Appendix 2 Current Profile Measurements at Albert Head and Finnerty Cove

CRD CORE AREA WASTEWATER TREATMENT PRE-DISCHARGE MONITORING PROGRAM

CURRENT PROFILE MEASUREMENTS AT ALBERT HEAD AND FINNERTY COVE 26 MAY – 29 JUNE 2010

Prepared for:

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EXECUTIVE SUMMARY

ASL Environmental Sciences (ASL) was hired to collect oceanographic current data at the Albert Head and Finnerty Cove potential wastewater outfall sites. These data were required for the impact assessment, in particular to characterize the details of the local circulation in terms of vertical density and 3D current structure. The data would also be used to calibrate and validate a numerical model to simulate the dynamics of the outfall plume.

ADCP current profile data were collected at two locations at each potential outfall site. One ADCP was moored at the potential outfall site, the other further afield. Data were collected from May 27 to June 29 2010.

The acquired data sets were generally of excellent quality. Tidal currents dominated with maximum speeds typically 150 cm/s at the Albert Head Site, reducing to about 75 cm/sec at the Finnerty Cove site. There were two days of the Haro Strait data set where kelp appeared to have significantly reduced the range of the current profile data collected by the ADCP.

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1 INTRODUCTION

1.1 STUDY OBJECTIVES

The study objectives and data requirements are stated in the CRD Core Area Wastewater Treatment Pre-Discharge Monitoring Program RFP, Appendix A, page 3:

"Site specific baseline oceanographic data are needed to provide a detailed level of characterization of the receiving environment and a refined impact assessment as input to a Stage 2 EIS for the proposed wastewater outfalls. Oceanographic measurements will consist of three-dimensional (3D) current profiles and water levels as well as salinity, temperature, and depth profiles that will be used to characterize the details of local circulation in terms of vertical density and 3D current structure. The data will be applied to calibration and validation of a model to simulate the dynamics of the outfall plume for a range of discharges.

The Year 1 field program will involve the deployment of two bottom-mounted oceanographic tripods at each of the proposed outfall sites (Albert Head and Finnerty Cove) at approximately 50 meter depths for a period of approximately one (1) month. The four tripods will be deployed simultaneously (during the same operation) to economize on mobilization and demobilization costs and to facilitate synchronous measurements at the two sites. Each tripod will be equipped with a suitable RD Instruments 300 kHz Acoustic Doppler Current Profiler (ADCP) (or equivalent), a 200-meter pressure sensor, as well as temperature and tilt sensors, and an acoustically operated release. The ADCPs must provide 3D velocity estimates in vertical bins of between 0.5 meter and 4 meter (depending on requirements for vertical resolution velocity uncertainty to be determined at a later date) from approximately 1 meter above the seabed to just below the water surface at each location. Due to high levels of vessel traffic in these areas, subsurface acoustically released float and line are strongly recommended."

1.2 MEASUREMENT LOCATIONS

Two Acoustic Doppler Current Profiler (ADCP) moorings were deployed at each of the proposed outfall sites: Albert Head and Finnerty Cove. At each site one mooring was positioned near the potential outfall site, while the second was located some distance away in order to provide far field data for the modelling (Figure1-1 & Figure 1-2).

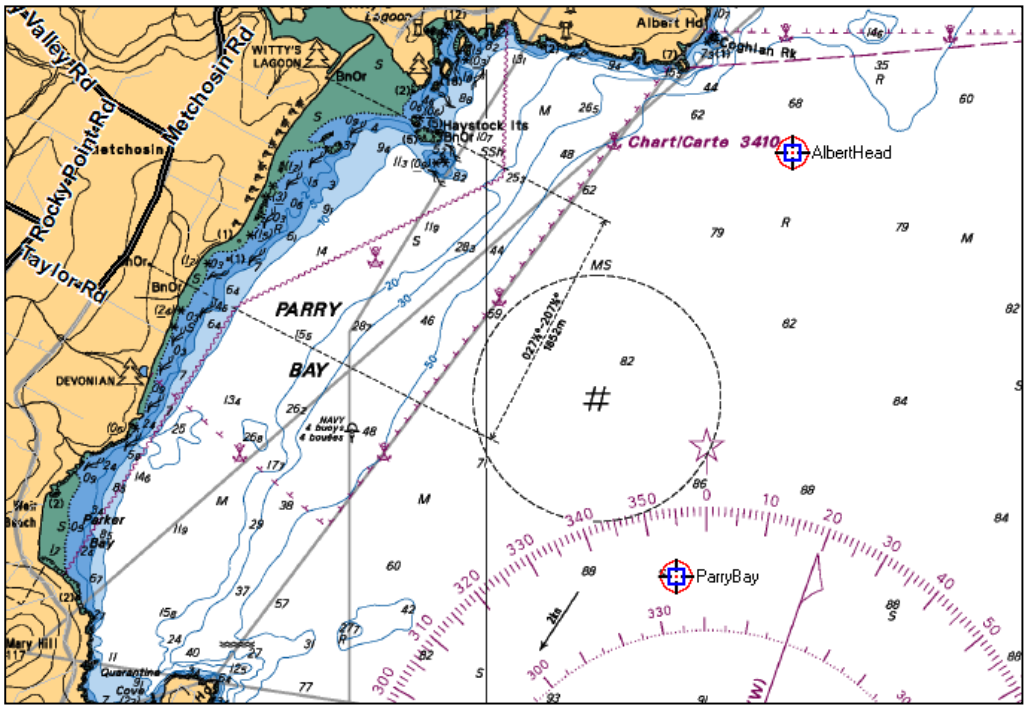

Figure1-1 Locations of the two Albert Head ADCP moorings.

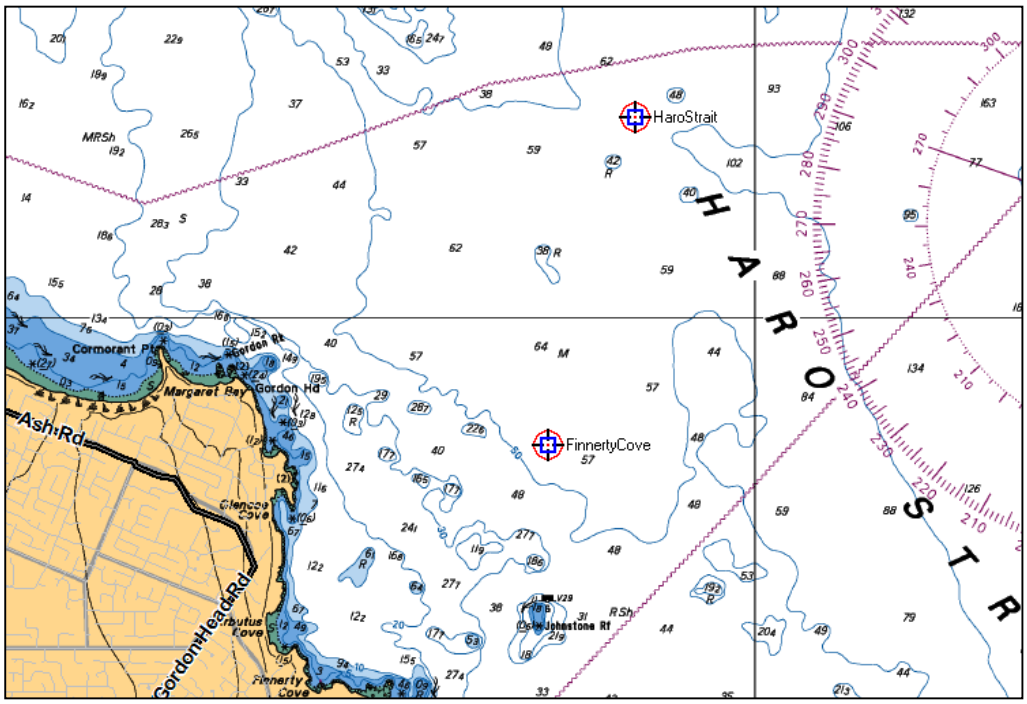

Figure 1-2. Locations of the two Finnerty Cove ADCP moorings.

2 DATA COLLECTION

2.1 ADCP CURRENT PROFILER INSTRUMENTATION

600 kHz TRDI ADCPs were used at the Finnerty Cove sites, while lower frequency 300 kHz ADCPs were used at the deeper Albert Head sites. Manufacturer's specifications for the ADCPs are included in the Appendix (ADCP Specifications).

2.2 ADCP MOORINGS

2.2.1 TAUT LINE MOORINGS – ALBERT HEAD

Taut-line moorings were used for the two ADCP moorings off Albert Head. The ADCP was suspended near bottom in a cage with four Viny floats. An acoustic release underneath the cage was used for recovery. The ADCP transducers were 2.2 m off bottom

Figure 2-1. Deployment of one of the taut-line ADCP moorings off Albert Head.

2.2.2 BOTTOM FRAME MOORINGS – FINNERTY COVE

The ADCPs off Finnerty Cove were moored using bottom frames (Figure 2-2). Ground lines lead off to acoustic release activated pop-up buoys used for recovery

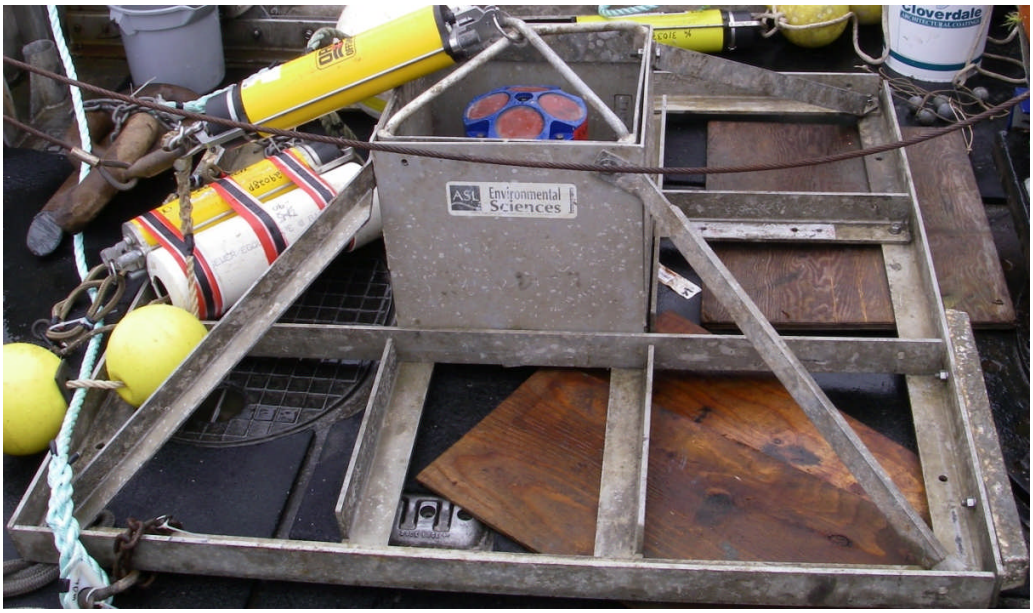

Figure 2-2. Bottom frame used for the ADCP current velocity measurements at the two Finnerty Cove sites.

2.3 ADCP CONFIGURATIONS

3D current velocity profiles were collected at each site. Each ADCP also measured water temperature (at the ADCP head) and water level via the pressure sensor. The ADCPs also record pitch, roll and heading. The vertical bin size for each profile was 2.0 meters and the high resolution sampling mode was used. All times are in local Pacific Daylight Time (PDT).

The actual configuration files used for the deployments are included in Appendix 4.2.

2.4 DEPLOYMENT / RECOVERY

The table below contains the details of the mooring deployments, including type of mooring, location, water depth, and times.

Table 1 Details of the mooring deployment locations, depths & times.

Site	Mooring Type	Lat/Long	Water Depth LLW (m)	ADCP Transducer depth (m)	Deployed (local time)	Recovered (local PDT time)
Albert Head	Taut-Line Mooring	48° 22.7106' 123° 28.1424'	71	69	10:28 May 27 2010	11:55 June 29 2010
Parry Bay	Taut-Line Mooring	48° 21.0027' 123° 28.8472'	88	86	09:58 May 27 2010	11:32 June 29 2010
Finnerty Cove	Bottom Frame	48° 29.4469' 123° 16.3517'	52.5	52	13:00 May 27 2010	13:45 June 29 2010
Haro Strait	Bottom Frame	48° 30.8746' 123° 15.7797'	57.5	57	13:40 May 27 2010	14:15 June 29 2010

2.5 VESSEL

The Marine Science Vessel "John Strickland" was chartered from The University of Victoria for the deployment and recovery of the moorings (Figure 2-3). Our thanks to Captain Ken Brown and crew for their very capable assistance with the mooring work.

Figure 2-3. Marine Science Vessel "John Strickland" http://web.uvic.ca/sciweb/images/stern.jpg

General specifications

Length overall: 16m (52')
Maximum beam: 4.5m (14'6")
Maximum draught: 2.6m (8')
Tonnage: 39.9
Propulsion: single screw, 275hp diesel
18" hydraulic bow thruster
Cruising speed: 8.5 knots
Maximum speed: 10 knots
Endurance: 10 days @ 12 hr/day
Generator: 35kva 220/110 VAC
Hull type: welded aluminum

3 PRELIMINARY REVIEW OF DATA QUALITY

The overall data quality is excellent. A small portion (2 days) of the Haro Strait data set has reduced range due to suspected kelp in the acoustic beams.

3.1 ALBERT HEAD; 300 KHZ ADCP #1089

The Albert Head data are of excellent quality. Pitch and roll are low and all other parameters are satisfactory. The flow here (as at all sites) was dominated by the tide with flood tide speeds up to ~100 cm/s, reduced somewhat during the ebb (Figure 3-1).

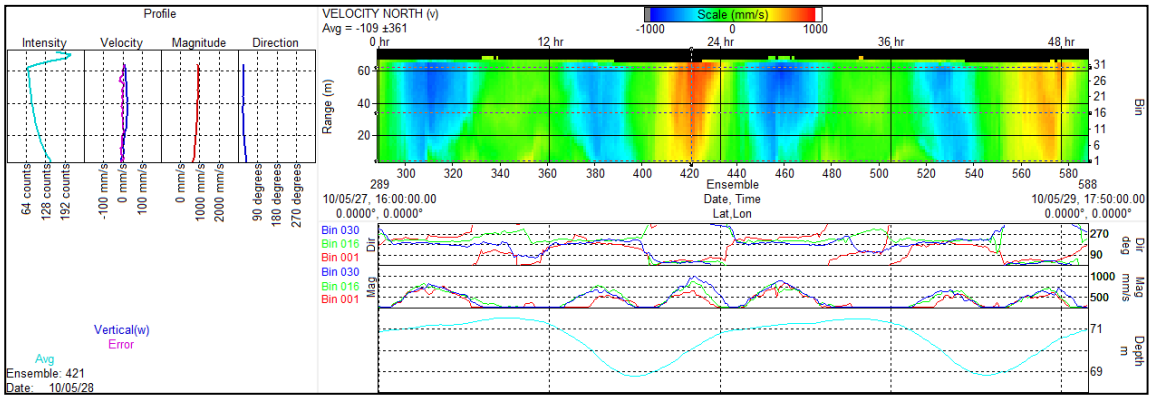

Figure 3-1. North south velocity contour plot for a 2-day period at Albert Head. Red is northerly flood current, while blue is southerly ebb. Also shown are profiles during flood, and time series for three levels.

3.2 PARRY BAY; 300 KHZ ADCP #8944

The Parry Bay data are of excellent quality as well. As at Albert Head, the flow here is largely tidal but at Parry Bay the current speeds are larger, up to ~150 cm/s (Figure 3-2).

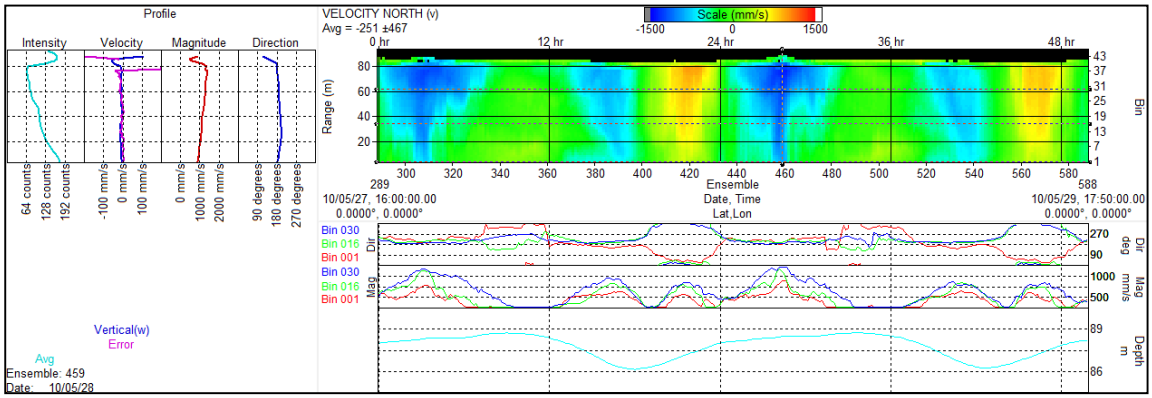

Figure 3-2. North south velocity contour plot for a 2-day period at Parry Bay. Red is northerly flood current, while blue is southerly ebb. Also shown are profiles during an ebb, and time series for three levels.

3.3 FINNERTY COVE; 600 KHZ ADCP #2634

The Finnerty Cove data are of excellent quality. Figure 3-3 shows the north-south velocity component over a 48 hour period. Compared to Albert Head, current speeds are less overall, approximately 75 cm/sec maximum, and note that the flood current is strongest in the lower portion of the water column (Figure 3-3).

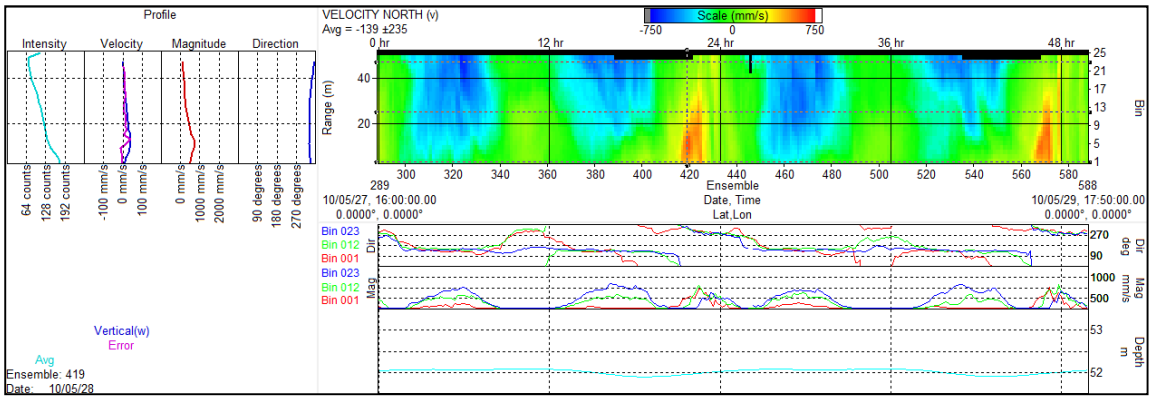

Figure 3-3. North south velocity contour plot for a 2-day period at Finnerty Cove. Red is northerly flood current, while blue is southerly ebb. Also shown are profiles during a flood, and time series for three levels.

3.4 HARO STRAIT; 600 KHZ ADCP #2610

The Haro Strait data are mostly of excellent quality. Figure 3-4 shows the north-south velocity component over a 48 hour period. Maximum current speeds are approximately 75 cm/sec with variation in the vertical (shear).

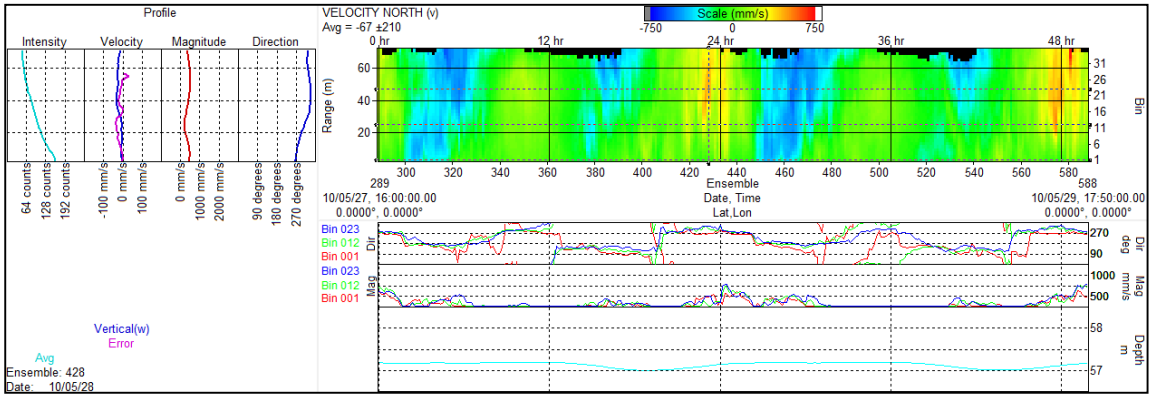

Figure 3-4. North south velocity contour plot for a 2-day period at the Haro Strait site. Red is northerly flood current, while blue is southerly ebb. Also shown are profiles during a flood, and time series for three levels.

The ADCP range was reduced during the June 6-8 period (Figure 3-5). We suspect this was due to kelp getting in the path of the acoustic beams.

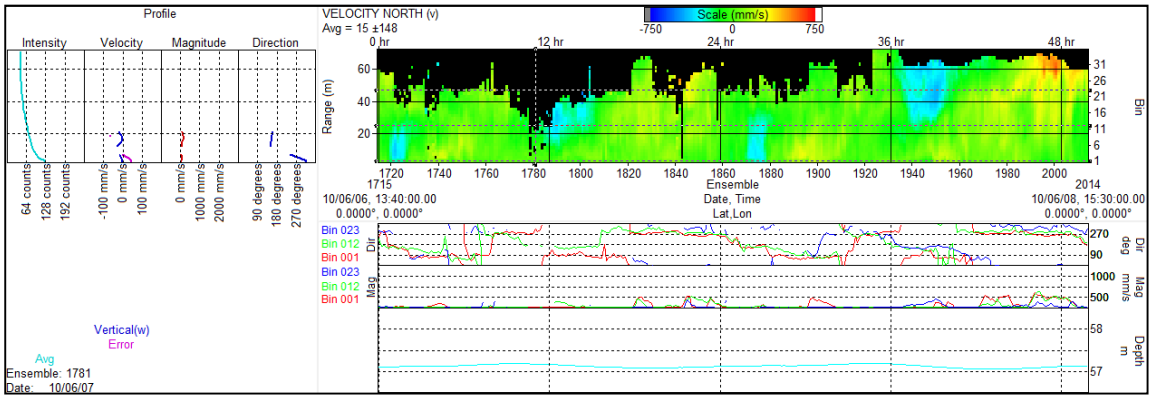

Figure 3-5. A portion of the ADCP data June 6-8 when the range was reduced, probably due to kelp getting in the acoustic beam path(s). Note the reduced echo intensity in the profile in the window on the left side.

4 APPENDIX

4.1 ADCP SPECIFICATIONS

Water Profiling

Depth Cell Size[a]	Typical range 12m[b] 1200kHz		Typical range 50m[b] 600kHz		Typical range 110m[b] 300kHz	
Vertical Resolution	Range (m)	Std. Dev.[c] (mm/s)	Range (m)	Std. Dev.[c] (mm/s)	Range (m)	Std. Dev.[c] (mm/s)
0.25m	11	182				
0.50m	12	66	36	182	see (a)	
1.0m	14	30	41	66	86	182
2.0m	15[b]	18	47	30	99	66
4.0m	see (a)		52[b]	18	112	30
8.0m					126[b]	18

Notes: a) user's choice of depth cell size is not limited to the typical values specified, b) longer ranges available, c) BroadBand mode single-ping standard deviation (Std.Dev.)

Profile Parameters

Velocity accuracy:
- 1200, 600: ± 0.25% of the water velocity relative to the ADCP ± 2.5mm/s
- 300: ± 0.5% of the water velocity relative to the ADCP ± 5 mm/s

Velocity resolution: 1mm/s
Velocity range: ± 5m/s (default): ± 20m/s (maximum)
Number of depth cells: 1-128
Ping rate: 2 Hz (typical)

Standard Sensors

Temperature (mounted on transducer)
- Range: -5° to 45°C
- Precision: ± 0.4°C
- Resolution: 0.01°

Tilt
- Range: ± 15°
- Accuracy : ± 0.5°
- Precision: ± 0.5°
- Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)
- Accuracy: ± 2°[e]
- Precision: ± 0.5°[e]
- Resolution: 0.01°
- Maximum tilt: ± 15°

Note: e) @ 60° magnetic dip angle, 0.5G total field

4.2 ADCP CONFIGURATION FILES

4.2.1 ALBERT HEAD; 300 KHZ ADCP #1089

```
CR1
CF11101
EA0
EB0
ED700
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF176
WN54
WP150
WS200
WV175
TE00:10:00.00
TP00:04.00
TF10/05/25 16:00:00
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 307200
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Ice Track         = NO
;Surface Track     = NO
;Beam angle        = 20
;Temperature       = 7.00
;Deployment hours  = 960.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]  = 996
;Saved Screen      = 2
;
;Consequences generated by PlanADCP version 2.05:
;First cell range  = 4.20 m
;Last cell range   = 110.20 m
;Max range         = 91.45 m
;Standard deviation = 0.57 cm/s
;Ensemble size     = 1234 bytes
;Storage required  = 6.78 MB (7107840 bytes)
;Power usage       = 355.13 Wh
;Battery usage     = 0.8
```

4.2.2 PARRY BAY; 300 KHZ ADCP #8944

```
CR1
CF11101
EA0
EB0
ED900
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF176
```

WN54
WP150
WS200
WV175
TE00:10:00.00
TP00:04.00
TF10/05/25 16:00:00
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 307200
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = NO
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Ice Track = NO
;Surface Track = NO
;Beam angle = 20
;Temperature = 7.00
;Deployment hours = 960.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 996
;Saved Screen = 1
;
;Consequences generated by PlanADCP version 2.05:
;First cell range = 4.20 m
;Last cell range = 110.20 m
;Max range = 91.56 m
;Standard deviation = 0.57 cm/s
;Ensemble size = 1234 bytes
;Storage required = 6.78 MB (7107840 bytes)
;Power usage = 355.11 Wh
;Battery usage = 0.8

4.2.3 FINNERTY COVE; 600 KHZ ADCP #2634

CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF88
WN25
WP150
WS200
WV175
TE00:10:00.00
TP00:04.00
TF10/05/25 16:00:00
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 614400
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = NO
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Ice Track = NO
;Surface Track = NO
;Beam angle = 20
;Temperature = 7.00
;Deployment hours = 960.00

;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 996
;Saved Screen = 1
;
;Consequences generated by PlanADCP version 2.05:
;First cell range = 3.08 m
;Last cell range = 51.08 m
;Max range = 47.72 m
;Standard deviation = 0.29 cm/s
;Ensemble size = 654 bytes
;Storage required = 3.59 MB (3767040 bytes)
;Power usage = 209.87 Wh
;Battery usage = 0.5

4.2.4 HARO STRAIT; 600 KHZ ADCP #2610

CR1
CF11101
EA0
EB0
ED470
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF88
WN35
WP150
WS200
WV175
TE00:10:00.00
TP00:04.00
TF10/05/25 16:00:00
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 614400
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = NO
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Ice Track = NO
;Surface Track = NO
;Beam angle = 20
;Temperature = 7.00
;Deployment hours = 960.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 996
;Saved Screen = 2
;
;Consequences generated by PlanADCP version 2.05:
;First cell range = 3.08 m
;Last cell range = 71.08 m
;Max range = 47.76 m
;Standard deviation = 0.29 cm/s
;Ensemble size = 854 bytes
;Storage required = 4.69 MB (4919040 bytes)
;Power usage = 235.79 Wh
;Battery usage = 0.5