NGWLMS GOES MESSAGE FORMATTING
FOR HOURLY TRANSMISSIONS

INTRODUCTION:

In order to keep pace with CO-OPS effort to provide data from field units in as timely a fashion as possible, a review of the current GOES "NOS" encoding scheme for Water Level and ancillary sensors was conducted to reduce the time between when data is collected and transmitted via GOES.

Within the past two years, over 98% of the NGWLMS network has been changed from transmissions every three hours to hourly transmissions Although this reduced the time from when data was collected to transmission from a maximum of about 4 hours for the oldest data to a maximum of two hours, the newest data reported could still be an hour old. This "lag" in data reporting came from a restriction of only sending blocks of complete hours of data starting on the "Top" of the hour.

The following is an explanation of the new satellite GOES formatting scheme which does not change how the data is encoded, but rather how it is formatted and transmitted. The results, for current Sutron 9000 DCP's, will be transmission of newest data from four to nine minutes old depending on the transmit slot, and somewhat less from Vitel 1100 DCP's since the formatter runs at the time of transmission. Most East Coast NGWLMS 9000 stations have already been changed to this new format, and some West Coast stations. New 9000 code is being developed to change over the entire network, including The Great Lakes.

BACKGROUND:

The GOES Binary Data Transmission scheme allows for six bits/byte to be used for data (ASCII 64 > 127) or 64 unique states. Two bytes allow 4096 unique states. Three bytes allow for 262,144 unique states. Since ASCII 127 is an unprintable character, ASCII 63 (?) is substituted in the transmitted messages. Therefore, a two byte reading of maximum value of 4095 would be encoded as "??". In all cases below, the values described are as they are stored in the WLMS 9000, as integer values, so when I talk about meters the coding will actually be of the millimeter value and pressure in decibars.

The present coding gives water level measurements of PWL, and RWL reported to a resolution of 0.001 meter, (or Paros sensors to 0.001 decibars). In order to reduce the number of bytes required for the necessary resolution, a offset coding scheme was adopted. For each hour of data to be formatted, the ten values are examined, the minimum selected, and an offset is determined to the nearest lower 1/4 meter. For example, if the smallest value of the ten readings is 1.555 meters, the Offset will be 1.500 meters, and the Offset value of 6 will be sent over the satellite for the hour (1.500M = 6 x 0.250 M). This is encoded as one byte at the beginning of each hour of PWL and RWL sent over GOES. One byte allows for a range of 0 to 15.750 M for the Offset. Each six-minute value for the hour has this value subtracted from it and the difference (0.055M in the

example above) encoded in two bytes. This allows for a range of + 4.095 meters for each water level value over the rest of the hour. This allows the necessary resolution (1 MM) to a maximum range of 19.845M be sent with the minimum number of bytes. Standard deviation is reported in MM to a maximum of 4.095M in two bytes. One byte of outlier (max 63) is sent.

To reproduce the PWL value on datum, the following formula is applied: WL = (Datum Offset - Sensor Offset - PWL). Both the BWL and Paros readings are direct, reading head of water above the sensor, but are scaled pressure readings and are not on datum. The Absolute Shaft Angle Encoder, which replaces the Aquatrak on the Great Lakes as the primary sensor, is leveled and uses the Datum Offset but has no sensor offset (removed at unit).

Backup Water Level, which is collected by the WLMS 8200 every six minutes but reported over GOES every half hour, is encoded using three bytes (not using the above scheme). The current versions send only the Water Level (mean scaled pressure readings) on the hour and half hour and this data is also sent as redundant data along with the primary..

New Format Details:

As mentioned above, the newest scheme that follows does not change the way actual data points are encoded in the current NOS GOES messages. What has been changed is the time and order that it is transmitted. For example, if a DCP was on an hourly slot transmitting at 43 minutes past the hour, the 36 minute water level value would be transmitted first, followed by the 30 minute value, 24 minute value, etc, in a block of an hour up till the 42 minute value from the previous hour. Using the same example, the 30 minute and the 0 minute backup water level values would also be sent, and the 0 minute ancillary values if only recorded once per hour. If ancillary values were recorded every six minutes, they would be transmitted starting with the 36 minute value as the primary water level value going back six minutes to the same 42 minute value of the previous hour for a total of ten readings also.

In order to absolutely identify when the first data value transmitted was collected, one additional byte of time information has been added to the header before the first time stamp. It is the binary encoded minute of the centering of the first data point. In the above example, it is “d”.

The NGWLMS DCP's have 29 available "flag" characters. We have currently assigned:

Flag	Meaning	Flag	Meaning
0	Time Tag	7	Conductivity
1	Primary Water Level (PWL)	8	(currently unassigned)
>	RedundantWaterLevel (RWL)	9	Dew Point
"	Backup Water Level (BWL)	:	Rain Fall
3	Wind Data (Speed,dir,gust)	;	Solar Radiation
4	Air Temperature	<	Analog #1
5	Water Temperature	=	Analog #2
6	Barometric Pressure	%	Paros Scientific #1

+	Frequency #1	&	Paros Scientific #2
!	Shaft Angle Encoder	'	Redundant Paros #1
.	Redundant Shaft Angle	*	Redundant Paros #2

Flags 8, 9, ":" and ";" will probably be reassigned for new sensor types.

The DAY referred to below is the Sutron Day, or number of days since Dec. 31, 1984. The header identifier byte is the letter N for this new format and may be expanded for different applications.

Ancillary data is sent as two bytes of Binary encoded data. Wind and Water Current have more than one parameter each being sent as two bytes. Temperatures are encoded using a 2's complement coding to allow the values to be positive or negative.

There has been a fairly recent change to the GOES message: seven additional bytes have been added. These were specifically added for field quality assurance, but are now being utilized by DPAS. After the regular message, a space (ASCII character 32) is added, and then one byte which encodes battery voltage measured during the previous GOES transmission since the 9000 GOES formatter runs several minutes before the actual transmission. This was originally implemented in the Vitel 1100, although the value sent is the battery voltage is for the current transmission as the formatter runs at transmit time. This voltage reading (to the tenths of a volt) has 9.5 volts subtracted from it, and the difference is sent as a one byte ASCII character from @ (character 64) to ? (representing 127). For example, "@" would equal 9.5 volts (9.5 + 0), "a" would be 12.8 volts, etc.

In addition, two additional values have been added: a two byte Backup Water Level Slope or gain value, and a three byte Backup Water Level Offset (encoded in millimeters). These are new values added as a result of the "Freezing" code and allow the decode software to scale the backup values to overlay the Primary Water level values for field intercomparison of data from the GOES transmissions. Additionally, the highest order byte of the status word in the normal message now defines whether the "Freezing" mode has been enabled or not.

Message Construction by Bytes:

Header:	HEADER	SITE ID	DATUM OFF	SEN OFF	SYS STAT	RSTS	CHKSM	TIMEOFF
# BYTE	1	8	3	2	2	1	2	1

TOTAL = 20 BYTES

Time:	0 FLAG	DAY	HOUR
# BYTE	1	2	1

TOTAL = 4 BYTES

PWL HEADER:	FLAG	PWL OFFSET
# BYTE	1	1

TOTAL = 2 BYTE

PWL |PWL|SIGMA|OUTLIERS|AQUA TEMP 1|AQUA TEMP 2|
# BYTE | 2 | 2 | 1 | 2 | 2 |
TOTAL = 9 BYTES/READING X 10/HR = 90 BYTES

Transmitted order: PWL value at TIMEOFF(TO), then TO-6, TO-12, TO-18, TO-24, TO-30, TO-36, TO-42, TO-48, TO-54.

FOR SIX MINUTE PAROS (OR SHAFT ANGLE ENCODER) VALUES (NO PWL):
PAROS HD: |FLAG|PAROS OFFSET|
# BYTE | 1 | 1 |
TOTAL = 2 BYTE
PAROS |PAWL|SIGMA|OUTLIERS|
# BYTE | 2 | 2 | 1 |
TOTAL = 5 BYTES/READING X 10/HR = 50 BYTES

Same transmission order as PWL above.

BWL |BWL|
# BYTE | 3 |
TOTAL = 3 BYTES/READING X 2/HR + 1 FLAG = 7 BYTES

Two readings for BWL are sent, most recent either the half hour or hour, and a half hour back from there. In the above example, the 30 minute and the 0 minute readings are sent.

RWL OR RPA|RWL|
# BYTE | 2 |
TOTAL = 2 BYTES/READING X 10/HR + 1 FLAG + 1 RWL OFFSET = 22 BYTES

Redundant data follows the same format as primary data, most recent to oldest starting at TIMEOFF.

WIND DATA |FLAG|SPEED|DIR|GUST|
BYTE | 1 | 2 | 2 | 2 |

CURRENT |FLAG|SPEED|DIR|
BYTE | 1 | 2 | 2 |

ANCILLARY |FLAG|SENSOR RD | (ANYTHING ELSE)
# BYTE | 1 | 2 |
TOTAL = 3 BYTES/SENSOR

Again, for one data value the top of the hour is transmitted, if ten then the same as primary or redundant, from newest to oldest.

Typical Messages:

Aquatrak and Backup:

```
                |HEAD|TIME  |PWL HEAD|1HR PWL|BWL|WIND DATA|5 ANC|
#BYTE           | 20     | 4     |  2           |  90       | 7    |   7            | 15    |
                |TIME  |RWL HEAD   |1 HR RWL     |BWL|
#BYTE           |  4     |  2             |  20            | 7 |
  "             |  4     |  2             |  20    | 7 |
                |SPACE|BATT. VOLT|BWL GAIN|BWL OFFSET|EOT|
#BYTE           |  1     |    1           |       2      |       3         |  1   |

                                TOTAL # BYTES 220
```

Dual Pressure Message:

```
                |HEADER|TIME|PA1 HD|1HR PA1|PA2 HD|1HR PA2|CNDCT|WTR TEMP|
#BYTE           | 20        | 4    |  2       |  50      |  2      | 50        | 3       |  3           |
        .       |TIME|RPA1 HEAD|1 HR RPA1|
#BYTE           |  4    |  2            |  20        |
        “       |  4    |  2            |  20        |
        “       |  4    |  2            |  20        |
                |SPACE|BATT. VOLT|BWL GAIN|BWL OFFSET|EOT|
#BYTE           |  1     |    1           |       2      |       3         |  1   |
                                TOTAL # BYTES 220
```

Typical Lakes Station with BWL added (code not completed yet):

```
                |HEADER|TIME|SAE HEAD|1 HR SAE| BWL |
#BYTE           |   20      |  4   |      2       |     50     |     7  |
                |TIME|RSAE FLAG|  RSAE   | BWL |
#BYTE       | 4    |    2          |  20       | 7     |
  "         | 4    |    2          |  20       | 7     |
  "         | 4    |    2          |  20       | 7     |
                |SPACE|BATT. VOLT|BWL GAIN|BWL OFFSET|EOT|
#BYTE           |  1     |    1           |       2      |       3         |  1   |
                                TOTAL # BYTES 189
```

For a station with only PWL and BWL:

```
                |HEADER|TIME|PWL HEAD|1 HR PWL| BWL |
#BYTE           |   20      |  4   |      2       |     90     |     7  |
                |TIME  |RWL FLAG   |  RWL   | BWL |
#BYTE           |  4     |    2   |  20      | 7     |
  "             |  4     |    2           |  20      | 7     |
                |SPACE|BATT. VOLT|BWL GAIN|BWL OFFSET|EOT|
#BYTE           |  1     |    1           |       2      |       3         |  1   |
                                TOTAL # BYTES 197
```

No changes have been done to RANDOM or STORM SURGE at this time.