter		√
External Camera	Direct to battery	√	
Internal Camera	Direct to battery via Q330 (wla02) controlled switch	√	
Wireless Modem	Direct to battery		√

[2] The HP hub itself has been modified to take 5Vdc rather than the standard product 7Vac.

Power-injection for the WiLan VIP-110 radio (mounted on the roof adjacent to the parabolic antenna) is done in the lightning protection box mounted above the horizontal caterpillar on the back-wall of the hut to the right of battery enclosure.

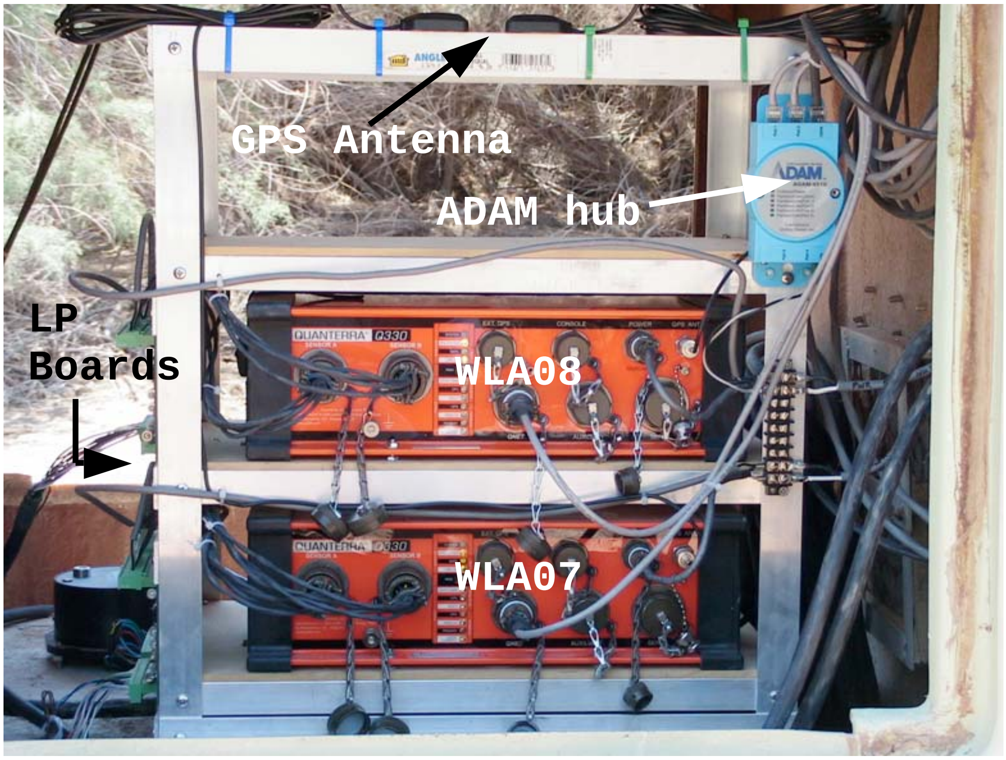
In summary the IP layout of WLA goes like this:

Description	IP Address	Note:
Main Radio	172.16.195.13	
VPN WAN	192.202.124.162	GW: 192.202.124.161 Mask: 255.255.255.248
Glen's Radio	172.16.195.48	
Marmot 2nd i/f	172.16.195.35	
Marmot	192.168.1.8	
CerfCube	192.168.1.5	
External Camera	192.168.1.10	
Internal Camera	192.168.1.11	Camera turned on by wla02 opto-out..
Lantronix to Davis & Marmot	192.168.1.15	Marmot Console: Port 10001 Davis: Port 10002
WLA Q330 and Baler	192.168.1.100/101	
WLA01 Q330 and Baler	192.168.1.102/103	Baler (as well as int-camera and PTAC)
WLA02 Q330 and Baler	192.168.1.104/105	access requires that the Netgear
WLA03 Q330 and Baler	192.168.1.106/107	switch is powered on via Q330
WLA04 Q330 and Baler	192.168.1.108/109	(wla03) opto-output…
WLA05 Q330 and Baler	192.168.1.110/111	
WLA06 Q330 and Baler	192.168.1.112/113	
WLA07 Q330	192.168.1.114	Remote T-Hut Q330
WLA08 Q330	192.168.1.116	Remote T-Hut Q330
PTAC#1	192.168.1.200	LQ3, LQ6
PTAC#2	192.168.1.201	LQ8, LQ1
PTAC#3	192.168.1.202	LQ4, LQ7
PTAC#4	192.168.1.203	LQ2, LQ5

Section V: Old-Site, T-Hut Details

There are two Q330 located in the T-hut at the "old-side", these Q330s are designated WLA07 and WLA08. They are housed in a aluminum rack bolted to the hut's concrete slab, and braced (not shown in the photo below) to the sides of the hut.

The remote site channels are recorded as ***NP_5210***_xxx_yy, reflecting its history as a pre-existing USGS installation.



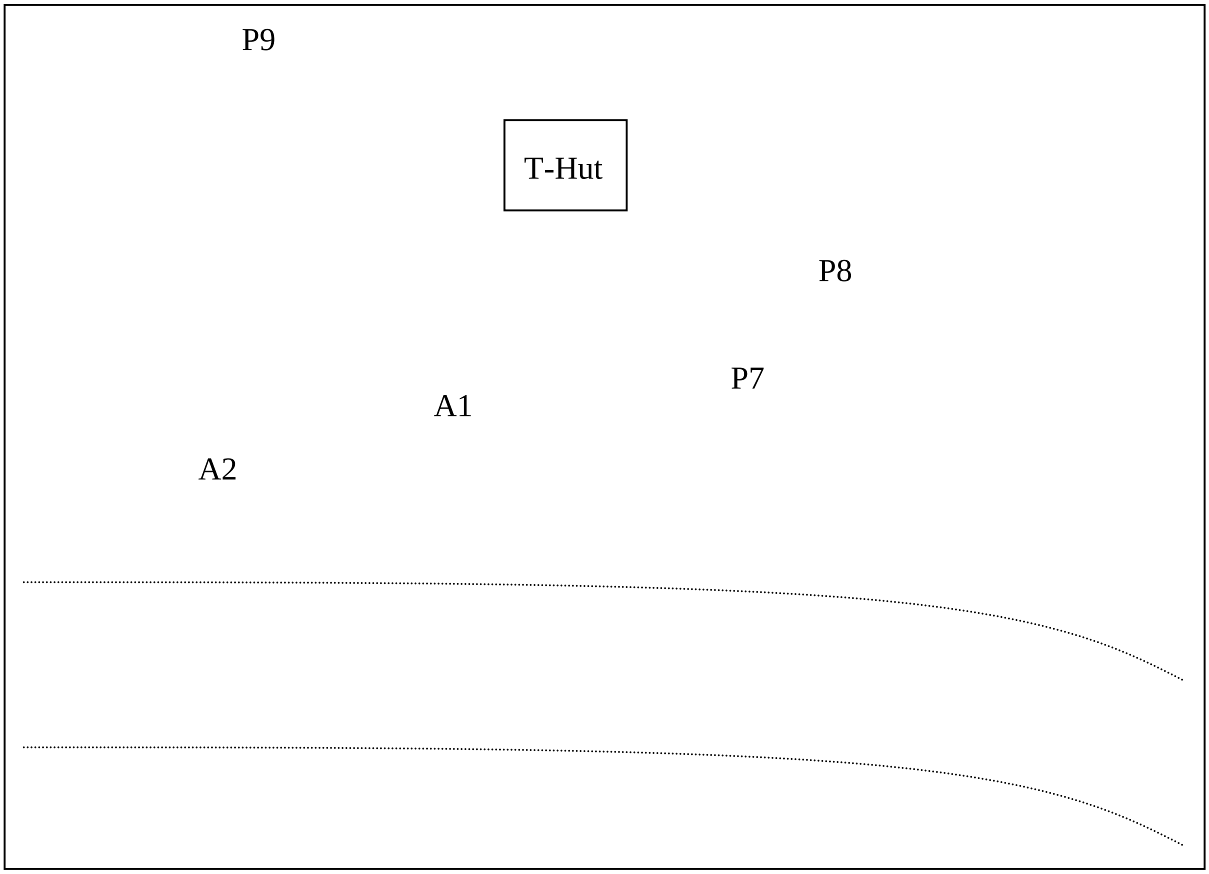
The hut is cabled to the main building with two power circuits (12 Awg pairs) and a single waterproof cat-5 network connection.

The network connection (an extension of the main-hut's 192.168.1.xx LAN) is terminated in the hut at an ADAM 4-port hub connected to the Q330s with a port available for a laptop etc.

The channels of the Q330's monitor

- A surface Episensor on the pad of the T-hut (can be seen in the photo above)
- Two downhole accelerometers (at 10' and 25'. Both Shallow Borehole EpiSensors)
- Three KPSI pressure transducer (at 10' 15' and 19', KPSI 730-43O-00045)

Approximate layout of the “old-site” sensors around the T-hut.



Location	Sensor	S/N#
In T-Hut	Surface EPI	2075
A1	Downhole 10'	241
A2	Downhole 25'	243
P7	KPSI 10' 45PSIA, 5V	504049
P8	KPSI 19' 45PSIA, 5V	509444
P9	KPSI 15' 45PSIA, 5V	509443

The sensors are wired directly to the LP boards mounted on the rack in the T-Hut.

Appendix I: Note on gain calculations

This Appendix shows *examples* of the calculation mechanisms for finding gain, 'calib' etc. values associated with cascaded stages in typical data-acquisition configurations….

Accelerometers

For accelerometers the device will be specified as volts-out per "g", in other words the analog output voltage generate by a physical acceleration of 1g.

To convert this to volts per m/s^2, just remember "g" = 9.80665 m/s^2 (NIST value)

So if an Episensor is rated as 10V/1g then the gain is $10V/(9.806)m/s^2 = 1.019783\ V/(m/s^2)$

To convert to nanometers remember $1nm = 1x10^{-9}m$ or $m=1x10^{9}nm$. Thus for the example above, the Episensor gain is $1.019783x10^{-9}\ V/(nm/s^2)$

If this signal is feed into a Q330 datalogger, the analog signal will be sampled by a 24-bit ADC which has a full-scale input range of 40V. In other words the sensitivity of the ADC is $40V/2^{24}$ counts or one count is equivalent to an input voltage of $2.384x10^{-6}V$ put another way the datalogger gain is $2.384x10^{-6}V/count$

Putting these stage gains together, the system gain can be seen to be

$$1.019783x10^{-9}\ V/(nm/s^2) * (1/2.384x10^{-6)}\ count/V = 0.000427761\ count/(nm/s^2)$$

And that's equivalent to the factor for mapping ADC value (counts) to acceleration (calib)…

$$2337.7504\ (nm/s^2)/count$$

(Schema rt1.0 SEGTYPE of "A" is used for accelerometers which represents data in nm/s^2.)

Pressure Transducers

When dealing with a Paroscientific pressure transducer the calculation of system gain is complicated by the configurability of the transducer and the ‘PTAC’ data converter combination.

The PTAC output voltage range is 0 to 10V, however the pressure range that maps to this full-scale output range is programmable by setting a low pressure that will map to 0V output and a high-pressure that will map to 10V with the range between mapped linearly. Additionally the pressure units used is programmable into the transducers.

Thus 0 to 10V is configured to map to Low (pressure-units) to High (pressure-units) meaning the instrument gain is given by 10V / (H-L) pressure-units.

For example, if the units are set to kPa and the Low and High values to 0 and 200 the gain would be… 10V/310kPa. (Transducer range is 0-45PSIA which is approx 0-310kPa).

This analog voltage is then applied to a Q330 channel with its 2^{24} ADC for a 40V full-scale so the counts to kPa would be

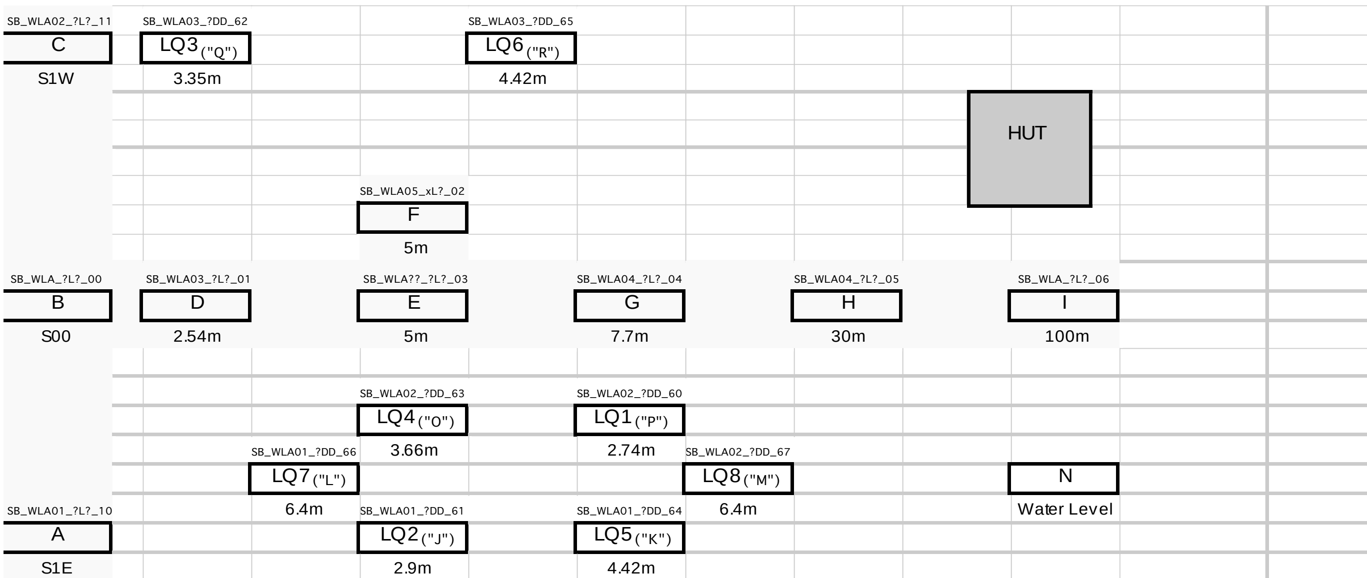
$$310\text{kPa}/10\text{V} * 40\text{V}/2^{24} = 73.909\text{x}10^{-6}\ \text{kPa/count}$$

(SEGTYPE of “K” is be used for pressure-transducers which represents data in kPa.)

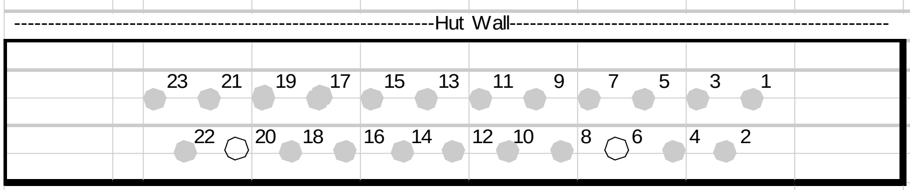
Appendix II: Site-layout Spreadsheet

Designation[1]	Q330 Channel[2]	Location Code	Description	Channel Naming	*Color Code[4]*	*Cable#[3]*	*Old Naming*	*Survey*
S1E	WLA01, Sensor A	10	S1E Surface accelerometer	SB_WLA01_[H,B,L]L[Z,N,E]_10	*Red*	*11*	*A*	*A6*
S00	WLA, Sensor A	00	S00 Surface accelerometer	SB_WLA_*[H,B,L]*L*[Z,N,E]*_00	*Green*	*18*	*B*	*A7*
S1W	WLA02, Sensor A	11	S1W Surface accelerometer	SB_WLA02_*[H,B,L]*L*[Z,N,E]*_11	*White*	*22*	*C*	*A8*
2.54M	WLA03, Sensor A	01	2.54M Borehole accelerometer	SB_WLA03_*[H,B,L]*L*[Z,N,E]*_01	*Red/Red*	*16*	*D*	*A1*
	WLA06, Sensor A	02	5M (rigid) Borehole accelerometer	SB_WLA06_[H,B,L]L[Z,N,E]_02			*E*	
	WLA06, Sensor B	03	5M (coex) Borehole accelerometer	SB_WLA06_[H,B,L]L[Z,N,E]_03	*Green/Green*	*12*	*F*	*A2*
7.7M	WLA04, Sensor A	04	7.7M Borehole accelerometer	SB_WLA04_*[H,B,L]*L*[Z,N,E]*_10	*White/White*	*14*	*G*	*A3*
30M	WLA04, Sensor B	05	30M Borehole accelerometer	SB_WLA04_*[H,B,L]*L*[Z,N,E]*_10	*Yellow/Yellow*	*17*	*H*	*A4*
100M	WLA, Sensor B	06	100M Borehole accelerometer	SB_WLA_*[H,B,L]*L*[Z,N,E]*_10	*Blue/Blue*	*8*	*I*	*A5*
LQ2	WLA01, Sensor B/2	61	2.9M Piezometer	SB_WLA01_*[H,B,L]*DD_61	*Red/Blue*	*5*	*J*	*P1*
LQ5	WLA01, Sensor B/3	64	4.42M Piezometer	SB_WLA01_*[H,B,L]*DD_64	*Red/White*	*7*	*K*	*P6*
LQ7	WLA01, Sensor B/1	66	6.4M Piezometer	SB_WLA01_*[H,B,L]*DD_66	*Red/Green*	*9*	*L*	*P2*
LQ8	WLA02, Sensor B/1	67	6.4M Piezometer	SB_WLA02_*[H,B,L]*DD_67	*Red/Blue/Blue*	*2*	*M*	*P5*
WL1	WLA05, Sensor B/1	70	Water Level	SB_WLA05_*[H,B,L]*DD_70	*Red/White/White*	*1*	*N*	*SP1*
LQ4	WLA02, Sensor B/3	63	3.66M Piezometer	SB_WLA02_*[H,B,L]*DD_63	*Red/Green/Green*	*4*	*O*	*P3*
LQ1	WLA02, Sensor B/2	60	2.74M Piezometer	SB_WLA02_*[H,B,L]*DD_60	*Red/Red/Blue*	*3*	*P*	*P4*
LQ3	WLA03, Sensor B/1	62	3.35M Piezometer	SB_WLA03_*[H,B,L]*DD_62	*Red/Red/White*	*21*	*Q*	*P7*
LQ6	WLA03, Sensor B/2	65	4.42M Piezometer	SB_WLA03_*[H,B,L]*DD_65	*Red/Red/Green*	*19*	*R*	*P8*
BP1	WLA03, Sensor B/3	69	Atmospheric barometer	SB_WLA03_*[H,B,L]*D0_69				

Notes: 1. See 'Site Layout' sheet for sensor physical locations and letter-designation mapping
2. See 'Hut-Wall Layout' sheet for physical locations of Q330s.
3. Cable# refers to the location of the cable in the hut's entry box. See diagram on 'Site Layout' sheet
4. Cable-ends and inside wellhead boxes have Color Code marking with electrical tape.



WLA Sensor layout for cabling conectivity (not-to-scale)

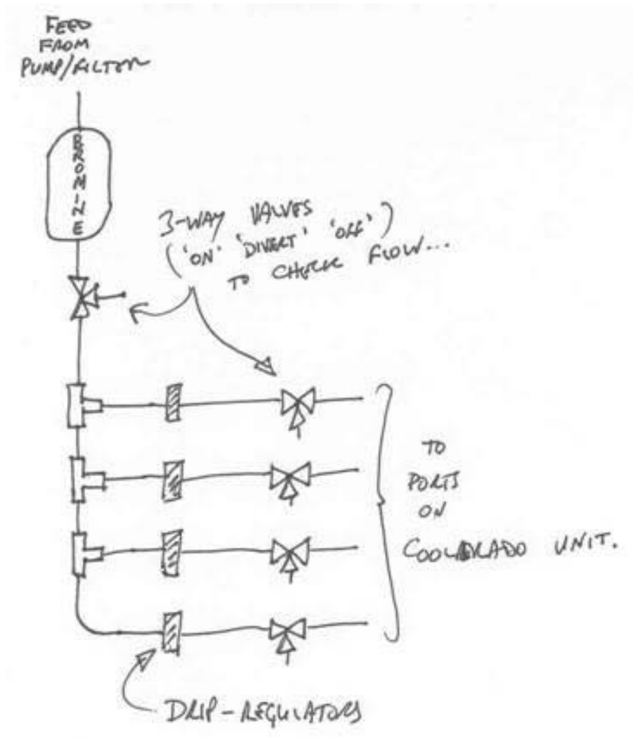


WLA Cable-Entry-Box Pattern and Numbering

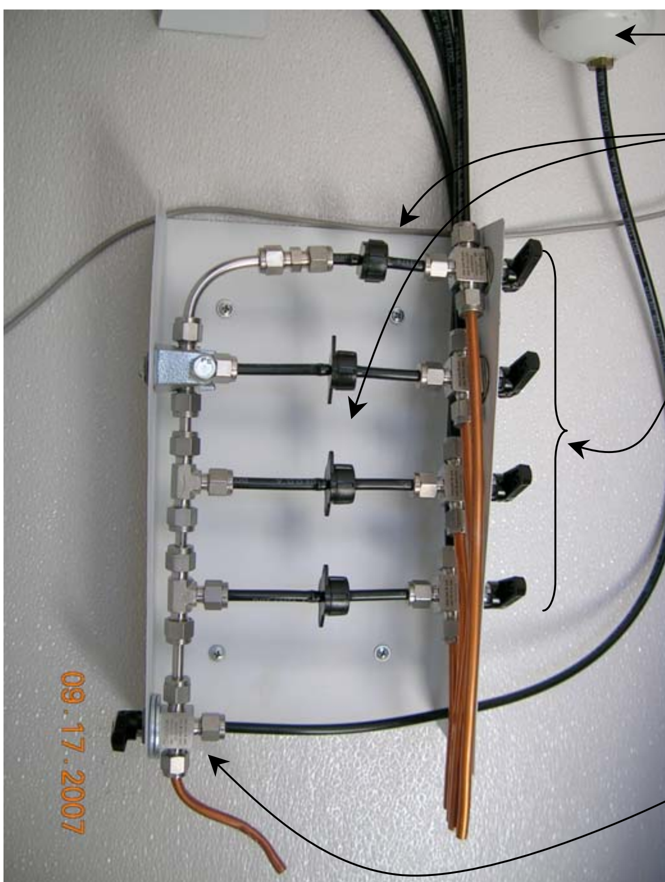
V1.6 10/03/07

Appendix III: Overview of changes to WLA cooling 9/19/07

Per the original plan, a separate accessible unit was built to allow easy access/maintenance and flow-checking of the drippers that deliver water to the cooler.



In the hut the assembly looks like this:



Bromine filter

Dirppers

Three-way valves (on-off-on)
for switching the dripper output to the cooler or the test-spouts

Three-way valve for turning off the flow from the filter, sending it to the drippers, or sending it to the test spout.

With this arrangement the water flow from the bromine filter can be checked, the flow to the dirppers can be turned off and they can be removed and replaced by way of the Swagelok compression fittings, and the flow for each of the individual dripper output can be checked in-place.

The ¼" tubes from the valves to the cooler where re-inserted into the end of the Coolerado unit and sealed with black Silicon II sealer.

Underneath the new valve/dipper assembly there is a trough with a drain tube to outside the building (the drain tubes runs outside where the blue, flexible vent air hose from the cooler penetrates the wall to the right of the battery inclosure). Any leaks from the assembly should be caught by the trough and drained to the outside. A Plexiglas door in front of the assembly should divert and 'spraying' leaks down to the trough.

A picture of the full set-up is shown below.

Finally, the control voltage to the ground-water pump[3] can now be monitored,

- visually by a red LED that lights when the pump is running. The LED is mounted to the rear diagonal brace to the wall in the picture above
- remotely by a version of the pumps 24V (fed through a resistive potential-divider) to channel 4 of WLA05. Approx. 0v indicated the pump is off, 1.2v indicates the pump is running.

Alas, in the days since the work the outside air-temperature has been cool so its not clear from the data that we can assess the operation of the cooling unit!
Over the longer term we can use inside vs out temps as well as pump-cycle times and site-visits to better understand the operation and water flow characteristics that will determine our next step.

[3] The 24V pump turns on only when BOTH the thermostat calls for cooling and the reservoir tank-pressure-switch turns on (this happens when the tanks pressure drops to about 25psi, the switch turns off again when the pressure reaches about 40psi)

To Do List

- Add a pressure regulator on the output of the water-filter unit on the roof as the top pressure of 40psi is likely to adversely affect the irrigation drippers.
- Replace the nylon pipe-fitting on the roof with stainless? A number of the compression fittings seem to have cracked.
- Add indication (visual/remote) on the thromstat
- Fail-safe system to stop pump if the system springs a leak?