Data Acquisition and Processing Report

N375-NRT3-04

Olympia Harbor, Budd Inlet, Washington

Hydrographic Letter Instructions dated January 12, 2005

Team Leader: Kathryn Simmons

This report includes descriptions of equipment used and methods employed by Navigation Response Team 3 during acquisition and processing of hydrographic survey data. It does not necessarily apply to fast-track data – a separate report will accompany data submitted directly to the Marine Chart Division.

A. EQUIPMENT

NOAA Survey Launch 1212 was used during this survey to acquire single-beam echosounder data, side scan sonar data, sound velocity profiles and detached positions. The vessel and any vessel configuration changes are described below.

NOAA Survey Launch 1212 is a 30-foot, 4.8-ton SeaArk Commander (SAMA115510000) acquired in January 2001. The launch is powered by two 150-horsepower Yamaha four-stroke outboards and is equipped with a Dell Pentium II PC which runs the primary software associated with data collection

A Trimble backpack DGPS system was used to position fixed aids to navigation, high water features, and natural shoreline.

Sounding Equipment:

1. Single-Beam Echosounder (SBES)

An Innerspace 455C single-frequency (208 kHz), vertical beam echosounder (VBES) was used for data collection.

The echosounder records both analog and digital data which may be acquired in feet, fathoms or meters. The unit has a beam width of eight degrees and an optional beam width of three degrees. Soundings were acquired in meters with an assumed speed of sound through water of 1500 m/sec. During data collection the analog screens were continuously captured and stored on an external zip drive for reference during digital data processing.

Sounding lines were run at spacing sufficient to define major contours. Line spacing was reduced over shoal areas and for contact development.

Lead line checks were performed periodically throughout the project to verify fathometer accuracy.

Coastal Oceanographic's Hypack Max Gold software was used for vessel navigation and line tracking during hydrographic data acquisition. Hypack was also used to log VBES data in "raw" format and to record detached positions in the form of .tgt files.

2. Side Scan Sonar (SSS)

The vessel is equipped with a Klein 3000 sonar system. The system includes:

- Dual frequency (100 kHz, 500 kHz) towfish with 300 PSI pressure sensor
- Transceiver Processing Unit (TPU)
- Workstation Display and Control Unit (WDCU)
- Thirty-five meters of Kevlar reinforced tow cable
- SonarPro software and VX Works TPU operating system

The horizontal beam widths for the low and high frequencies are 1° and 2°, respectively; vertical beam width is 40°. Maximum low-frequency range scale for the Klein 3000 is 500 meters; at high frequency maximum range scale is 150 meters. The high-frequency data were recorded and stored in the data base; the low frequency image is observed during data collection but not converted separately.

A range scale of 100 meters was maintained except in very deep water, when the scale was increased to 150 meters, or during development of submerged obstructions, when the scale was reduced to 75 or 50 meters. The towfish height above the bottom was maintained at 8 to 20 percent of the range scale whenever possible. Exceptions occur in very shallow areas or in areas where rapidly changing terrain raises the risk of hitting the towfish on the bottom.

Side scan sonar lines were spaced according to the range scale appropriate for water depth to assure overlap of at least 25 meters and to assure 200% coverage.

Vessel speed was maintained at or below five knots to ensure that an object one meter square could be detected across the sonar swath. Confidence checks were performed by observing the outer edges of the sonargram while moving alongside pier faces or known submerged targets.

Sonar images of visible objects or known submerged objects (such as buoy blocks), were captured during data acquisition using the program SnagIt. Identification of these images before and during processing helped to avoid selection of these objects as side scan contacts to be investigated.

All SSS data collection was controlled with SonarPro software operating in a Microsoft Windows 2000 environment on the WDCU. The sonar data were recorded digitally and stored on the WDCU in the Klein SDF format.

Launch S1212 is equipped with a Dynapar cable counter that logs the length of deployed towfish cable to the WDCU via the Hypack delph signal. The measurements are made by counting revolutions of the towing block on the J-frame. Before each use, the cable counter was calibrated by adjusting the readout to reflect the measured marking on the towfish cable at the tow point.

Positioning Equipment:

1. Survey Launch S1212

The launch is equipped with a Trimble DSM212L integrated 12-channel GPS receiver and a dual-channel DGPS beacon receiver. The beacon receiver can simultaneously monitor two independent U.S. Coast Guard (USCG) DGPS beacons. There are three modes: Auto-Range, which locks onto the beacon nearest the vessel; Auto-Power, which locks onto the beacon with the greatest signal strength; and Manual, which

allows the user to select the desired beacon. Additionally, the DSM212L can accept differential correctors (RTCM messages) from an external source such as a user-established DGPS reference station.

The following parameters were monitored in real-time through Trimble's TSIP Talker software to ensure position data quality: 1) number of satellites used in the solution, 2) horizontal dilution of precision (HDOP), 3) latency of correctors, and 4) beacon signal strength. The DSM212L was configured to the auto-range mode, to go off-line if the age of DGPS correctors exceeded 20 seconds, and to exclude satellites with an altitude below 8 degrees.

2. Trimble Backpack Unit

A Trimble backpack unit was used to collect DGPS position data on fixed aids to navigation, high water features and natural shoreline. The unit consists of the following:

- Pro XRS 12-channel DGPS receiver
- Combined L1 GPS/Beacon/Satellite Differential Antenna
- TSCe data logger with Windows CE operating system

The ProXRS receiver was set to collect data using the following restrictions:

Minimum No. of satellites:	5
Maximum PDOP:	6
Minimum SNR:	4
Minimum Satellite elevation:	15 degrees

Position data were collected at one-second intervals; periods of collection varied as follows:

Major fixed aids to navigation:	3 to 5 minutes
Range lights:	5 minutes
Private fixed aids	5 to 30 seconds
Shoreline construction	1 second point, line, or area data

Trimble's TerraSync software was used on the Trimble TSCe data logger to collect DGPS position data in the field. Three data dictionaries for use with the data logger were created by NRT3: one for point features, one for line features and one for area features. Each data dictionary included S-57 Object Classes along with attributes for each object class. The relevant dictionary was used in the collection process to facilitate acquisition of essential information in the field. A copy of each data dictionary is included in Appendix IV.

Trimble's GPS Pathfinder Office software was used to download and convert data from the data logger, and to verify that individual points and lines met accuracy standards. Positions on major features with standard deviations greater than 0.075 meters were rejected.

Point data on aids to navigation were post-processed to achieve greater accuracy using the nearest CORS station.

B. DATA PROCESSING AND QUALITY CONTROL

Single-Beam Echosounder Data

Following acquisition, single-beam echosounder data were converted from HYPACK to the CARIS HDCS format using the CARIS HIPS conversion wizard. SBES navigation data were checked using CARIS HIPS attitude and navigation editors. Navigation fliers were rejected and the depths either interpolated between good navigation points or rejected. Depths were then edited in the single beam editor by comparing the digital record with screen captures from the echosounder. The digital record was edited to ensure that peaks of shoals and abrupt changes in slope were properly digitized by the echosounder.

Side Scan Sonar Data

Following acquisition, SSS data were also converted to the CARIS HDCS format using the CARIS HIPS conversion wizard, then reviewed with the attitude and navigation editors in the same manner as the SBES data. Using the CARIS SSS Editor, fish height was recomputed (if necessary) and the data were slant-range corrected. Sonargrams were then examined and significant contacts (shadow height of 1.0 meters or greater) selected for further development with the VBES. The selected contacts were exported to Mapinfo, where the HydroMI program was used to generate target and line files to be used in Hypack. Line spacing for contact development was five meters or less.

Processing Software:

CARIS HIPS and SIPS software was used to convert and edit VBES/SSS data, apply vertical and horizontal correctors, and analyze VBES/SSS data and detached positions.

NOAA's Pydro software supplied by the Hydrographic Systems and Technology Program (HSTP) was used for analyzing VBES data and SSS contacts, processing and editing detached positions, excessing data, and creating preliminary smooth sheet (PSS) files.

HSTP's HydroMI Mapbasic program was used in combination with MapInfo software for creating Hypack line and target files, creating CARIS tide files, drawing tracks, and drawing the PSS file created by Pydro.

MapInfo software was used to plan survey operations, analyze collected hydrographic and Trimble backpack data, and create final survey plots.

HSTP's Velocity Program for Windows (VelocWin), 8.50 was used to process sound velocity data that were obtained with Seacat and Digibar profilers.

A complete list of software and versions is included in Appendix I.

Data processing flow diagrams are included in Appendix II.

C. CORRECTIONS TO ECHO SOUNDINGS

Sound Velocity

The speed of sound through the water was determined by periodic sound velocity casts conducted in accordance with the NOS Hydrographic Surveys Specifications and Deliverables Manual

Corrections for speed of sound through the water column were computed from data obtained with an Odom Digibar Pro sound velocity profiler, except for DNs 067 and 073, when a Sea-Bird Electronics conductivity, temperature and depth profiler, model SeaCat-19 was used. NOAA's VelocWin software was used to process all casts and generate sound velocity files for CARIS. Sound velocity correctors were applied to sounding data in CARIS using the 'nearest in time' sound velocity cast.

Calibration reports for the SeaCat-19 profiler and the Odom Digibar are included in Appendix IV of this report. Dates and locations of the sound velocity casts are included in Section C of the descriptive report.

Vessel Offsets and Dynamic Draft Correctors

Static Draft

Static draft measurements for Launch S1212 were calculated on October 4, 2004 *(DN 278)*.

The following procedure was employed: First, the depth of the transducer face from a reference mark on the hull was measured. Next, with the launch in the water, fuel tanks half full and two persons aboard, the depth from this reference mark to the waterline was measured. Combining the two measurements, a static draft of 0.4 meters was calculated.

Dynamic Draft

Settlement and squat measurements for NOAA Launchl S1212 were calculated on October 4, 2004 *(DN 278)* in Grays Harbor near Ocean Shores, WA. Field records are included in Appendix V.

Transducer and antenna offsets, static draft, and dynamic draft correctors were incorporated into the 'vessel config' files, and applied during the merge process in CARIS. Values for offsets and dynamic draft data are included in Appendix III.

Tide Correctors

The operating National Water Level Observation Network (NWLON) station at Tacoma, Commencement Bay, WA (944-6484) served as datum control for the survey area

Verified, six-minute water levels relative to Mean Lower Low Water were downloaded from the NOAA, NOS, Center for Operational Oceanographic Products and Services (CO-OPS) web site: (www.http://co-ops.nos.noaa.gov/data_res.html). These were imported into a text file on a local computer and appended to the CARIS tide file, 9446484.tid.

There are 3 tide zones within the project limits. The tide corrector values, referenced to the tide station at Tacoma, Commencement Bay, are provided in the zoning file ***N375NRT32004CORPrev.zdf*** which is included with the project data.

Using CARIS HIPS, the tide data were loaded, soundings were sorted into the appropriate zone, time and height adjustments were computed and corrected tides were applied to sounding data. These correctors are included in Appendix IV.

Finally, the CARIS "merge" utility applies tide, draft, dynamic draft, and vessel offset correctors and creates the depth filed used by Pydro.

Data Decimation and Field Sheet Production

All soundings were combined in the CARIS HDCS project. To produce the Final Field Sheet, all non-rejected soundings that passed all other quality-assurance checks were imported into a Pydro Preliminary Smooth Sheet (PSS) file using shoal-biased "line-by-line" binning and a cell size of 1.5 millimeters at the scale of the survey. For this 1:10,000 scale survey, data were imported using a 15 meter cell size. The resultant thinned data were then excessed in Pydro using a 3-millimeter character size, which ensures that the largest spacing between selected soundings does not exceed 5 millimeters at survey scale. Final selected soundings were exported to Mapinfo. Digital terrain models (DTMs) of sounding data created by Vertical Mapper in MapInfo help to expose potential hazards as well as depth errors and systematic errors.

D. APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were used during this project in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables Manual, as updated for 2004.

All of the information contained in this report is complete and accurate to the best of my knowledge.

Approved and forwarded,

Kathryn Simmons
Team Leader

APPENDIX I

Software Versions and Hardware Serial Numbers

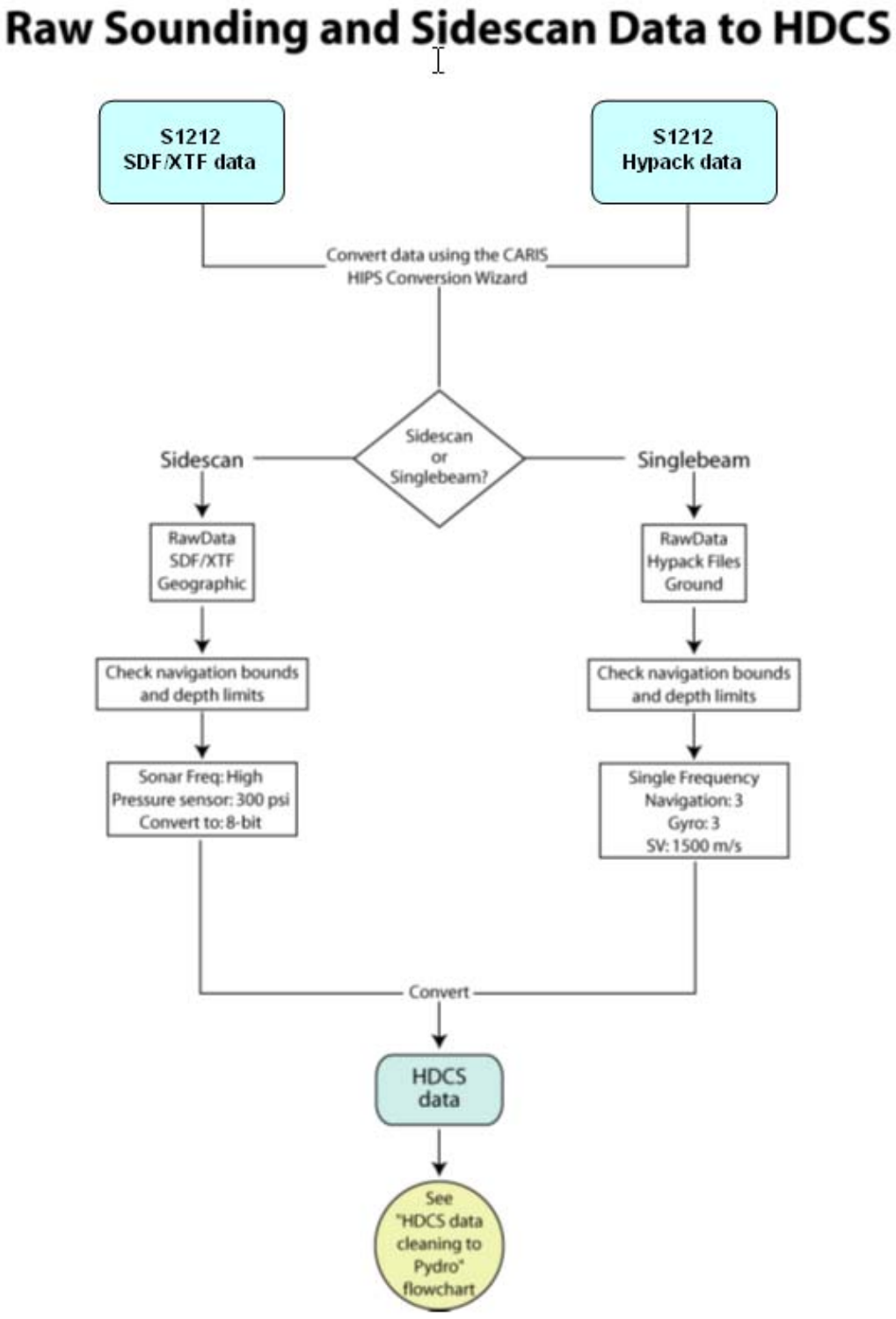
In-service date	Software	Version
	Acquisition	
03/03/2004	Hypack Max	2.12a
03/07/2005		4.3
03/03/2004	Klein 3000 Sonar Pro	8.0
03/03/2004	TSIP Talker	2.00
	Trimble TerraSync	2.4
	Processing	
	Pydro	4.6.1
		4.8.2
		4.9.0
07/25/2005		5.3.3
08/23/2005		5.8.0
03/03/2004	KapConv	1.3
7/19/2005		5.7.2
03/03/2004	MapInfo Professional	6.5
03/24/2005		7.8
10/21/2005		8.0
	Hydro_MI	4.8.1
4/5/2005		5.4.1
03/03/2004	Vertical Mapper	3.0
	Caris HIPS/SIPS	5.4
11/15/2005		6.0
03/03/2004	CARIS GIS	4.4a
03/03/2004	Tides and Currents for Windows	2.5b
03/03/2004	Pathfinder Office	2.9
	Sound Velocity	
03/03/2004	VelocWin	8.52
03/07/2005		8.73
03/31/2005	Digibar Pro Log	2.3

Equipment

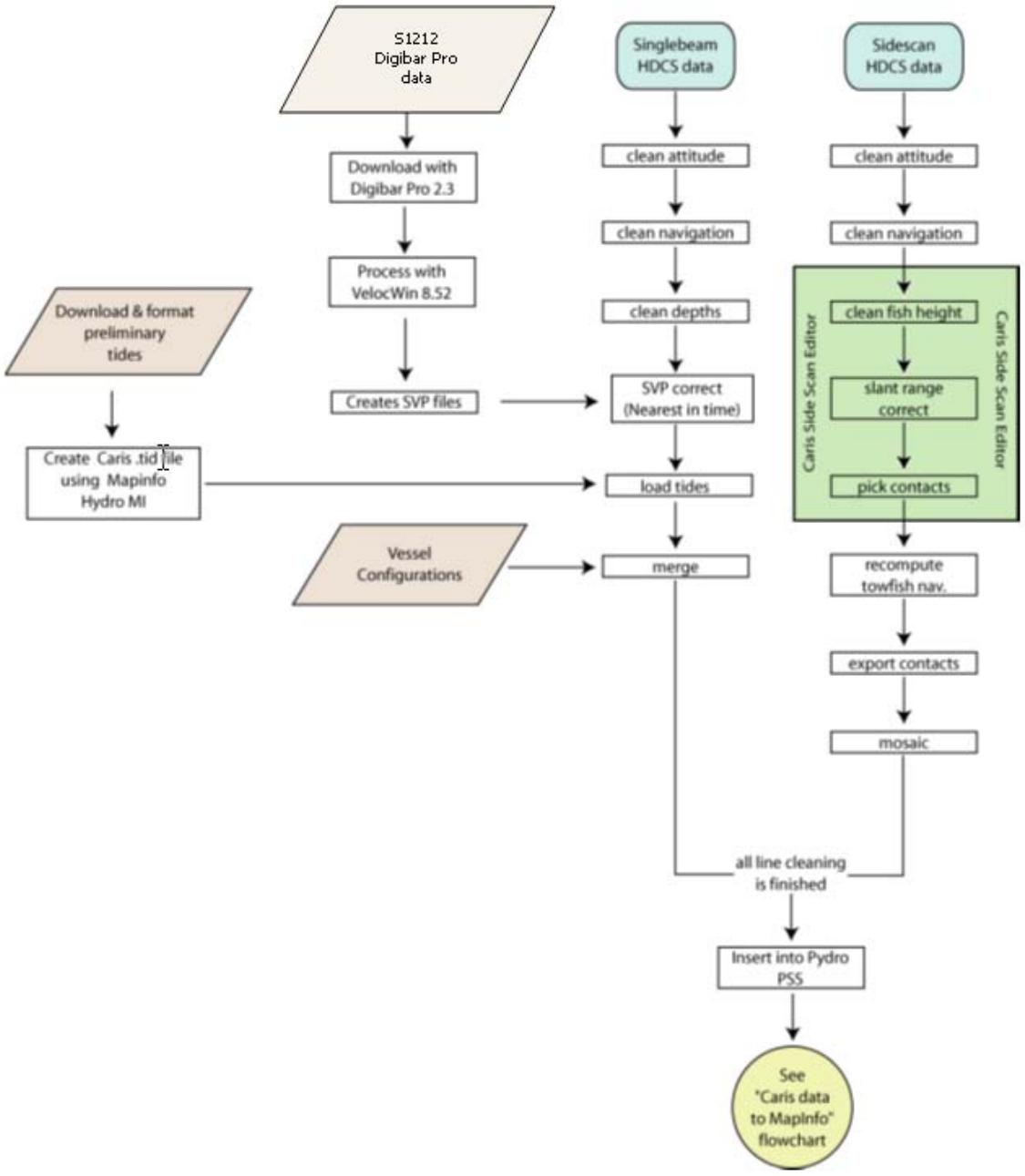
In-service date	Description	Serial Number
	Survey Launch 1212	
03/03/2004	Innerspace Technology 455c Survey Depth Sounder	192
	Klein 3000 Dual Frequency Towfish (Model 3210)	456
03/03/2004	Klein 3000 TPU	312
03/03/2004	Klein 3000 Workstation	22-291
03/07/2005	Hypack Computer (Dell Pentium IV)	
03/03/2004	Trimble DSM212L	0220164491
03/03/2004	Trimble Antenna	0220330095
03/03/2004	Dynapar Max Count Cable Counter	
03/03/2004	SBE SeaCat-19	1912344-1892
03/31/2005	Odom Digibar Pro DB-200	98308
	Trimble Backpack Unit	
11/17/2003	Pro XRS 12 Channel DGPS Receiver	SN 0224011684 / PN 33302-51
11/17/2003	Combined L1 GPS/Beacon/Satellite Differential Antenna	SN 0220187539 / PN 33580-50
11/17/2003	Trimble TSCe Datalogger	SN 00030866 / PN 45268-50

APPENDIX II

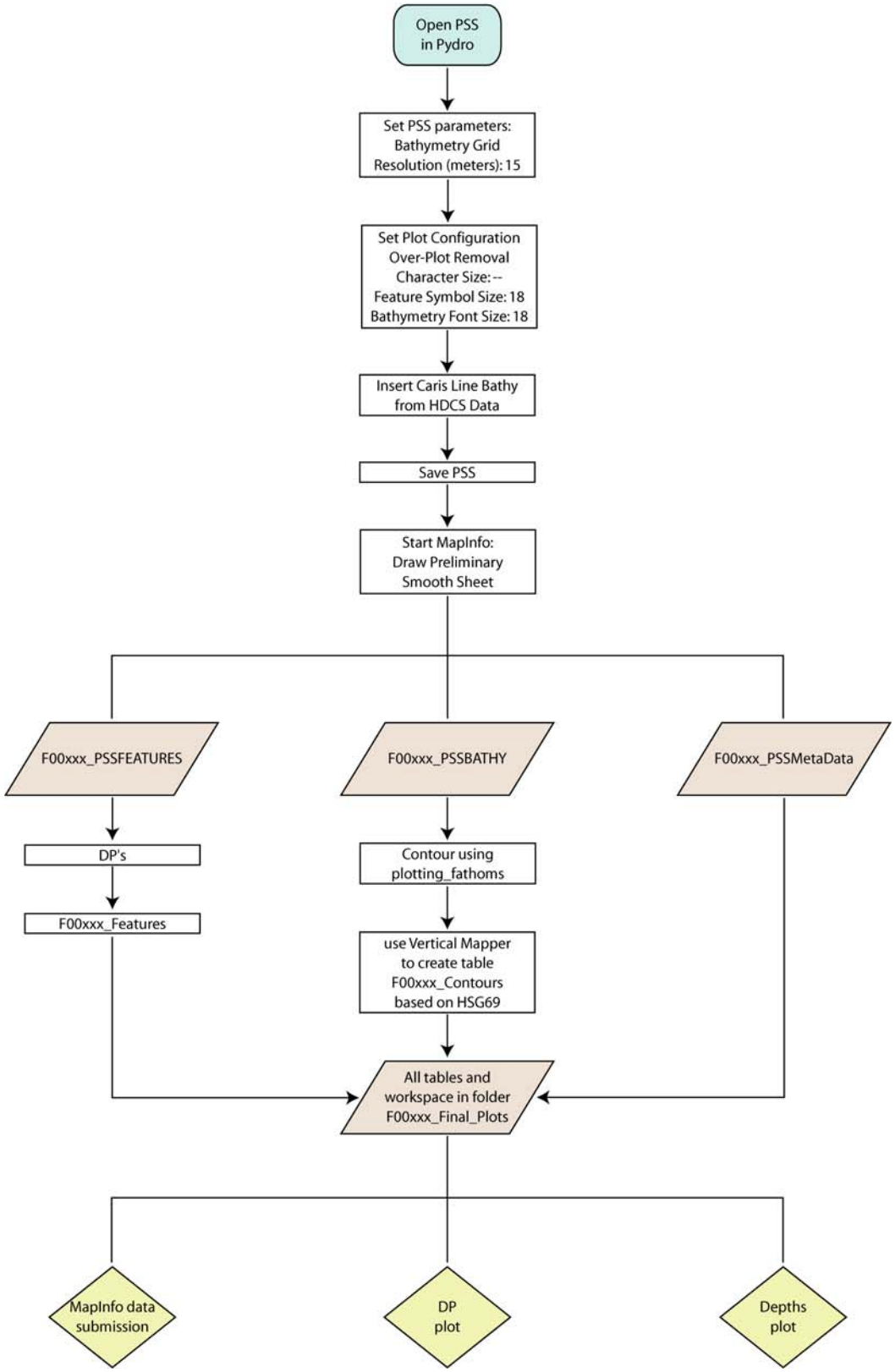
Data Processing Flow Diagrams



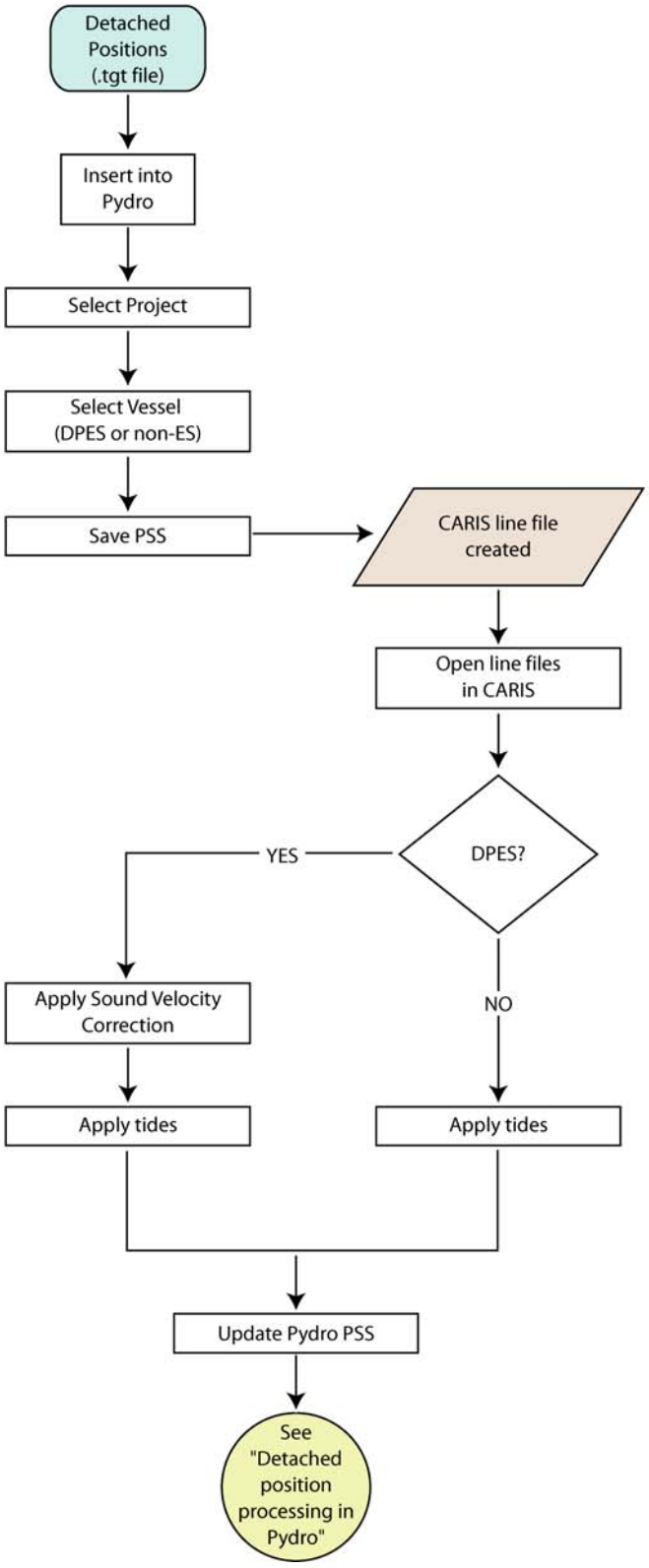
HDCS Data Cleaning to Pydro



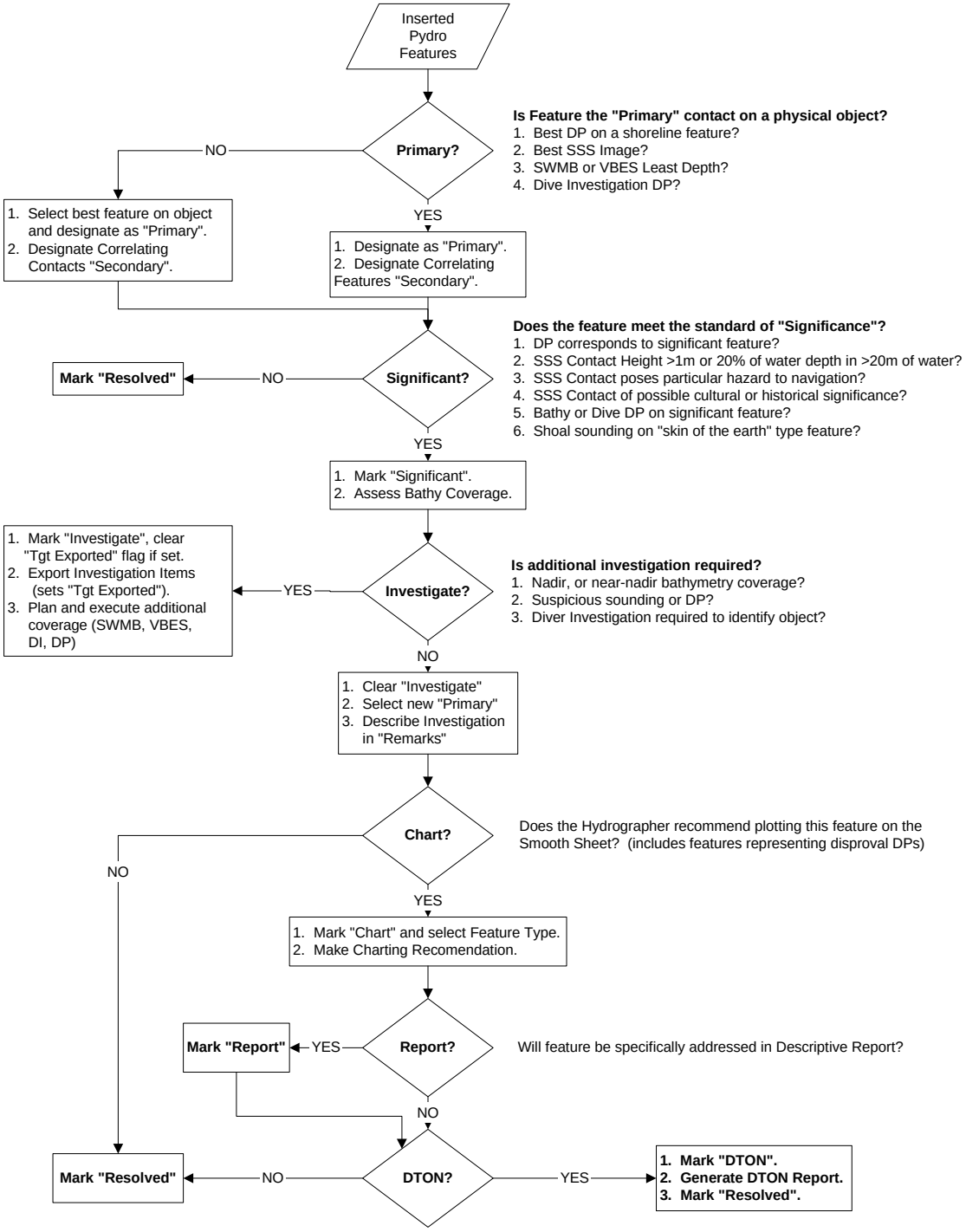
Caris Data to MapInfo Plot



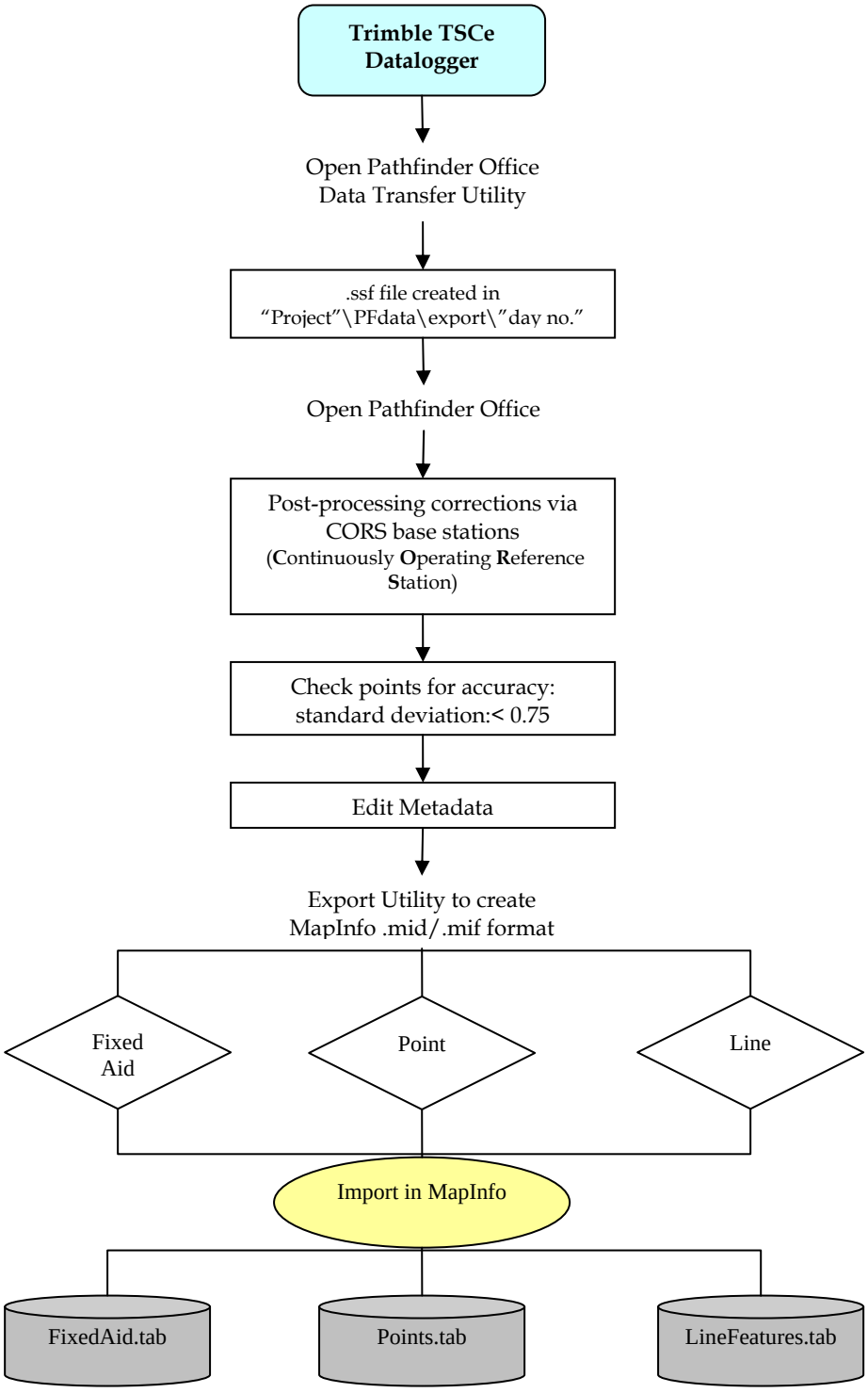
Detached Position Processing



Detached Position processing in Pydro



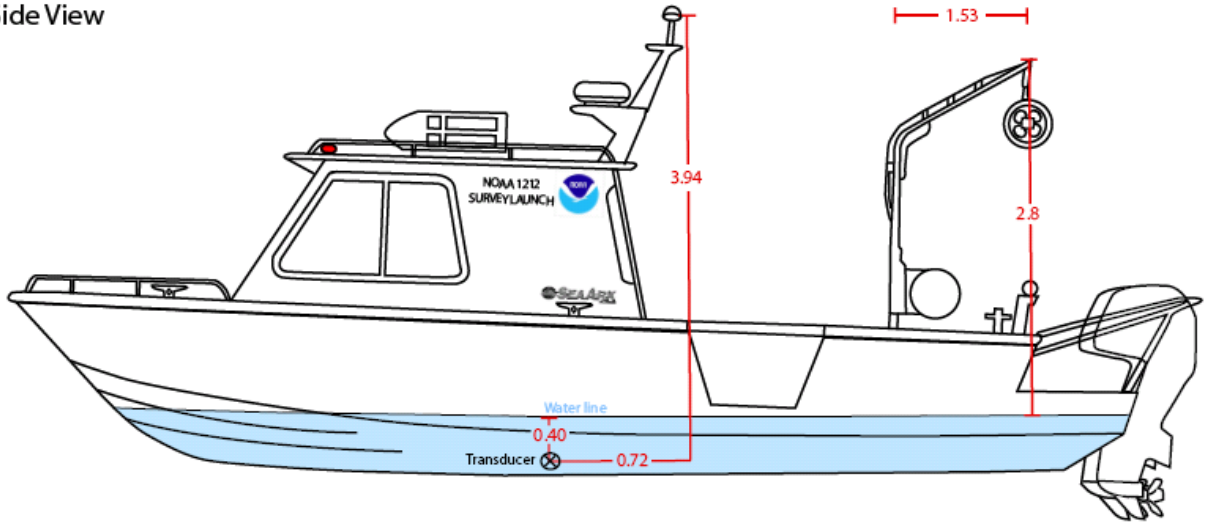
Trimble GPS Data Processing



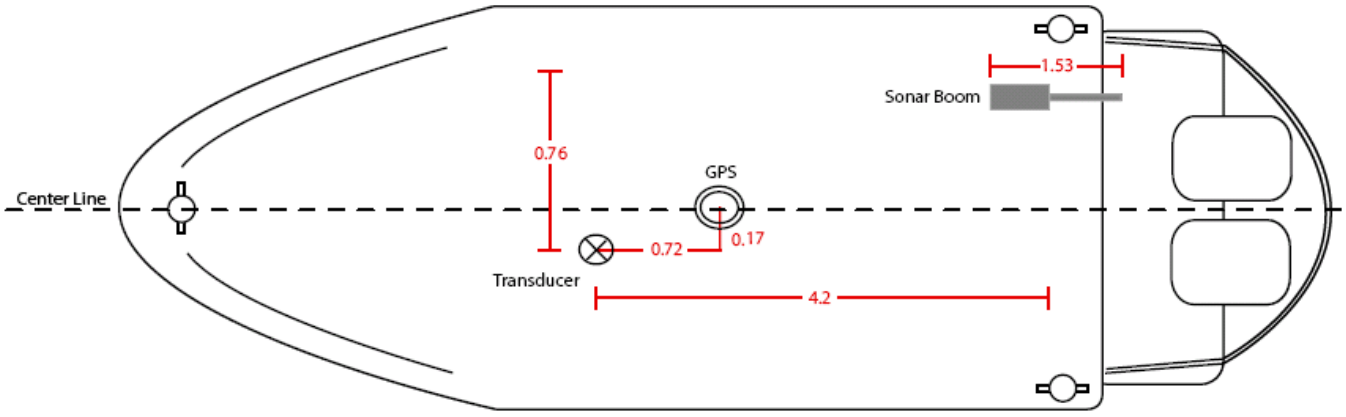
APPENDIX III

Vessel Offset Diagrams

NOAA Survey Launch 1212
Description: Aluminum SeaArk VC Commander
Vessel Length: 27 feet
LOA: 32 feet
Side View



Top View



Vessel Dynamic Draft Offsets

Launch 1212

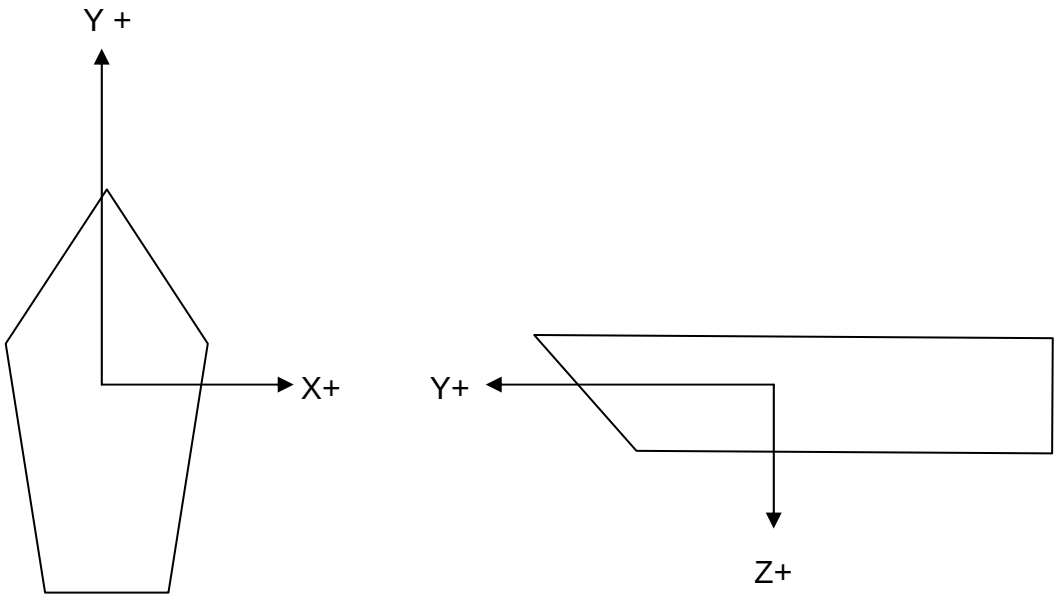
Table

	Draft (m)	Speed (m/s)
1	0.000	3.100
2	0.045	4.900
3	0.099	5.500
4	0.149	6.300
5	0.128	7.000
6	0.117	7.600
7	0.098	8.100
8	0.091	8.300
9	0.079	8.700
10	0.043	9.400
11	0.029	10.100
12	0.025	10.800
13	-0.023	11.800
14	-0.063	12.900
15	-0.058	13.800
16	-0.073	15.000
17	-0.044	15.800
18	-0.020	18.400
19		

OK Cancel

Dynamic Draft 2004-278

CARIS Offset Sign Conventions



APPENDIX IV

Calibration Reports

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 04-Jun-03

SBE19 PRESSURE CALIBRATION DATA
500 psia S/N 171607 TCV: 332

QUADRATIC COEFFICIENTS:

PA0 = 2.493263e+002
PA1 = -6.515209e-002
PA2 = 5.797276e-008

STRAIGHT LINE FIT:

M = -6.516334e-002
B = 2.497077e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.71	3613.3	14.67	-0.01	14.25	-0.09
99.85	2302.3	99.63	-0.04	99.68	-0.03
199.86	765.0	199.52	-0.07	199.86	0.00
299.85	-773.1	299.73	-0.02	300.08	0.05
399.85	-2305.0	399.81	-0.01	399.91	0.01
499.84	-3831.2	499.79	-0.01	499.36	-0.10
499.84	-3831.2	499.79	-0.01	499.36	-0.10
399.85	-2308.0	400.01	0.03	400.11	0.05
299.85	-779.8	300.17	0.06	300.52	0.13
199.86	758.0	199.98	0.02	200.32	0.09
99.85	2297.0	99.98	0.02	100.02	0.03
14.71	3610.1	14.87	0.03	14.46	-0.05

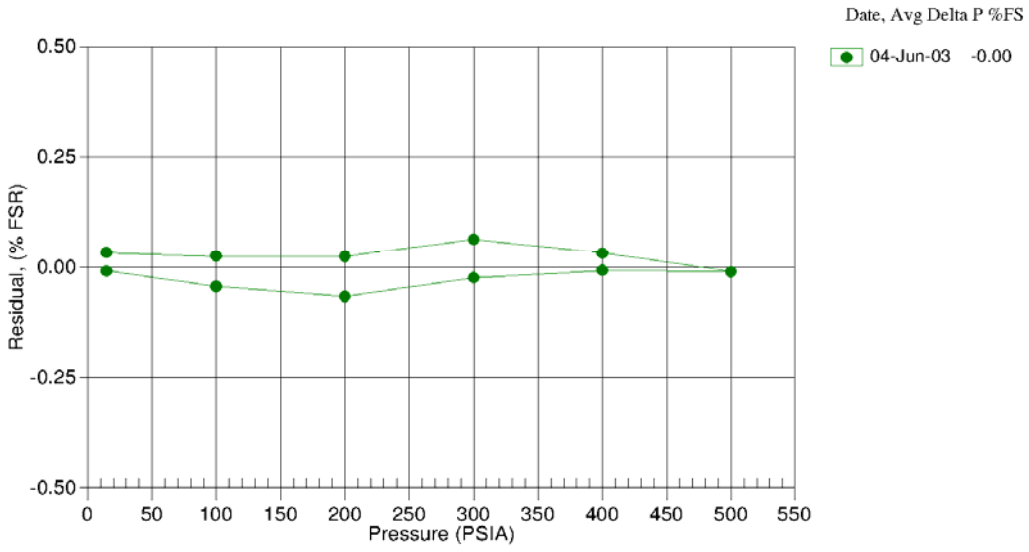
Straight Line Fit:

Pressure (psia) = M * N + B (N = binary output)

Quadratic Fit:

pressure (psia) = PA0 + PA1 * N + PA2 * N^2

Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



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Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 28-May-03

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.12415784e+000
h =  4.92329896e-001
i =  1.12234354e-003
j = -2.73529351e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.77608933e-002
b =  4.40510537e-001
c = -4.10781106e+000
d = -1.07983879e-004
m =  2.1
CPcor = -9.5700e-008 (nominal)
```

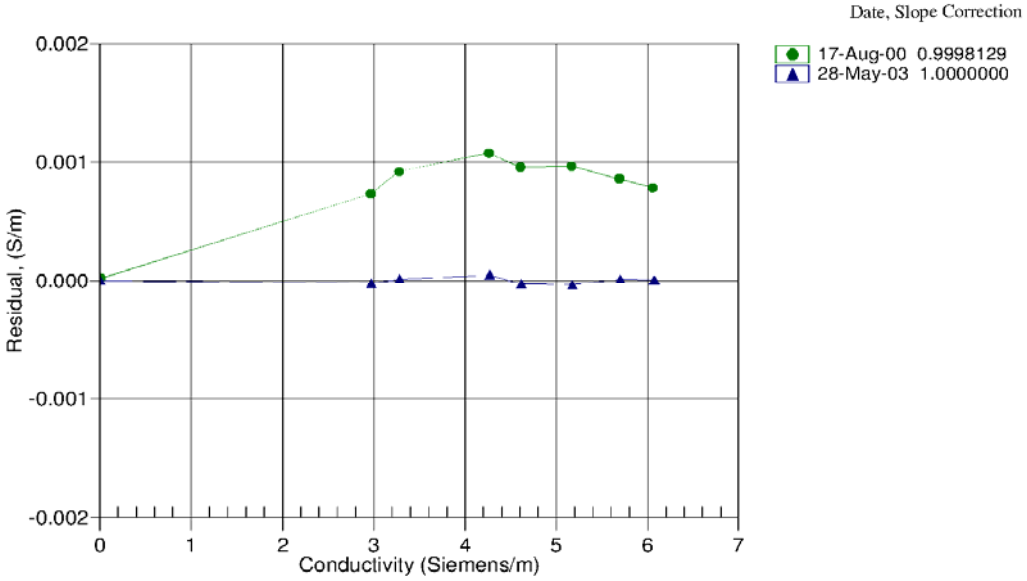
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88547	0.00000	0.00000
1.0000	34.7636	2.97189	8.22950	2.97187	-0.00002
4.5000	34.7641	3.28028	8.59429	3.28030	0.00002
15.0000	34.7634	4.26581	9.66712	4.26586	0.00005
18.4997	34.7632	4.61205	10.01641	4.61203	-0.00003
24.0001	34.7626	5.17153	10.55625	5.17149	-0.00004
29.0000	34.7619	5.69441	11.03676	5.69442	0.00001
32.5001	34.7605	6.06737	11.36694	6.06738	0.00001

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



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SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 28-May-03

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.19803398e-003
h = 5.96584364e-004
i = 2.24795894e-006
j = -2.32105182e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64764128e-003
b = 5.86538966e-004
c = 8.74099851e-006
d = -2.32072586e-006
f0 = 2531.819

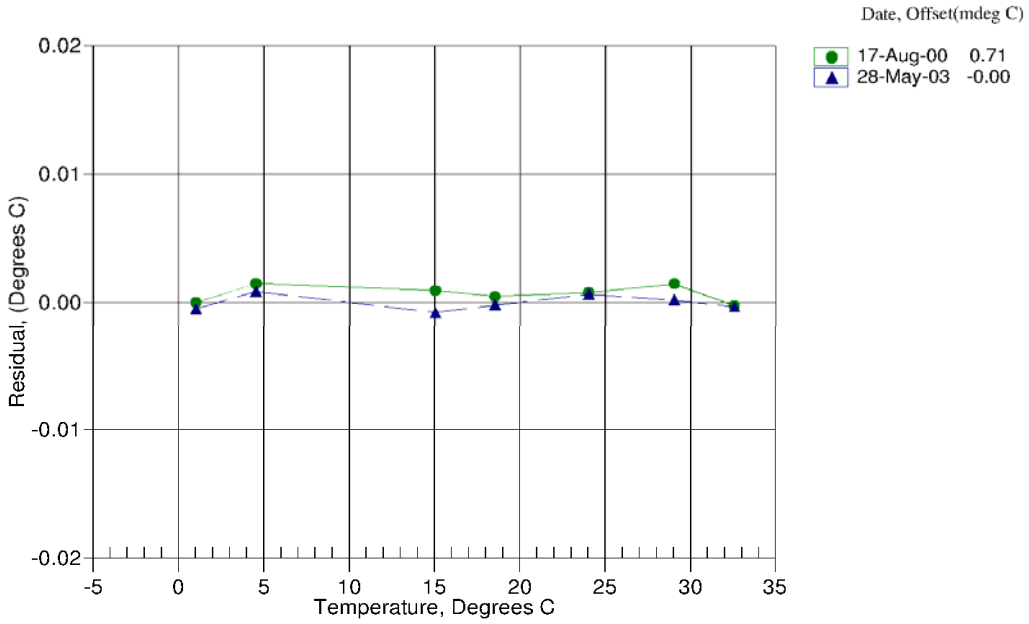
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2531.819	0.9995	-0.00047
4.5000	2738.677	4.5009	0.00088
15.0000	3430.267	14.9992	-0.00076
18.4997	3685.811	18.4995	-0.00018
24.0001	4113.978	24.0008	0.00065
29.0000	4532.226	29.0002	0.00021
32.5001	4842.067	32.4998	-0.00032

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature ITS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 08-Jun-05

SBE19 PRESSURE CALIBRATION DATA
500 psia S/N 171607 TCV: 332

QUADRATIC COEFFICIENTS:

PA0 = 2.491941e+002
PA1 = -6.515453e-002
PA2 = 5.601192e-008

STRAIGHT LINE FIT:

M = -6.513845e-002
B = 2.495167e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.61	3612.0	14.59	-0.00	14.24	-0.07
99.65	2303.2	99.43	-0.05	99.49	-0.03
199.65	765.5	199.35	-0.06	199.65	0.00
299.64	-773.0	299.59	-0.01	299.87	0.05
399.64	-2303.9	399.60	-0.01	399.59	-0.01
499.62	-3829.2	499.50	-0.02	498.94	-0.14
399.64	-2306.9	399.80	0.03	399.79	0.03
299.65	-778.1	299.93	0.06	300.20	0.11
199.66	760.0	199.71	0.01	200.01	0.07
99.67	2298.0	99.76	0.02	99.83	0.03
14.61	3609.3	14.76	0.03	14.41	-0.04

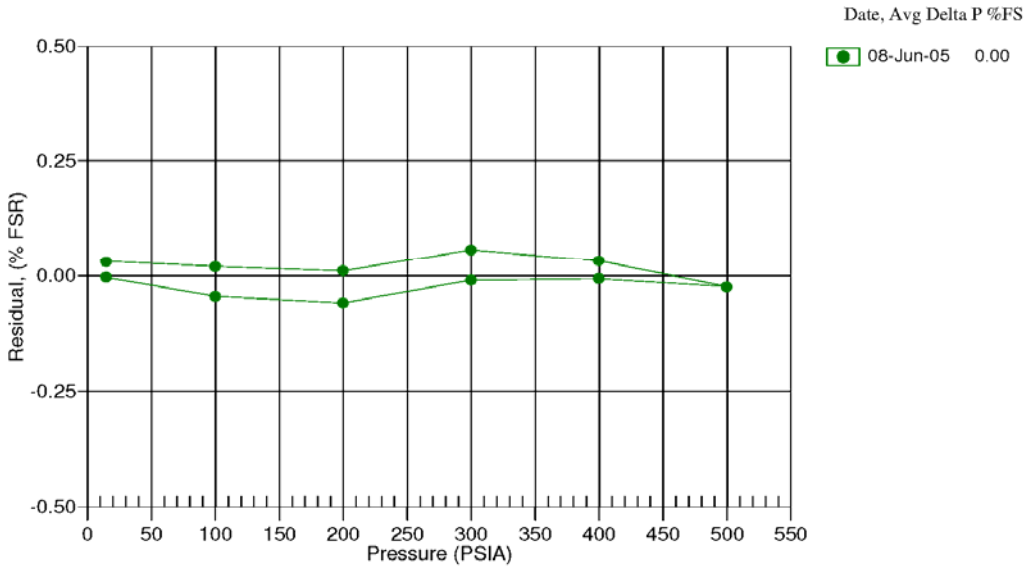
Straight Line Fit:

Pressure (psia) = M * N + B (N = binary output)

Quadratic Fit:

pressure (psia) = PA0 + PA1 * N + PA2 * N^2

Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 20-May-05

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.12302201e+000
h =  4.92310720e-001
i =  1.09950796e-003
j = -2.52693790e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.93070056e-002
b =  4.38507909e-001
c = -4.10472139e+000
d = -9.91386917e-005
m =  2.1
CPcor = -9.5700e-008 (nominal)
```

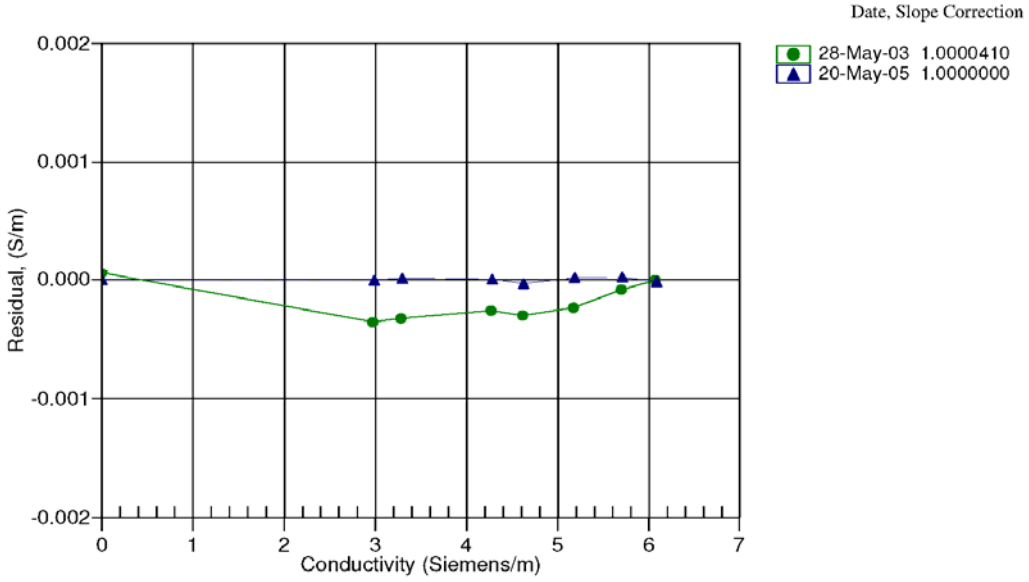
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88526	0.00000	0.00000
1.0000	34.9358	2.98520	8.24600	2.98520	-0.00001
4.5000	34.9152	3.29314	8.60954	3.29315	0.00001
15.0000	34.8729	4.27782	9.67971	4.27782	0.00001
18.4999	34.8637	4.62397	10.02848	4.62394	-0.00003
24.0000	34.8537	5.18357	10.56780	5.18359	0.00002
29.0000	34.8486	5.70701	11.04817	5.70703	0.00002
32.5000	34.8462	6.08062	11.37847	6.08060	-0.00002

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



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Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1892
CALIBRATION DATE: 20-May-05

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.19867779e-003
h =  5.98324001e-004
i =  3.73176956e-006
j = -1.91577213e-006
f0 = 1000.0
```

ITS-68 COEFFICIENTS

```
a =  3.64763921e-003
b =  5.86571504e-004
c =  9.09530398e-006
d = -1.91535637e-006
f0 = 2531.756
```

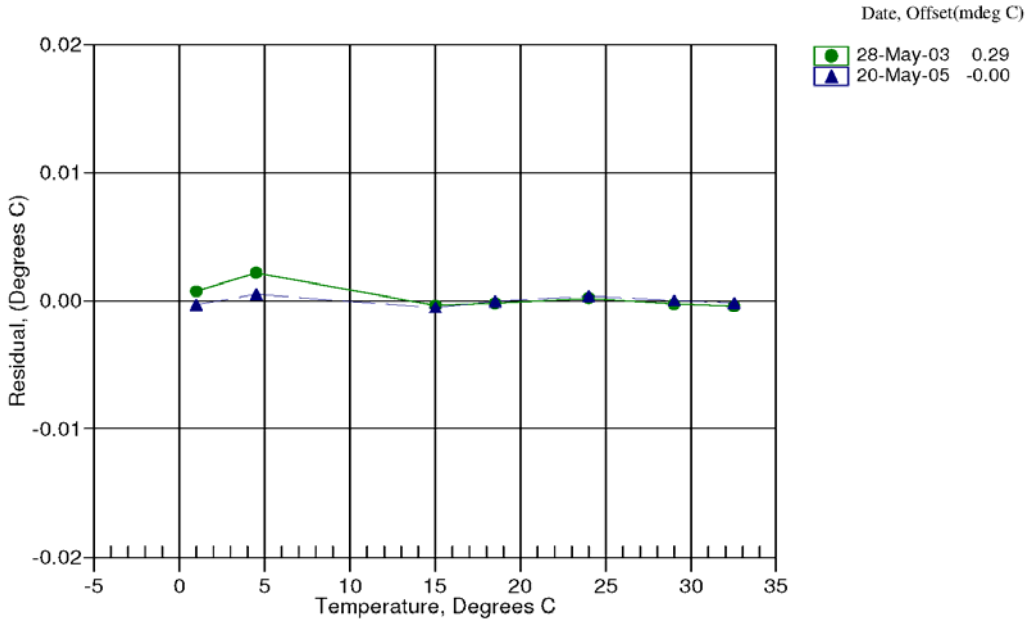
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2531.756	0.9997	-0.00029
4.5000	2738.579	4.5006	0.00054
15.0000	3430.251	14.9994	-0.00054
18.4999	3685.841	18.4999	-0.00001
24.0000	4113.985	24.0004	0.00040
29.0000	4532.248	29.0000	0.00006
32.5000	4842.083	32.4999	-0.00016

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature ITS-68 = $1/\{a + b[ln(f/f)] + c[ln^2(f/f)] + d[ln^3(f/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



Date:
Sep 22, 2004

Serial #:
SN:98308-092204

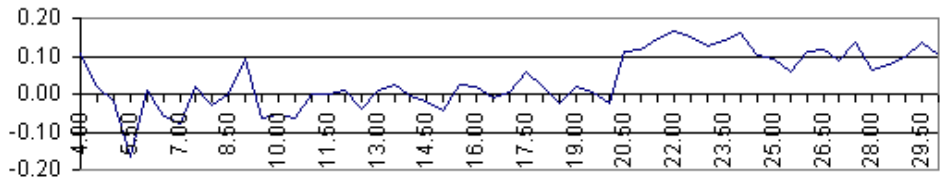
DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

STANDARD DEL GROSSO H^2O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL	TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5544.91	1421.73	0.11	17.50	1474.38	5745.84	1474.44	0.06
4.50	1423.90	5553.27	1423.92	0.02	18.00	1476.01	5751.90	1476.03	0.02
5.00	1426.15	5561.71	1426.13	-0.02	18.50	1477.62	5757.86	1477.59	-0.02
5.50	1428.38	5569.64	1428.21	-0.16	19.00	1479.21	5764.08	1479.22	0.02
6.00	1430.58	5578.68	1430.59	0.01	19.50	1480.77	5769.99	1480.78	0.00
6.50	1432.75	5586.71	1432.69	-0.06	20.00	1482.32	5775.78	1482.29	-0.02
7.00	1434.90	5594.83	1434.82	-0.08	20.50	1483.84	5782.11	1483.95	0.11
7.50	1437.02	5603.28	1437.04	0.02	21.00	1485.35	5787.86	1485.46	0.12
8.00	1439.12	5611.08	1439.09	-0.03	21.50	1486.83	5793.63	1486.98	0.15
8.50	1441.19	5619.09	1441.19	0.00	22.00	1488.29	5799.27	1488.46	0.16
9.00	1443.23	5627.24	1443.33	0.09	22.50	1489.74	5804.73	1489.89	0.15
9.50	1445.25	5634.36	1445.19	-0.06	23.00	1491.16	5810.06	1491.29	0.13
10.00	1447.25	5642.00	1447.20	-0.05	23.50	1492.56	5815.47	1492.71	0.14
10.50	1449.22	5649.47	1449.16	-0.07	24.00	1493.95	5820.83	1494.11	0.16
11.00	1451.17	5657.15	1451.17	0.00	24.50	1495.32	5825.80	1495.42	0.10
11.50	1453.09	5664.47	1453.09	0.00	25.00	1496.66	5830.90	1496.75	0.09
12.00	1454.99	5671.75	1455.00	0.01	25.50	1497.99	5835.82	1498.05	0.06
12.50	1456.87	5678.73	1456.83	-0.04	26.00	1499.30	5841.02	1499.41	0.11
13.00	1458.72	5685.98	1458.74	0.01	26.50	1500.59	5845.95	1500.70	0.12
13.50	1460.55	5693.00	1460.58	0.02	27.00	1501.86	5850.69	1501.95	0.09
14.00	1462.36	5699.78	1462.36	0.00	27.50	1503.11	5855.65	1503.25	0.14
14.50	1464.14	5706.52	1464.12	-0.02	28.00	1504.35	5860.07	1504.41	0.06
15.00	1465.91	5713.14	1465.86	-0.05	28.50	1505.56	5864.77	1505.64	0.08
15.50	1467.65	5720.03	1467.67	0.02	29.00	1506.76	5869.41	1506.86	0.10
16.00	1469.36	5726.56	1469.38	0.02	29.50	1507.94	5874.05	1508.07	0.13
16.50	1471.06	5732.91	1471.05	-0.01	30.00	1509.10	5878.37	1509.21	0.10
17.00	1472.73	5739.33	1472.73	0.00					



Odom Hydrographic Systems, Inc.
1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
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E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

Date:
Sep 22, 2004

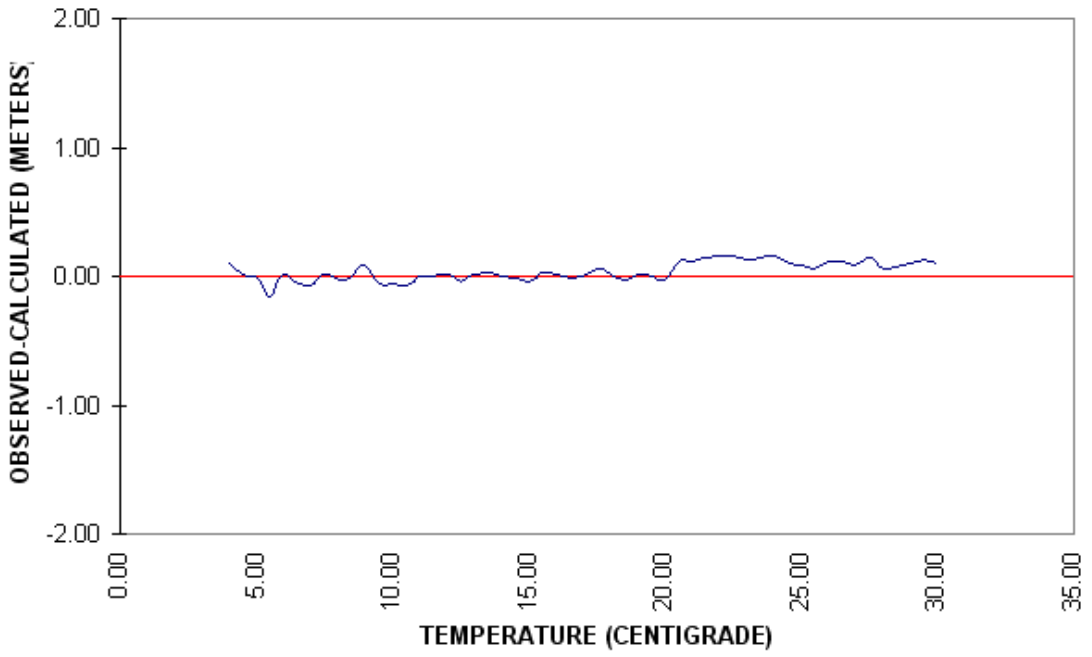
Serial #:
SN:dbp092204

DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

Burn these numbers to EPROM:	Gradient	**3359**
	Intercept	**330**



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