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NSWC CRANE
5090.3a

Final
Field Sampling Plan
for
RCRA Ground Water Monitoring
at the
Ammunition Burning Grounds, Old Rifle Range, Demolition Range, and Old Jeep Trail
Naval Surface Warfare Center Crane Division
Crane, Indiana

VOLUME II - APPENDIX A AND APPENDIX C

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0038

September 1999

APPENDIX A

BORING LOGS AND MONITORING WELL CONSTRUCTION SHEETS

APPENDIX A.1

AMMUNITION BURNING GROUNDS

Hole No. WES-3-B2-86

DRILLING LOG	DIVISION U.S Navy	INSTALLATION NWSC, Crane Ind.	SHEET OF SHEETS

1. PROJECT: Hydrogeologic Studies, A86
2. LOCATION (Coordinates or Station): NWSC Boundry, Little Sulphur Creek
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): 3-B2
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.6
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 15.8'
10. SIZE AND TYPE OF BIT: 2" split spoon
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 6/27/87 COMPLETED 6/27/87
17. ELEVATION TOP OF HOLE: 502.15
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF ~~INSPECTOR~~ Geologist: R. W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0–3.0		Clayey-Sdy silt w/ occ SS pebbles + cobbles, d Br, moist		1 (0–1.0), 2 (1.0–3.0)	Samples were taken w/a 2" dia split spoon by pushing w/hydra. Cleaned hole w/ 8" dia flight auger. Samples were put in Qt mason jars.
	3.0–6.0		Below 3' cobr is y Br, increase in SS pebbles + wet		3 (3.0–4.5), 4 (4.5–6.0)	
	6.0–7.5		Gravelly silty sand to silty sandy Gravel, Br, Gravel is friable SS, subrounded + oxidized. Zone is saturated		5 (6.0–7.5), 6 (7.5–7.8)	
	7.8–15.8				7	No 7-8+9 Spls taken w/ folding auger.

PROJECT | HOLE NO.

Hole No. WES-3-B2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-B2	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10			10.3		
	11			8		
	12			12.3		
	13			9		
	14			14.3		
				10		
				14.6		
	15		(Elwren fm) Shale, rBr + Gr Shale.	11		
	16		Bot Depth - 15.8			

PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-82	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-B2-86 (Little Sulphur Creek Alluvium)			Date well screen was set: 6/27/87
504.65						
502.15			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen – ~5.0'
			3.0'			
			Bentonite Pellets			
			5.0'			
						Teflon pipe – 4.6 to 15.6'.
			Filter Pack			
			9.6'			
			Well Screen			
			14.6'			
			Trap			
			15.6'			
			15.8' Boring Depth			

HOLE NO.

Hole No. WES-C2-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Grane In	SHEET 1 OF 14 SHEETS

1. PROJECT NWSC Groundwater Study	10. SIZE AND TYPE OF BIT HQ wireline
2. LOCATION (Coordinates or Station) (ABG) Burning Grounds), Geologic Study	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-C2-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES 10
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 8.5'	16. DATE HOLE: STARTED Aug 28 1986; COMPLETED Sept 4, 1986
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE ~ 581.5'
9. TOTAL DEPTH OF HOLE 132.7'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silt (mL) dBr, clayey, w/ small ss frags, becomes sdy w/ depth, firm, moist in upper 1½' becoming sli-moist w/ depth.			Drilled from 0.0 to 10.2' with an 8" dia. folding auger.
	1					
	2					
	3					
	4					
	5		Silt (mL), drBr + yBr, sdy, num ss frags w/ Fe crusting (rounded-angular), firm, sli-moist-dry.			
	6					
	7					
	8					
	9		Silty Sand, (soft ss) (Big clifty ss), lyTan, vf, firm, oxidized weathered			
	10					

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Hole No. WES C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Grades to SS			Set Temporary Surface Casing to ~10.0.
			Sandstone, ly Tan w/ lgr lens, vf uniform grain, th bd w/ shallow cross bd'ing + ripples (bed dip 8-10°) oxidized, mod hard, friable, blk min stain + Limonite along jts.	Run 1		Started coring w/ HQ wireline bbl at 10.2' w/clear water.
	11					Lost all water return at ~11.5
	12			4.8 / 5.3	Rec. / Run	
	13			(-0.5)		
	14					
	15			15.5	Run 2	
	16					
	17		Concentration of Blk Fe grains.			
	18		Thin clay lens	8.2 / 8.9		
	19		drBr, highly oxidized zone (Limonite concentration) soft rk.	(-0.7)		
	20					

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Hole No. WES-CC-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS, (cont)			
		85	(20.3 - 22.2') slightly coarser, 1 Br oxidized num Fe grains. (vf-m)			
	21					
		5 / 45	Joints have Blk min stains + limonite coating, generally rough + planar to sli irregular.			
	22	20				
		10	Color becomes 1 tan, Gr below 22.2 - 25.0'			
	23					
	24			24.4 Run 3		
		18				
	25		(25.0 - 26.4') slightly coarser (vf-m) 1-d Br num oxidized Fe grains, 1 Br + d Br			
		10 / 18				
	26					
	27	10		8.1 / 9.1		
			Color 1 tan-Gr below 26.4' to ~32.5'			~27 to 28' (Projected Top of Beech Creek Ls prior to Solutioning processes. Big Cliff SS below ~28' has settled into Solution Cavities in upper Beech Creek Ls
	28	10 / 10 / 15		(-1.0')		
	29	60 / 10				
	30					

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Hole No. WES-77-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		SS, (cont) (Big clifty)			
	31		Blk min stn along Jts.			
	32					
	33		open (clay filled?)			
				33.5' / Run 4		
	34		(33.5-36.5') SS is dBr + lBr, vf-m grain w/ minor coarse grains num oxidized Fe grains + small Fe nodules up to ¼" size.			
	35		Lim + blk min stn along Jts.			
	36					
	37		Note: The core loss zone represents solutioning in the upper Beech creek Ls. The overlying Big Clifty SS has dropped down, or settled into the cavities created by the solutioning. Joints and bedding planes in the lower Big Clifty SS have opened in proportion to the degree of settlement.	3.0/8.0' (-5.0)		
	38					
	39					
	40					

PROJECT HOLE NO.

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Hole No. WES-CZ-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40					
	41			41.5 Run 5		8/29/86 water level – 36.0'
	42					
	43					
	44			3.0 / 6.0'		
			solution surface ?			
	45		Limestone (Beech Cr. - Lower zone) m br Gr & wea in top 1½', ydGr & unwea in bot 1½', f-m crystalline, v hard, fossiliferous, slightly shaly w/ pyrite inclus at contact w/ underlying Elwren shale. Joints are coated w/ white calcareous & lim stn.	(3.0')		– Beech Creek Ls. (Lower Zone)
	46					
	47		Pyrite crystals at contact ?	47.5 Run 6		Top Elwren fm 47.5'
	48		Shale (Elwren fm) dgr Gn, mass-thin bd, mod hard, crumbly-flakey, occ s'sides			
	49			3.1 / 4.7 (1.6)		
	50					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WEL-C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Shale (cont.)			In an effort to set 4" casing - ran a 5 3/4" RR Bit to ~ 45.0'. Rods broke off at top of 10' Guide above bit. Retrived tools from hole and went back in with a 6 3/4" RR Bit. Bit was "grabbing" so bad in cavity zone that the possibility of breaking off in hole over-shadowed continuing w/RR Bit. Using a diamond shoe on end of 6" casing - reamed hole to 54.8' and set 4" PVC casing to 54.8'. Sealed casing in the Elpuren Sh w/ Grout. 9/3/86 - started back coring w/HQ wireline bbl
	51					
	52		Shale, dgrGn w/alter drBr layering, thl bd, platey, hard	52.2' Run 7		
	53			2.1/2.6		
	54			-0.5		
			num drBr veinlets (like healed frac's) in Gn Sh	54.8' Run 8		
	55		Claystone, drBr, mass, hd, blocky, s'sides dip ~5°.			
	56		Shale, dgrGn, mass, highly frac w/ occ angular GnGr Ls(?) and drBr claystone inclus, hard, blocky, (zone has somewhat of a brecciated appearance)			Getting most of water return thr. 4" casing.
	57		mottled w/ drBr clst.	7.9/8.3		
	58			-0.4		
	59					
	60		See next sheet.			

PROJECT | HOLE NO.

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Hole No. CWES-C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Shale dGrGr, w/alter lens + partings of mGr, vf silty sandstone (v thinly laminated sh + SS), hard			
	61					
	62					
				62.7		Pull depth
	63			63.1		
				Run 9		
			Top Reelsville fm 63.8'			Top Reelsville fm 63.8'
	64		Limestone, v hard, brittle olive grBr, sdy, ferruginous, lGr, vf granular-crystalline sdy(?). alter olive grBr + lGr Ls (as above), cross bedding (Breaks appear fresh)			
	65					
	66		lGr Ls (as above)	10.4 / 10.0		
			(66.4-70.0) Shale dGr laminated w/mGr silty ss/Ls. (Similar to above), small angular Ls frags are included in the top 0.3'.	+0.4		
	67					
	68					
	69					
	70					

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Hole No. WES-C2-B6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 18 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		(70.0 - 73.1) Sandstone, mgr Br, fine grained, mass w/ num gr Gn shale partings & flattened inclusions, v hard, brittle (Jt's are rgh, irreg, part) filled w/ Gr clay			
	71		Ls, lGr, w/ occ Gn sh pts, v hard, brittle			
	72		Ls (as above)			
	73		← Top of Sample fm	73.1		Top of Sample fm 73.1'
			Shale, dGr, thbd w/ num to occ lGr, v fine thin SS / Ls lens, hard, platey - flakey	Run 10		
	74					
	75					
	76			10.0 / 10.0		
	77					
	78					
	79		Ls, lGr, v fine, granular, brittle, v hard, occ Sh pts.			
	80					

PROJECT | HOLE NO.

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Hole No. WES-C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Shale (Cont.)			
	81					
	82					
	83			83.1 Run 11		Pull 9/4/86
	84					
	85		Ls, olive Gr, v hd, v Fine			
	86					
	87			8.8'/10.0		
	88			100%		
	89					
	90					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Shale (Cont.)			
	91					
				91.9		Pull depth
	92					
				93.1		
	93			Run 12		
	94					
	95			100%		
	96			10.1 / 9.4		
				(+0.7 +0.5 +1.2)		
	97					
	98					
	99					
	100					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C2-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Shale (cont)			
	101		Sandstone, mGr, fine grained (uniform rounded qtz sd grains), mum vdGr-Blk wavey shale partings, hard, sli friable. (101.0-114.5')	102.0 / 102.5 Run 13		Pull depth
	102					
	103	S S				Good water Ret.
	104	60	It's rough, irregular, Fresh (v tight insitu)	100%		
	105	80				
	106		lighter Gr + less friable SS than above and below, calcareous (sdy Ls?)	10.4 / 10.3 (+0.1) +0.4 (+0.5)		
	107					
	108					
	109	70				
	110					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WEK-12-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		Sandstone (cont.)			
	111	6	Fresh			
	112			112.4		Pull depth
				112.8		
				Run 14		
	113	8	Fresh			
	114					
			Shale, dGr, thbd, mod hard, "earthy"			
	115					
				100%		
	116			10.4 / 10.0		
			Alter. Ls lens up to 1" thick			
			Clay v/Gr, soft	+0.4		
	117		Limestone, l-m grBr, Coarse grained oolitic (?) v hard, brittle.			— Top of Beaver Bend Ls - 117.0'
	118					
			dGr Sh lens			
			Limestone, Gr-brGr, fine-med grained-crystalline, oolitic (?), v hard, brittle, occ well developed stylolites			
	119					
	120					

PROJECT HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. CUES-C2-26

DRILLING LOG	DIVISION	INSTALLATION	SHEET 13 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120		Ls (cont.)			
						Loosing 50% of drill water
	121					
	122	90	partially open, light stn along jts			
		80		122.8		
				Run 15		Fbrge
	123					
	124					
	125	5°	- Lost all drilling water that was remaining at this depth			- Lost all drill water
	126					
	127	15				
	128					
	129					
			Top of Bethel fm			Top of Bethel fm. 129.5'
	130		Shale, dGr, th bd w/ num vf ss pts + thin			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-CZ-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 14 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED 9/4/86
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130		disc shaped lens, hard, platey.			
	131					
	132					
	133		Bottom of hole 132.7'			water level 9/5/86 68.7' (water in Beaver Bend Ls)
	134					
	135					
	136					
	137					
	138					
	139					
	140					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C2P2-86 (Beech Creek Ls)			Date well screen was set: 10/29/86
583.6			+2.5			
581.1			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen - 36.0'
			14.0'			
			Bentonite Pellets			Teflon Pipe between 27.6 to 49.0'
			17.0'			
			Filter Pack			
543.1			38.0'			
			Well Screen			
533.1			48.0'			
			Trap			
			49.0'			
			49.0' Boring Depth			

PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane, In	SHEET 1 OF 15 SHEETS

1. PROJECT: NWSC Groundwater Study
2. LOCATION (Coordinates or Station): (ABG) (Burning Grounds), Geologic Stud.
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-C3-86
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.0
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 150.7'
10. SIZE AND TYPE OF BIT: HQ wirline Corn 86
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES: 11
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 9/5/86 COMPLETED 9/13/86
17. ELEVATION TOP OF HOLE: ~ 598.5' (Topo map)
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Clayey Silt (ML), Tan, w/small to large rk frags, v firm, moist			Drilled from 0.0 to ~8.0' w/ 8" folding auger; 8.0 to 17.2 w/ pitcher sampler using water, 17.2 to 18.5 w/ 6" RR bit; + 18.5 to Bot. w/ HQ wire line core bbl using water. (Bot Depth 150.7')
	1					
	2					
	3		Silty Clay (CL) olive Br - Br, w/rk frags, v.firm, moist			
	4					
	5					
	6					
	7		Silty Clay (CL), rBr, v firm, moist			
	8		Clay (CL) rusty Br, w/ abundant rk frags (mostly sub-rounded to angular wea SS frags), v firm, moist.			
	9					
	10					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Clay w/rk frags (cont.)			
			← Base of stream cut.			
	11		Clayey Sand (SC) rusty Br & lGr (mottled) mass, firm, moist, highly wea SS frags occur w/depth. (Zone is weo residual on top of Big clifty sandstone)			
	12					
	13					
	14		Sand to soft sandstone, (highly wea SS) w/ mod hd SS frags, oxidized, vf-f, moist, yBr.			
	15		Big clifty SS			
	16					
	17		✓ Top of Trio Rk (17.2')			
			Sandstone, lyBr, vf-f, uniform grained rounded qtz sd, tk bd, hard, friable, oxidized, shallow cross bedding + ripples.			Set 6" dia PVC surface casing to 18.5'.
	18		(weak sandstone)	Run 1		9/8/86 started coring w/ HQ wire line bbl, using water.
	19		Big clifty SS			
	20					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 15 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont.)			
	21					
	22					
		40		9.5 / 9.5	Rec. / Run	
		45				
	23					
		20	Jts are tight, lightly stn sli rough, planar			
		20				
	24	15				
		20				
	25					
	26					
	27					
	28			29.0 / Run 2		
	29					← Zone should correlate w/ 18.2-19.3 in WES-C2-86
	30		← Br. highly oxidized + lim stn; occ Fe nodules; softer than above & below			

PROJECT HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		SS (cont)			
	31					good water return
	32	15, 20, 30				
	33			33.2 Run 3		
	34	10, 10				
	35	30				
	36		← 35.7' probable high ground water level in zone confined above the Elwren Shale fm.			
	37		(35.7-42.5') SS is pale Br + less oxidized than above	10.2 / 10.2		
	38					
	39					
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (Cont.)			
	41	0				
	42	0				
	43	0				Flange
	44	60	dBr coarser grained oxidized num small oxidized Fe grains (Base of Big Cliffy SS) 45.1'	R44.4		
	45	5°	dGr shale lens			- Top of Beech Creek Ls. - 45.1'
	46		slight solutioning at Ls contact. (open jt) Limestone (Beech Cr) l-m grBr, m-coarse crystalline, mass, fossiliferous, v hard, v dense, Brittle,			
	47	8 5	Open jts along bedding have tan-yBr clay coating or stains (oxidized)	10.0 / 10.0		Losing slight amount of drill water
	48	70 5	Tight			
	49	70	Tight			

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-P3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Ls (cont.)			
	51		Tan clay stn			
	52					
	53		Tan clay along Jt.			
			53.4' - probable low ground water level (?) in zone above the Elwren shale fm. No oxidation along Jts below 54.4'	53.4 Run 5		good water Return
	54					
	55		Limestone Below 53.1' is dGr, fm crystalline, mass, fossiliferous w/ occ to num Blk wavey shaley pts and or poorly to well formed styolites (similar to above otherwise)			
	56			9.9/10.0		
	57			0.1		
	58					
	59					
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60	0	Ls (Cont.)			
		3				
	61					
	62					
		5				
	63			63.3 / 63.4		Pull Depth
				Run 6		
	64					Good water Return
		5	Num dgrGn sh inclus in bot 0.5'.			
	65		Base Beech Creek Ls (65.5') / Elwren Fm (Top)			Top Elwren fm - 65.5'
	66		Shale dgrGn, thbd, mod hd, highly frac. (random) w/ s'sides.			
	67			10.1 / 10.6		
	68		drBr + grGn mottled			
	69					
	70		Shale or Claystone drBr mass, hard			

ENG. FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WEK-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Blocky - flaky, num random frac. w/s'sides			
			Shale (cont)			
	71					Reamed hole w/6" RR Bit to 71.5' + set 4" PVC Casing Grouted the casing w/ seal set 6' into the Elwren Sh.
	72					
	73					
				73.4 / Run 7		Flange 9/11/86
	74					
	75					Good water Return
	76					
	77		Shale, dgrGn, mass at top w/occ sub-rounded to sub-angular Gr Ls (?) inclus ranging From 3/4" to >2" size. Grades into th bd w/depth, mod hard-hard,	9.7/10.0		
	78					
	79		Thinly laminated w/silty sand pts + lens below ~79', shallow cross bd + ripples.			
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Shale (cont)			
	81		Sandstone, mgr Br, vf grained, w/gr Gn shaley pts, hard, cross bd, shallow ripples.			
	82		Base of Elwren			Top of Reelsville - 82.3'
			Top Reelsville fm. 82.3' Limestone, lgr Br, sdy, f granular - crystalline, v hard, brittle, cross bd (?)	83.2' 83.4 Run 8		Pull depth.
	83					
	84		num wavey Gn shaley pts.			
	85		conglomeratic - fossiliferous (?)			good water return.
	86		Shale, vd gn Gr, mass th bd, blocky-flakey, occ ls inclus up to ~3/4" size, num random frac w/s'sides, hd - mod hd.	10.2/10.0		Note from 85.4 to 85.9' frac's are coated w/ Blk Crude oil.
	87		laminated w/lGr ss lens.			
	88		laminated w/lGr ss lens			
	89					
	90		Sandstone, mGr, vf grained, w/num dGr			

ENG FORM ... PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		wavey shale pts, shallow cross bd, hard, brittle			
	91		Base of Reelsville			Top of Sample fm - 91.4'
			Top Sample Fm (91.4')			
	92		Shale, vdGr-Blk, th bd, w/occ to num thin lGr ss lens and pts (from 91.4 to 99.0'), hard platey-blocky, occ pyrite inclus.	93.4 Run 9		
	93					
	94		- Ls len			
						Good water Return
	95					
	96			9.7/10.0		
	97			-0.3		
	98					
	99		From 99.0' to 110.2' occ thin ss lens,			
	100					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Shale (Cont.)			
	101					
	102					
	103			103.1		Full depth
				103.4		
				Run 10		9/12/86
	104					
						Good water Return
	105					
	106					
	107			10.3 / 10.0		
				+0.3		
	108					
	109					
	110					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		Sh (Con't) (110.2 to 111.3) - num SS/LS lens			
			-LS lens			
	111					
	112					
	113			113.4		
				Run 11		
	114		(113.5 to 120.5') num 1Gr SS lens + pts.			
	115					
	116					
				10.2 / 10.2		
	117					
	118					
	119					
	120					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 13 OF 15 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120		Shale (cont.)			
	121		Sandstone, lt-m grBr, vf-f grained, w/num vdGr wavey shaley pts, cross bd, hd sli friable - brittle.			
	122					
	123		calc SS / sdy Ls, v hd, brittle, occ fossils, lgrBr.	123.6 / Run 12		
	124					
	125					
	126					
	127		Shale, Blk, th bd w/ lGr ss lens + pts, occ pyrite inclus, hd, plaky - flaky	9.7 / 10.0		
	128			~~0.3~~ 0.1		0.1' core ground away in shale
	129					
	130		See Next sheet			

PROJECT | HOLE NO.

ENG FORM 1836

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130		Sandstone, 1-m gr Br, (as above)			
	131					
	132					
	133		Shale, dGr-Blk, th bd, hd, platey, flakey	133.4 / 133.6		Full Depth
	134					water return left a Blk "earthy", "flat" film on water in mud pan noticed in lower zone of shale; possibly near top of Ls.
	135					
	136			10.2 / 10.0		
	137		Base of Sample fm			Top of Beaver Bend Ls - 137.2'
	138		Limestone (Beaver Bend fm), m gr Br, f-m granular-crystalline, fossiliferous, occ stylolites v hard, v dense, Brittle, Joints along bding as shown are most probably open	100.2		loosing ~25% of drill water.
	139					Lost all drill water at ~139.5'
	140					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C3-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 15 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140		Limestone (Cont.)			
	141					
	142	o				
		o				
	143	o		143.6	Run 14	
	144					
	145			3.7/3.7		
	146					
	147		Ls has num shaley pts/or num stylolites containing insoluble residue (Blk)	147.3	Run 15	Blocked
	148	o		1.7/1.7		
	149		Bot of Beaver Bend.	149.0	Run 16	Blocked Top of Bethel Fm - 149.0'
			1 Gr soft clay			
	150		Shale, v dgn Gr, sdy in top 0.5', mass, num random frac, hd, blocky-flaky	1.7/1.7 150.7		Bot. Depth - 150.7'

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C3-86			Date well screen was set: 9/13/87
600.3			+2.5			
597.8			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen - 85.2'
			133.0'			
			Bentonite Pellets			Teflon pipe between 134.0 & 150.0'
			136.5			
			Filter Pack			
458.8			139.0			
			Well Screen			
448.8			149.0			
			Trap			
			150.0			
			150.7 Boring Depth			

PROJECT HOLE NO.

Hole No. WES-3-B4

DRILLING LOG	DIVISION US Navy	INSTALLATION Nwsc Crane Ind.	SHEET 1 OF 2 SHEETS

1. PROJECT: Hydrogeologic Studies, ABG
2. LOCATION (Coordinates or Station): NWSC Boundry, Little Sulphur Creek
3. DRILLING AGENCY:
4. HOLE NO. (As shown on drawing title and file number): 3-B4
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.5
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 16.5
10. SIZE AND TYPE OF BIT: 2" split spoon + Auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: ; UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 6/30/87; COMPLETED 6/30/87
17. ELEVATION TOP OF HOLE: 503.77
18. TOTAL CORE RECOVERY FOR BORING %:
19. SIGNATURE OF INSPECTOR: R. W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Sandy silt w/ ss pebbles + cobbles, dBr, loose to mod firm, moist, becomes more sdy w/depth + more wet (below ~4')	1		Samples were taken w/a 2" splitspoon or w/ 8" folding auger where spoon would not penetrate. Samples were put in qt jars.
	1			1.5		
	2			2		
				3.0		
	3			3		
	4			4.5		
	5			4		
	6		Sandy silt, drBr, w/ss grit + pebbles, soft, v moist to wet.	6.0		
				5		
	7			7.5		
	8			6		
	9			9.0		
	10		Silty sand Gravel to gravelly silty sand	7		

PROJECT | HOLE NO.

ENG FORM 1836

Hole No. WES-3-84-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-84	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Saturated; gravel is subrounded to rounded, friable, oxidized SS, ranging from pea size to Cobble size, dy Br		10.5	
	11				8	
	12				12.0	
					9	
	13				13.5	
	14		(Base of Alluvium)		10	
			(Elwren fm)			
	15		Shale, dr Br + Gn, dry to sli moist (at top)		15.0	
					11	
	16				16.5	
	17		Bot. Depth - 16.5'			

ENG FORM ....

PROJECT

HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No. WES-3-B4-86 (Little Sulphur Creek Alluvium)			Date well screen was set: 6/30/87
507.27			+2.5			
503.77			0.0' Ground surface			
			Grout mixture			Water level just prior to setting screen - ~7'
			5.0			
			Bentonite Pellets			
			7.0			Teflon pipe - 4.5 - 15.5'
			Filter Pack			
			9.5			
			Well Screen			
			14.5			
			Trap			
			15.5			
			16.5 Boring Depth			

PROJECT HOLE NO.

Hole No. WES-C4-86

DRILLING LOG	DIVISION U S Navy	INSTALLATION Crane In	SHEET 1 OF 7 SHEETS

1. PROJECT: NWSC Groundwater / Geologic studies
2. LOCATION (Coordinates or Station): 48G
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-C4-86
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 3.7'
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 85.3'
10. SIZE AND TYPE OF BIT: H Q Wire line core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 9/30/86 COMPLETED 10/3/86
17. ELEVATION TOP OF HOLE: ~623.0'
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silt (ML) dBr, w/occ ss frags, mod firm, sli moist			Sampled w/8" dia Folding auger to 11.2'. Set Tempo. Casing to that depth. Cored from 11.2 to 21.8' w/ H Q wireline, using clean water. Core recovery was poor so went back from 11.2' to 21.8' w/ an 8" folding auger
	1		Silt (ML), yBr-rBr, sdy in part, occ ss frags, firm, sli moist.			
	2					
	3		Silty Clay (CL), yBr, w/occ ss frags, v firm, sli moist.			
	4		Shale, d olive-gr olive, th bd, v firm, weak, blocky-flakey. num s'sides. (Big Clifty fm)			~ Base of Golconda fm(?) (determined from stratagraphic projection)
	5					
	6					
	7					
	8					
	9		Color grades to dGr at ~9' to 13.5'			
	10					

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Hole No. WES-C1-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale (Cont.)			
	11			11.2 Run 1		Started Run at 11.2' w/ H.Q wireline; ground most of shale away.
	12					
	13					Note: Ls frags w/ solution surfaces in "float" down slope, indicate Ls interbeds are possibly dissolved out of the shale near the valley side. The Ls beds were encountered in boring WES-C1-86, and are also present elsewhere in the valley walls.
			Shale d olive, wea (as above)			
	14					
	15			2.8/10.0		
	16					
	17					
	18					
	19					
	20					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. W[illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Shale (Cont.)			
	21			21.2		Can 8" auger (tabling) to 21.8')
				21.8		
	22					Pushed 2" split spoon
				22.4		
						cleaned hole to 23.2' w/ 4" E.E.E.-4
	23			23.2		Pushed 6" PVC casing to 23.2'
				<4 in		Started coring w/ HQ wireline coring 0 – 23.2'
	24		[illegible]			
			Top of [illegible]			
	25		Sandstone, l olive tan, th bd, w/shallow ripples, v fine grained (uniform qtz), hard, friable, occ Fe inclus (small)			
	26			9.9/10.1		[illegible] heated [illegible]
	27			0.2		
	28		[illegible]			
	29					
	30					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. [illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Sandstone (cont.)			
	31					
	32					
	33			33.1 / 33.3 / 24.3		- Pull Cap'd.
	34					
	35		- lim stn, r-Br			
	36			9.0 / 9.6 +0.2		- RQD / Run
	37					
	38					
	39		lim stn [illegible]			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C486

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		LL s.: SS, (cont.)			
	41					
	42					
	43			42.9 / Run		Losing 25-50% water return.
	44					
	45					
	46			10.2 / 10.2		
	47					
	48		Lim s.:			
	49		highly Lim s.: similar to above below in hard s.: (no data post)			
	50					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-C4-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 9 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		SS, (Cont)			
		45	limestone w/ th clayey coating			
		50				
	51					
	52					
	53			53.1 / 24.1.5		Losing ~ 25-50% water return
			light stn, tight			
	54					
	55					
	56					
	57			9.9 / 10.0		
			light stn 1/16" clayey filling			
	58					
	59					
	60					

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C4-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS, (Cont.)			
	61	5	[illegible]			
	62		v hard calc ss			
			Base of Big Cliffs ss - 624'			
			Top of Green Creek Ls.			
	63	0	- clay along [illegible] or dried	63.0 / 63.7		Full Capacity
				Run 6		
	64		Limestone, l br Gr, mass, m-c crystaline, fossiliferous, v hard + dense, occ stylolites Lim stn along jts to a depth of 733'			Losing ~ 75% water return
	65	3	[illegible]			
	66	3	highly oxidized [illegible] rusty br, still v hd.	10.3 / 10.2 / 10.1		
	67					
	68	3	[illegible]			
	69	5	Ls changes to dk br color at 698, fm crystaline, fossiliferous, increase in stylolites + blk wavy shaley pts. Lim stn			
	70					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C4-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Ls (Cont.)			
	71					Losing ~ 75% water Return.
	72	S	Lim stn, tr shaly filling (?)			
		S	stn			
	73	0.1	Lim stn (Base of oxidation) 73.3' open	73.3 / Run 7		
	74					
	75					
	76	0 / S	dk & stn. (open)			
	77		Num stylolites & occ to num Blk wavy shaley pts. below ~ 76'.	10.1 / 10.1		
	78					
	79		-sh lens, Blk			
	81					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-CY-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 9 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED 10/3/86
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Ls (Cont.)			
	81	5	slight open ?			Losing ~ 75% water return
			vd Gr below ~80'			
	82					
			small grGn shale inclus in bot 0.1'.			
	83		Base of Beech Creek Ls	83.4		
		0	Top of Elkreek Sh - 83.4'	Run 8		
	84		Shale, dgrGn, mass, hard, blocky num random 5' sides.	1.9/1.9		
	85			85.3		
			Bot Cap'd - 85.3'			
	86					
	87					
	88					
	89					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C4-86 (Beech Creek LS)			Date well screen was set: 11/25/86
624.6			+2.5			
622.1			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen – 74.0
			21.5			
			Bentonite Pellets			
			24.5			Teflon pipe between 68.0 to 84.5'
			Filter Pack			
548.6			73.5			
			Well Screen			
538.6			83.5'			
			Trap			
			84.5			
			85.3' Boring Depth			

PROJECT | HOLE NO.

Hole No. WES-C7-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Grane In	SHEET 1 OF 10 SHEETS

1. PROJECT NWSC Geologic/groundwater studies	10. SIZE AND TYPE OF BIT HQ wireline core
2. LOCATION (Coordinates or Station) ABG	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-C7-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED Oct 17, 1986 / COMPLETED Oct 20, 1986
	17. ELEVATION TOP OF HOLE ~ 634.0'
7. THICKNESS OF OVERBURDEN 6.5'	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR Geologist Richard Wilhum
9. TOTAL DEPTH OF HOLE 101.6'	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty-clayey sand (SC) yBr, w/ ss frags + blocks, (highly wea ss zone) - large ss blocks were ripped up by dozer leveling drill site			Dozer cut down ~ 4' from orig surface too level for drill site. Drilled to 6.5' w/ 6" folding auger.
	1					
	2		Penn - (Mansfield fm)			Steam cleaned all tools prior to begining of drilling.
	3					
	4		↙ unconformity			
	5		Clayshale, olive gray, th bd, firm, moist. (Golconda)			
	6			6.5' ↑ RR Bit		
	7		Limestone, mgrBr, Coarse granular - Crystaline very few apparent fossils, mass, v hard, dense, evidence of oxidation.	7.9' Run 1		Set 6" dia PVC casing to 7.9'. Cored from 7.9' to 10.8' w/ 2' long NX core bbl.
	8			1.5/1.5 Rec/Run		
	9			9.4 Run 2		
	10					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WE-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 10 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Ls (cont.)	1.4/1.4		
	15		clay coating	10.8'		
				2.8 9.+		
	11			Run 3		Started coring w/ HQ wireline bbl at 11.0'. Using clean water as drilling fluid.
	12					
	15'					
	13					
	14					
	15			9.0/10.0		
	10					
				-1.0' Core loss		
	16					
	17		Base of Golconda 17.4'			
			Top of Big Clifty Fm			
	18		Shale, blk-vd Gr, th bd, platy-fissile, abundant carbonaceous flakes and specks, mod hard, uniform			
	19					
	20					

PROJECT HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Shale Cont			
				21.0' Run 4		
	21					
	22					
	23		Note: Core loss was ground away during drilling.			(17.4'-38.0') Shale zone represents the upper member of the Big Clifty fm.
	24					
	25			6.6/8.0 -1.4' core loss		
	26					
	27					
	28					
	29			29.0' Run 5		
	30					

PROJECT | HOLE NO.

Hole No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Shale (cont.)			
	31			4.0 / ~~4.0~~	4.5	
				~~0.8~~ / ~~0.2~~ / 0.5		
	32					
	33			33.5 / ~~33.8~~	Run 6	Full Depth
	34		Lower 4 ft of shale is m-Gr Olive, highly oxidized w/ massive appearance, num tight fractures w/ lim stn + s'sides. many fractures w/ s'sides are dipping parallel at about 30°.			
	35			10.0		
	36			5.2 / 5.0		
	37			+0.2 / +0.3		
	38	0	Sandstone (Lower member - Big Clifty fm) l olive tan, thin bd w/ shallow ripples, vf uniform grained, mod hard, friable, oxidized lim stn along jts, some jts have thin clayey			
		60 / 20		38.7 / ~~38.8~~	Run 7	Full Depth
	39					
	40	0				

PROJECT | HOLE NO.

Sample No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40	0	Coating, occ small Fe inclusions, highly oxidized in top 1½'. Jts are generally rgh and planar.			
	41	0				
	42	5, 5				Lost all drill water at ~ 42.0'
	43	35, 0		10.1/10.0		
	44			+0.1		
	45					
	46	0, 10				
	47	5				
	48	5		44.9 Run 6		
	49	0				
	50	0				

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 10 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		SS (cont.)			
	51	S				
	52					
	53					
	54			100/100		
	55					
	56	60 0 1 10 35 45	Lim stn, minor clayey coating			
	57					
	58					
	59			58.0' / Run 9		Oct 20, 1986 No water in well.
	60					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C7-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60					
	61	20 / 30	Rusty Br, highly oxidized			
	62	2				
	63			100%		
	64			9.9/10.0		
	65			Soil		
	66	0 / 0				
	67	0				
	68		Rusty Br, highly oxidized	68.7 / 69.8		Full Depth
	69	5	slight. oxidized	Run 10		
	70					

PROJECT HOLE NO.

Hole No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		SS (Cont.)			
		3 60				
	71					
		0				
	72					
	73					
	74			10.1/10.0		
				10.1		
	75					
		0				
	76					
		0				
	77		Rusty Br, oxidized, w/num 1/16" to 1/4" rounded Fe inclus.			
	78		Coarser grained, Calcareous, Fossil Frags.			
					78.8' Run 11	
	79	0	Base of Big Clifty fm / Top of Beech Creek fm 79.1'			
		0	LS			
	80		Solution open (description on next sheet)			

PROJECT | HOLE NO.

Hole No. WES-C7-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 10 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Limestone, mgrBr, m-c crystaline, highly fossiliferous, v hard, v dense, occ styolites, oxidized along most jts down to 86.7'.			
		0 solution open				
	81					
	82					
		0				
	83	0	open, solutioning + Lim stn along jts			
		80				
		40				
	84	5		10.1/10.1		
		0				
	85					
			LS color changes to dGr, m grandular-crystaline, w/occ to num wavy shaley pts. + occ styolites.			
	86					
		30	solutioning, (last jt w/Lim stn) (Base of oxidation)			
	87					
		20	solutioning open			
	88	10				
		0				
	89	5		Run 12		
		0				
	90					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C786

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 18 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Ls (Cont.)			
	91			5.0/5.0		
	92					
	93					
	94		1/2 to 1' gray soft clay in Jt	93.9 Run 13		Blocked off
	95		vd Gr in bottom 2-3'.			
	96			4.0/4.0		
	97		Base of Beech Creek Fm 97.8'	97.9 Run 14		
	98		Top of Elwren Fm Shale, dgrGn w/dBr mottling, mass to th bd, blocky-flakey, num random frac w/s'sides hard.			Note: ground top part of Elwren away
	99			2.6/3.7, -1.1 core loss		
	100		Bot depth: 101.6'	101.6		

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-07-86 (Beech Creek CS)			Date well screen was set: 10/21/86
636.8			+2.5			
634.3			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting Screen - 77.2
			18.0			
			Bentonite Pellets			
			23.0			Teflon pipe between 73.5 to 77.7
			Filter Pack			
545.6			88.7			
			Well Screen			
535.6			98.7			
			Trap			
			99.7			
			101.6 Boring Depth			

HOLE NO.

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane In	SHEET 1 OF 19 SHEETS

1. PROJECT: NWSC Groundwater Study
2. LOCATION (Coordinates or Station): ABG (Geologic Studies)
3. DRILLING AGENCY: WES.
4. HOLE NO. (As shown on drawing title and file number): WES-C8-86
5. NAME OF DRILLER: Don Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 6.1 ft
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 187.7 ft
10. SIZE AND TYPE OF BIT: HQ wireline core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED Oct 31, 1986 COMPLETED Nov 20, 1986
17. ELEVATION TOP OF HOLE: ~ 628.0'
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Geologist Richard Wilhiff

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay (CL), Br w/ abundant sdy grit + ss frags, firm, moist.			0.0 to 6.1' samples were obtained w/a 6" folding Auger.
	1					
	2					
	3					
	4					
	5					
	6			6.1 Run 1		Started Coring w/2 ft nx core bl at 6.1
	7		Sandstone, tan, v fine grained, hard, friable oxidized, clay in jt's, carbonaceous specks, occ. vugs. (Penn. - Mansfield fm)	1.2/2.4 (-1.2)		
	8			8.5 Run 2		
	9			1.4/2.0 (-0.6)		
	10		(9.9') Top of Mississippian Period			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale, olive-olive Br, th bd, (however bedding appears reworked + distorted, possibly by creep down slope) num small ss frags mixed in occ carbonaceous pts' + frags, highly wea + oxidized v firm-firm, moist-v moist.	10.5 / Run 3		
	11			0.3 / 1.7 (-1.4)		
	12			12.2 / Run 4		Started Coring with HQ wireline at 12.2'
	13		(Golconda)			Losing 50-60% water return
	14			3.0 / 4.8 (-1.8')		
	15					Reamed hole w/ 7 3/4" RR Bit & set 6" PVC Casing to 16.4'
	16					
	17		Limestone, m-dgr Br, med crystalline, fossiliferous, especially in bot 0.2-0.3', v hard, v dense. (Golconda Ls)	17.0 / Run 5		
	18			1.3 / 1.5 -0.2		
			Base of Golconda fm - 18.4'	18.5		
	19		Top of Big Clifty fm. Shale, Blk-odGr, th bd, platy-flakey, hard, carbonaceous flakes + specks along bd	Run 6 0.5/0.5 19.0 / Run 7		- Blocked - 2" split spoon Nov 1, 1986
	20					

PROJECT — HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Shale (cont.)			
	21					
	22					
	23					Run 7 (19.0 - 29.2') was made w/o inner bl by mistake. Core was burned in at bot. to make recovery. Core loss was ground away by drill action.
	24			7.2/10.2 (.30)		
	25					
	26					
	27					
	28					
	29				29.2 RR 8.4	Ran 5⅞" R.7 3.4 to a depth of 30.6 in effort to straighten hole.
	30		? (29.1-30.1) LS lens			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Shale (Cont.)	RR Bit		
				30.6 Run 8		
	31					
	32					
	33					
	34					
				5.7 / 8.2		
	35					
				(2.5)		
	36		Shale is olive, mass weathered, oxidized, num s'sides + random fractures.			
	37					
	38					
				38.8 Run 9		
	39					
			Sandstone (8.9 cliffy)			
	40					

PROJECT | HOLE NO.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 5 OF 19 SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING %	
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40	0	Sandstone (Cont.), olive tan w/rusty Br zones, oxidized, vf uniform rounded qtz grains, th bd, w/ shallow cross bd/ripples, Jts are generally lim stn.			
	41	5				
		5	Lim stn			
	42	87				
		90	lim stn			
	43					Losing ~25% of water return
	44		v highly oxidized	9.8/9.8		
	45					
		0				
	46		v highly oxidized, Jts are coated w/ lim & partly healed w/ calcite			
		70				
	47	90				
		5				
	48	20	healed w/calcite			
		0		48.6 Run 10		
	49	95	calcite			
		75	lim stn			
	50		½" shaley lim			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		SS (Cont.)			
		5	shaley casting			
	51					
	52					
		53	1.2 lim stn.			
	53			8.4/8.4		
	54					
	55					
	56					
	57	30		57.0' Rall 11		Nov. 3, 1986 Hole was blocked at ~41' this morning; had to clean out w/5" RR Bit to 57.1' before starting back boring.
		0				
	58					
	59			6.0/6.3		
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60					
	61					
	62	D				Losing ~ 25% water return.
	63			63.3 Run 12		
	64	U				
	65	S, D, U, S	64.5-65.8, V highly oxidized, Rusty Br			
	66			9.8/10.1		
	67	S, S		-0.3'		
	68					
	69	S	shiny			
	70					

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		53, Cont			
			(70.4-72.4') coarser grained			
	71	45				
		45				
		20	stn (L.in)			
	72					
	73			73.4		
				Run 13		
	74					
	75	0	stn			
		35				
	76					
				10.0 / 10.0		
	77					
						Losing ~25% water return
	78	0				
		10				
	79	10	(78.8 to 80.7') is coarser grained than above.			
	81					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80					
			Base of Big Clifty fm-80.7'			
			Top of Beech Creek fm-80.7'			
	81		Limestone, l-m gr Br, mass, m-c crystalline, fossiliferous, v hard, v dense, brittle, occ stylolites.			
	82					
	83			83.4 / Rw 9.4		
	84					
	85		Gr clay coating			
	86		Ls is dGr, w/occ shaley pts below 86.1'	10.0 / 10.0		
	87					
	88					
	89					
	90					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Ls (Cont.)			
	91					
	92					
	93			93.4 / Run 15		Nov 4, 1986
	94					
	95					~50% water return
			sh law			
	96			7.0 / 7.0'		
	97					
	98					
			Ls is vdGr in bot 2-3!			
	99					
			tight			
	100					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Inclus. of Elwren sh in bot 0.2'			
			Base of Beech Creek fm	100.4		
			Top of Elwren fm -100.4'	Run 16		
	101		Shale, dgrGn, mass-th bd, blocky-flakey, hard, num random s'sides	100% 1.9 ~~3.0~~ 1.9 -Th		
	102			102.3		-Full Depth
				RR Bit		
	103		Shale, alter dkgrGn + drBr bedding, th bd, Platey-blocky, occ ss pts (minor), occ s'sides, hard	103.4		Reamed hole w/ 5 7/8" dia RR Bit + set Casing (4" PVC) to 103.4' - Grouted to surface, w/bot of Casing sealed in Elwren shale.
				Run 17		
	104					
	105					Nov 7, 1986 started back Coring
	106			8.8 / 8.9		
	107			~~0.1~~ ~~0.1~~		good water return
	108		Shale/Claystone, dgrGn, mass zones w/ irregular rounded grBr small ss inclus, alter w/ th bd zones w/ silty ss pts, hard			
	109					
	110					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		Shale/Claystone (Cont)			
	111					
	112			112.2 / 112.3		Pull depth
				Run 18		
	113					
	114					
	115		Base of Elmwood fm - 1150'			
			Top of Reelsville fm			
			Cole Sandstone/Sdy Limestone, mgr Br, th bd w/shallow cross bd or ripples, vfine grained, hard brittle	9.5 / 10.6		
	116			-1.1 / +1.2 / +0.1		
	117					
	118		Rt. Tight			
	119					
	120					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 13 OF 19 SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING %	
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120					
	121		Shale/claystone dgrGn, mass, occ small v hard Ls inclus	121.7		Pull depth
	122		Shale, dgrGn-gnGr (dpBr mottling in upper 2.7'), th bd, blocky, hard, dense.	122.9 Run 19		
	123					
	124					
	125					
	126			9.6 / 9.4		
	127		Cale SS (predominate) 1-m grBr w/closely spaced alter dgrGn Shale pts, hard	+0.2 +1.0 / +1.2		
	128		Base of Reelsville / Top of Sample Fm - 127.9 Shale, dgnGr in top few feet changing to vdGr below top few ft, th bd, platey-fissile, occ (seat) lGr SS lens, hard.			
	129					
	130					

PROJECT

HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130		Shale (Cont.)			
	131		1 Gr SS w/shaley pts.	131.3		Pull depth
	132		1 Gr SS w/shaley pts	132.3		
				Run 20		
	133			(+1.0)		
	134					
	135					
	136			9.5 / 9.5		
	137					
	138					
	139					
	140					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 15 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140		Shale (Cont.)			
				140.8		Pull depth
	141					
				141.8		Nov 10, 1986
				Run 21 (+1.0) 100%		
	142					Note Had to shut down drilling most of Nov 10 & all of 11th Nov. due to contractors in Ash Pile.
				2.5/2.5		
	143			143.3		Pull depth
						Water level - 76.7'
	144			144.3		Nov 12, 1986
				Run 22		
	145					
			1 Gr SS w/ shaley pts.			
	146			100%		
				9.0/9.0		
	147			+1.0'		
	148					
	149					
	150					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 16 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	150		Shale (Cont.)			
	151					Note: Between a depth of 152.3 & 170.6 ft, the Short core runs, blocking off, & poor core recovery was due to loss of circulation at the bit. What appeared to be water return at top of well was largely circulating through a hole in the section of drill stem that was added just before run 23.
	152			152.3 Run 23		
	153			1.6/2.1		
				.0.5		
	154			154.4 Run 24	(blocked)	
	155			0.7/1.5, .6.6		
				155.7 Run 25		Blocked
	156		Sandstone, m Gr, fine grained, w/ Blk shale pts, hard, brittle			Nov 13 1986 Temp 8° F this morning /chill factor 20 below, started rig and broke gears (in Transmission that operates rig water pump) first thing. (Transmission frozen?) Had repairs made on Rig (Trans.) & started back drilling on Nov 17, 1986. (week end included)
	157					
	158			5.5/7.3		
	159					
	160					

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DRILLING LOG	DIVISION	INSTALLATION	SHEET 17 OF 19 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160		Sandstone (Cont.)			
	161					
	162					
	163			163.0 Run 26		Blocked Nov. 17, 1986
	164		Shale, Blk. vd Gr, th bd. platy - flaky hard, occ sdy pts, (as above)	2.0/3.7		
	165					
	166			166.7 Run 27		Blocked
	167			0.8/1.5		
	168			168.2 Run 28		Blocked Nov 18, 1986
	169			1.5/2.4		
	170					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 18 OF 19 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	170		Base of Sample Fm. 170.6'	170.6		
			Top of Beaver Bend Fm	Run 29		
	171		Limestone	RR Bit		
	172			172.5		
				Run 29		Note: Runs 29+30 were made w/o the inter bl. The core from run 30 was not retrieved & had to be cut out w/a RR Bit.
	173			1.5/1.7		
	174			174.2		
				Run 30		
	175					
	176					
	177			0.0/9.9		
	178					
	179					
	180					

PROJECT | HOLE NO.

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.LING LOG | DIVISION | INSTALLATION

T

ION (Coordinates or Station)

NG AGENCY

NO. (As shown on drawing title or number)

OF DRILLER

CTION OF HOLE

ERTICAL ☐ INCLINED _____ DEG. FROM VERT.

CKNESS OF OVERBURDEN

TH DRILLED INTO ROCK

TAL DEPTH OF HOLE

10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED Nov 20, 1986
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	180		Ls Cont.			
	181					
	182		Base of Beaver Bend fm ~182.6'			
			Top of Bethel fm			
	183		sdy shale / shaley sandstone			
					184.1	
	184				RR Bit	
	185					
	186					
	187					
	188		Bot. Depth - 187.7 ft			

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C8PZ-E6 (Beech Creek LS)			Date well screen was set: 11/26/86
629.7			+2.5			
627.2			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen – 71.3'
			35.0			
			Bentonite Pellets			
			39.5			
						Teflon pipe between 64.5 to 101.0'
			Filter Pack			
537.2			90.0			
			Well Screen			
527.2			100.0			
			Trap			
			101.0			
			101.6 Boring Depth			

HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane In.	SHEET 1 OF 17 SHEETS

1. PROJECT NWSC Groundwater Study	10. SIZE AND TYPE OF BIT HQ wireline core
2. LOCATION (Coordinates or Station) ABG (Geologic Studies)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-C9-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES 14
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 7.8'	16. DATE HOLE — STARTED Nov 27 1986 — COMPLETED Dec 5 1986
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE ~ 601.5'
9. TOTAL DEPTH OF HOLE 162.9'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard Williams

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Crushed Ls road bed rk.			0.0 to 12.0 drilled with 8" + 4" folding auger. Set 2.3' of 6" PVC surface casing.
	1		Silt (ML) olive Gr, occ rk frags, firm, sli moist, sli organic odor?			
	2		Silt (ML), sandy, clayey, rBr, w/nun ss frags.			Steam cleaned tools before starting drilling operations.
	3					
	4					
	5					
	6		may grade to clayey sand (SC) in bottom zone			
	7					
	8		Shale, d olive Gr, th bd, v firm, s'sides, wea, oxidized in lower 1 to 2 ft.			
	9					
	10					

PROJECT | HOLE NO.

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Hole No. WES-CG-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale (cont.)			
	11					
	12			12.0' Run 1		Started coring w/ HQ wireline core bl at 12.0', using clear water as drilling fluid.
	13		Top Big Clifty SS - 13.2'			
	14	0	Sandstone, l olive yel Br, th bd w/shallow cross bd/ripples, vf grained, uniform, hd, friable, acc small Fe nodules (1/8-1/4" dia).			
	15					
	16			9.5/10.0 -0.5'	(20% Run)	
	17	0				
	18					
	19	0				
	20					

ENG FORM ... OBSOLETE PROJECT HOLE NO.

Hole No. WES-C7-95

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 7 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (Cont.)			
	21	0	sh clay fillings			
		0	sh	22.0 Run 2		
	22	0	sh clay fillings			
	23					
	24					
	25		sli coarser grained, greater degree of oxidation than above + below; Rusty Br zones.	9.9 / 10.0		
	26			0.1		
			No jts			
	27					
	28					
	29					
	30					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30					
		30	sli. stn			
	31					
	32			32.0 / Run 3		
		35	✓ little stn			
	33					
		30				
	34					Losing 25-50% water return
	35			10.0 / 10.0		
	36					
		0				
	37	0	highly oxidized, rusty Br,			
		0				
	38	0				
	39					
		20				
	Hi					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-RC-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 17 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40					
		0	Blk min. stn.			
	41	0	" " "			
		0	" " "			
		0	" " "			
	42			42.0 / Run 4		
		3				
		70	Blk min. stn			
	43	3	Lim stn			Losing 50% of drill water return
		3	Blk stn			
	44	0	Lim stn			
		3				
		0	Lim stn			
	45	30	sli. coarser grained			Lost all water return at ~ 46'.
		70	Fresh 70° jt			
		20	Lim stn	9.6 / 10.0		
	46	60	patchy white powdery coating along 60° jt.			
		10	sh clay coating			
	47					
	48					
	49					
	50					

PROJECT | HOLE NO.

Hole No. WES-29-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50					
			- Solution (Core loss) Lim stn on top			
	51	5	Top of Beech Creek Limestone - 51.0'			Base of oxidation - 51.3'
		40 0	L-m grBr med.-coarse crystaline, fossiliferous, v hard, v dense, occ stylolites			
	52			52.0 Run 5		
		0				
	53					
	54	0	Jts are rough, irregular and show evidence of being open (staining)			No water return
	55					
	56			9.8/10.0		
		0		-0.2		
	57		Darker grBr between 57.2 + 60.3'			
	58	80	stn open			
		0				
	59	30				
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Ls (cont.)			
	71					
			Base of Beech Creek fm	72.3		Nov 28, 1986
	72		Top of Elwren fm · 72.0' Shale, dgrGn, mass to th bd, hard, blocky-flakey.	Run 7		No water return
	73					
	74			4.8/4.8		
	75					Reamed hole w/ 5 7/8 RR bit to 76.8'; Set 4" dia PVC casing to 76.5', + grouted to surface.
	76		Shale/Claystone, drBr w/grGn mot, mass, hard; contains sub-rounded Cal ss/Ls inclus up to ~2" dia in bot 2-3'	76.8 Run 8		Dec 2, 1986
	77					Started back coring w/HQ wireline bit through the 4" casing.
	78			6.6/6.9		getting good water return
	79			20-3		
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		sh/claystone (cont.)			
	81					
	82					
	83		Claystone/shale, dGn yh bd to mass, siltstone pts in upper & lower zones, occ sub-rounded small siltstone inclus. hard, dense.	83.1 / 83.7 Run 9		Full depth
	84					
	85					
	86			9.8 / 9.8		good water return
	87					
	88					
	89					
	90		Top of Rockville - 89.7'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Sandstone/limestone, lm grBr, vf, vdense, hard, faint cross bd,			
	91					
	92		Conglomeritic w/fossil frags in bot 0.1'.			
	93		Shale, dgrGn w/drBr mottling, th bd, hard, has alter lGr sdy pts + thin lams below ~96'; bedding is disturbed + swirled.	93.2 / 93.5 Run 10		Full depth 12/3/86
	94					
	95					
	96					
	97			10.3 / 10.0 +0.3		
	98					
	99		Sandstone/limestone (similar to above), but coarser, occ grGn shale pts.			
	100					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
			Top of Sample fm-100.3'			
			Shale, d Gr, th bd w/ num lGr ss pts & thin lens, hard, platey			
	101					
	102					
			cal ss, v hd, dense			
	103		Shale, v d Gr, - Blk, th bd, hard, platey-flakey, occ sdy pts, occ pyrite nodules	103.5 Run 11		
	104					
	105					
	106					
				9.9 / 10.0		
	107			>0.1		
	108					
	109					
	110					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-R6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110					Note: Drill water return is leaving a blk "earthy" film on top of the water in the mud pan. The source is in the sample fm.
	111					
	112					
	113			113.1 / 113.5		Full depth
				Run 12		
	114					
	115					
	116					
	117			9.8 / 10.0		
				-0.2		
	118					
	119					
	120					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C9-F6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 13 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120					
	121					
	122					
	123			123.2		
				123.5		
				Run 13		
	124					
	125					
	126					
	127			10.3 / 10.0 +0.3		
	128					
	129					
	130					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-C-

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-C9-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130					
	131					
	132		Sandstone, l-m Gr, vf grained, well rounded qtz, th bd, occ shaley pts, occ pyrite inclus, hard.			
	133			133.5 / Run 14		12/4/86
	134					
	135					
	136		Shale (as above)			
	137			9.3 / 9.3		
	138					
	139					
	140					

PROJECT HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C9-E6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 15 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	141					
	142					
				142.8		
				Run 15		
	143					
	144					
			Top of Beaver Bend fm - 144.6			
	145		Limestone, l-m gr Br, f-m crystalline, fossiliferous v hard, v dense occ stylolites, scattered shaley pts,			
	146			8.7 / 10.8		Note: Run 15 originally went from 142.8 to 152.9'. The core was not retrived when the core bbl was pulled. It took 2 attempts at running the core bbl back over the core spl before at least the larger portion of core from run 15 was recovered. In going back over the core, 2.1' of core spl was ground away and the run was deepened to 153.6'.
	147			-2.1		
	148					
	149					Losing 25-50% water return
	150					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C9-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 16 OF 17 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	150		Ls (cont.)			
	151					
	152					
	153			153.6 Run 16		
	154		numerous blk shaley pts			
	155					Losing ~50% water return.
			Top of Bethel Fm - 155.2			
	156		Sandstone, 1-m Gr vf grained, th bd, w/numerous thin shaley pts & lens, hard sli friable.			
	157			9.2 / 9.2'		
	158		50-50 shale & SS 19.3.			
	159					
	160					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C2-56

DRILLING LOG	DIVISION	INSTALLATION	SHEET 17 OF 17 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160		40% blk sh pts + thin lams			
	161					
	162					
	163		Bottom Depth - 162.8'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C9P2-E6 (Beech Creek LS)			Date well screen was set: 12/7/87
604.0			+2.5			
601.5			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen – 43.0'
			10.0			
			Bentonite Pellets			
			13.0			Teflon pipe between 37.2' to 73.0'
			Filter Pack			
539.5			62.0			
			Well Screen			
529.5			72.0			
			Trap			
			73.0'			
			73.0' Boring Depth			

PROJECT | HOLE NO.

Hole No. WES-C10-86

DRILLING LOG	DIVISION US Army	INSTALLATION Camp Ira	SHEET 1 OF 8 SHEETS

1. PROJECT: NWSE Groundwater Study
2. LOCATION (Coordinates or Station): ABG (Geologic Studies)
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-C10-86
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 7.0
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 78.8'
10. SIZE AND TYPE OF BIT: HQ w. reline core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES: 6
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 1/17/87 COMPLETED 1/21/87
17. ELEVATION TOP OF HOLE: ~ 606.5'
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF ~~INSPECTOR~~ Geologist: Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay (CL) yBr-rBr firm, w/ occ sub-rounded wea ss pebbles + fragments (Alluvial / Colluvial deposits)			0.0 to 11.1' drilled w/ 8" dia. folding Auger
	1					
	2					
	3					
	4					
	5					
	6					
	7		Shale, (Upper Big Clifty Fm), d olive Gr, th bd, w/ num carbonaceous specks + flakes along bedding, wea, occ lim along bedding planes, v firm.			
	8					
	9					
	10					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C10-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale (cont.)			Set 6" dia. PVC Casing to 11.1' + Grouted in
	11			11.1 Run 1		
	12					
	13		Limestone, m gr Br m-c granular-crystalline v hard, v dense, w/ occ d Gr shaly pts.	123/4.8		
	14		Shale, (as above) in upper zone, changing to d-m gr Gn mass shale without carbonaceous inclus in lower zone.	2.5		Drill action indicated a soft zone 1 to 1½ thick underlying the LS layer.
	15					Cleaned hole w/5" RR Bit to 16.0'
	16		Note: core loss is most probably shale, ground away during drill action.	15.9 ERBit Run 2		
	17			2.1/2.8		Note: oil film (earthy) on top of drill water in mud pan; (coming from shale zone?)
	18			.07		
			Top of Big Clifty ss - 18.8'	18.8		
	19		Sandstone, Lt olive Tan, w/ shaley pts + tans + occ Cherty inclus, friable, v fine weak ss.	Run 3		
	20					

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C10-82

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		ss (cont.)			
	21			3.9/4.4, -0.5		
	22					
	23	11	Sandstone, olive-yel Tan, v fine uniform grained qtz, shallow cross bd'ing/ripples, oxidized, hard, friable (weak ss)	23.0 / 23.2 Run 4		Pull depth
	24	10				
	25					
	26	5	most jts have Lim or clay coating	10.2/10.0 +0.2		
	27	5 / 25				
	28	15 / 13				
	29	13				
	30					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C10-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 8 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		SS (cont.)			
		10				
	31	10				
	32	0				
	33			33.2 / Run 5		
	34					Losing ~25-30% drill water
	35					
	36	30		9.9 / 10.0		
		30				
	37			-0.1		
	38					
	39					
	40					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C10-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (Cont.)			
	41					
	42					
	43			43.2 / Run 6		Jan 20, 1987 - Burned out Rig starter/had to make repairs. Jan 21, 1987 - started back coring.
	44					
		20				
	45					
		25°	- Blk stn - lost all drill water at this jt.			
	46					
		20		10.0 / 10.0		
	47					
	48					
		5				
	49					
		0				
	50					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C10-E6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		SS (Cont.)			
	51					
	52	5				
		0				
		0				
	53			53.2'		
				Run 7		
	54					
	55					
		5				
	56			10.0		
				10.0		
		20				
	57		Loose, [illegible]			
		0				
	58	15				
			58.8' base of oxidation			
	59	0	Bot. of Big Clifty Fm - 59.2			
			Top of Beech Creek Ls.			
			Limestone; m gr Br, m-c granular-crystalline, fossiliferous, v hard.			
	60					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-910-56

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		v dense, occ stylolites			
		0	sol open			
	61		most jts in Ls are along bedding; possibly minor solutioning along many jts.			
	62					
	63	0	sol open	63.2 / Run 8		
	64	0				
		0				
	65			10.0 / 10.0		
	66					
		5	Br clayey-Lim sh			
	67	0				
		0				
	68	0				
		0	Ls changes to dGr + contains occ to num blk shaley pts (wavey), occ stylolites			
	69					
	70					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-C10-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Ls (cont.)			
	71					
	72					
	73			73.2 Run 9		
	74					
	75			5.6 / 5.6		
	76					
	77					
	78		Elwren sh. inclusion bot 0.2'. Top Elwren - 78.2 ft. Shale dgrGr mass, occ gr Br 'LS nodules, hd	78.8		
	79		Bot. Depth - 78.8'			
	80					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION US Navy	INSTALLATION Camp Ir	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C10-87 (Beech Creek Ls)			Date well screen was set: 1/22/87
608.1			+2.5			
605.9			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen – 47.0
			17.0			
			Bentonite Pellets			Teflon pipe between 40.7' to 77.0'
			20.0			
			Filter Pack			
539.0			66.0			
			Well Screen			
529.0			76.0			
			Trap			
			77.0			
			78.8' Boring Depth			

Hole No. WES-C11-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane Ind	SHEET 1 OF 6 SHEETS

1. PROJECT Nwsc Groundwater studies	10. SIZE AND TYPE OF BIT HQ wire line
2. LOCATION (Coordinates or Station) ABC. (Geologic Studies)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-C11-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES 5
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED Jan 27 1987 — COMPLETED Jan 28, 1987
7. THICKNESS OF OVERBURDEN 6.3	17. ELEVATION TOP OF HOLE ~ 590.0'
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 59.5	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay (CL) Br-yBr, sdy, w/ weathered SS frags & pebbles, firm - mod firm, moist (v moist w/depth) (Recent rain + snow) Alluvial/Colluvial Deposits			moved Rig to well site Jan 23, 1987 (had
	1					
	2					
	3					
	4					
	5					
	6			6.3'		
			Sandstone/Clay, yBr - rusty Br, highly wea + oxidized friable SS w/ clay filled joints. (Surface - near Surface Residual wea zone in Big Clifty SS.)	Run 1		Started Coring w/ 2' NX Core bbl. Run 1 was taken extra foot by mistake related to easy drilling. Using clean circulating water.
	7			0.0/3.0'		
	8		Poor to no Core Recovery	-3.0'		
	9			9.3 Run 2		
	10					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C11-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		wea SS (cont.)	0.8/2.0		
				-1.2'		
	11			11.3		
				Run 3		changed to 10' HQ wireline core bl at 11.3'
	12		Sandstone (Big cliff) cont.) yel-olive Tan + rusty Br, vfine uniform qtz grains, th bd w/ shallow ripples, hd, friable weak SS, mod to highly oxidized			
	13					
	14					
	15			9.8/10.5		
				-0.7'		
	16					
	17					
	18					
	19					
	20					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-211-26

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 6 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont)			
	21					
				21.8 / Run 4		
	22					
	23					
	24					
	25			9.8 / 10.0		
	26			-0.2'		
	27					
	28					
	29					
	30					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C1-B2

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		SS (Cont.)			
	31					
				31.8		
				Run 5		
	32					
	33					
	34					
	35			9.6 / 10.0		
				~~0.4~~		
	36			0.1		
			Bot of Big Clifty fm			
			Top of Beech Creek Fm - 36.4'			
			Limestone, m gr Br, m-c granular/crystalline, fossiliferous, v hd v dense, occ stylolites			
	37					
	38					
	39					
	U.1					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C11-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Ls (cont.)			
	41			41.5		Pull depth
				41.8'		
				Run 6		
	42					
	43					
	44					
	45			10.3 / 10.0		
	46			~~10.3~~		
	47					
	48					
	49					
	50					

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-C11-96

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Ls (cont.)			
	51					
				51.8		
	52			Run 7		
	53					
	54			5.3 / 5.7 / 5.3 ~~0.4~~		
	55					
	56					
	57		Base of Beech Creek fm.	57.1		Full depth
			Top of Elwren fm			
			Shale, dGn mass	57.5		
				Run 8		
	58			1.8 / ~~1.4~~ 1.8 ~~1.0~~		
	59			58.9		- True bot. of hole
				59.5'		
	60		Bot. Depth - 59.5'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET	OF SHEETS
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C11-86 (Beech Creek Ls)			Date well screen was set: 1/28/87
592.8			+2.5			
590.3			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen - 35.2
			10.0			
			Bentonite Pellets			
			13.0			
						Teflon pipe between 32.4 to 58.5'
			Filter Pack			
542.8			47.5			
			Well Screen			
532.8			57.5			
			Trap			
			58.5			
			59.5 Boring Depth			

PROJECT | HOLE NO.

Hole No. WES-3-C12-86

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane In	SHEET 1 OF 5 SHEETS

1. PROJECT NWSC Groundwater Studies	10. SIZE AND TYPE OF BIT HO Wireline Core
2. LOCATION (Coordinates or Station) L-46 (Geologic studies	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-3-C12-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 2/2/87 COMPLETED 2/3/87
7. THICKNESS OF OVERBURDEN 5.4 ?	17. ELEVATION TOP OF HOLE ~585.5
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 51.2'	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay (CL), Br becomes sdy w/depth occ ss frags + sub-rounded ss pebbles mod firm,			Drilled w/8" holloW Auger from 0.0 to 5.4'. Steam cleaned all tools before starting
	1					
	2					
	3					
	4		rBr - yBr in bot.			
	5					
			?			
	6		Sandstone yBr, highly wea, w/clay along Jts ? No core recovery (Big Hill fm)			Attempted to core w. 2' NX bl from 5.4 to 10.0; No Recovery. Water return ranged between 0 & 50% during drilling. Cleaned hole out w/a 7 7/8 RR Bit to 11.0' & set 6" PVC Casing
	7					
	8					
	9					
	10		Less wea ss at ~10.0'.			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-C12-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Sandstone, ytan, vf uniform grained, wea, friable, lim & manga along jts, occ lim nodules.			set 6" PVC to 11.0' + Grouted around out-side.
				11.0' Run 1		2/3/87
	11					
	12					
	13					Lost all water, return at ~13'.
	14					
	15			8.4 / 10.0		
				-1.6		
	16					
	17		- v high; oxidized, weathered, rusty, Br			
	18					
	19					
	20					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-3-CIT-96

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (Cont.)			
	21			21.0 Run 2		
	22		limonite crust + clay coating			
	23					
	24		Coarser grained (f-m)	7.7 / 8.4		
	25		mag + clay coating	-0.7'		
	26					
	27		mag stn			
	28					
	29			29.4 Run 3		
	30					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WEC-2-9-12-80

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30					
	31		30.5 - 39.0 - very soft drilling w/no core recovery. Zone is largely a cavity created by solutioning in the Beech Creek Ls. The cavity is partially filled w/wea SS blocks, clay + sd ?	1.1/9.6'		
	32					
	33					
	34		Lighter colored upper portion of the Beech Creek Ls is missing (A total of ~9-10' of Ls is missing or nearly equal to the cavity thickness)	-8.5'		
	35					
	36					
	37					
	38		Rgh planar suture at top of Beech Creek Ls	39.0		
	39		Beech Creek Lm ~39.0 Limestone dGr, f-m crystalline fossiliferous, non Blk shale, occ crystalline vuggs	R-1-4		
	40					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WFS-3-C12-96

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Base of oxidation ~40.0'			
			Ls (cont.)			
		0		2.0/2.8		
	41					
		10		41.8 / Run 5		Blocked
	42					
		5				
	43					
		0				
	44					
		0		7.1/7.2		
		0				
	45			-0.1		
		0				
	46					
		0				
	47					
		0				
		0	Base of Black Creek. 48.9'			
	49		Top of Elwien fm	49.0 / Run 6		
			Shale [illegible] mass hd	1.0/1.0		The boring was drilled to 51.2' however 1.2' of core was left in hole
	50					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C12-86 (Beech Creek LS)			Date well screen was set: 2/3/87
587.6			+2.5'			
585.1			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen - 37.0
			10.0			
			Bentonite Pellets			
			12.0			Teflon pipe between 34.0 to 50.0'
			Filter Pack			
546.1			39.0			
			Well Screen			
536.1			49.0			
			Trap			
			50.0			
			51.2' Boring Depth			

HOLE NO.

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane In	SHEET 1 OF 11 SHEETS

1. PROJECT: NWSC Groundwater Studies
2. LOCATION (Coordinates or Station): ARG (Geologic Studies)
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-3-C15-86
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 7.0'
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 101.1'
10. SIZE AND TYPE OF BIT: HQ wireline
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES: 8
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 2/23/86 COMPLETED 2/26/87
17. ELEVATION TOP OF HOLE: ~ 618.6
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF ~~INSPECTOR~~ Geologist: Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay (CL), rBr, sl. sdy, occ ss frags, firm, (Residual-Colluvial soil)			Drilled to 9.0' w/8" dia. folding Auger. Steam cleaned all Tools before starting
	1					
	2					
	3					
	4					
	5					
	6					
	7		Shale (Hardinsburg fm) Olive + wm (7.0 to 9.5'), changing to dGr below 9.5', th bd, fissile v firm.			
	8					
	9					
	10					Drill from 9.0 to 10.0' w/ 7 3/4" RRBit. Grouted 10' of 6" PVC Casing.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-1130

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 11 SHEETS
1. PROJECT		10. SIZE AND TYPE OF BIT	
		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
2. LOCATION (Coordinates or Station)		12. MANUFACTURER'S DESIGNATION OF DRILL	
3. DRILLING AGENCY		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)		14. TOTAL NUMBER CORE BOXES	
5. NAME OF DRILLER		15. ELEVATION GROUND WATER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		16. DATE HOLE	STARTED / COMPLETED
		17. ELEVATION TOP OF HOLE	
7. THICKNESS OF OVERBURDEN		18. TOTAL CORE RECOVERY FOR BORING %	
8. DEPTH DRILLED INTO ROCK		19. SIGNATURE OF INSPECTOR	
9. TOTAL DEPTH OF HOLE			

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale (cont)	run 1		2/24/87 Started coring w/ HQ wireline at 10.0'
	11		Top of Gatesville - 11.6'			
	12		Limestone lgr8r finely crystalline fossiliferous, v hard, v dense, occ stylolites			
			Sh are dim sm			
	13					
	14			9.8/10.0		
	15			-0.2		
	16		45 fract			
	17		Shale, dGr (sample was crushed during removal from core bl)			
	18		Limestone (as above)			
	19					
	20				20.0	

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-3-C15-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Ls (cont.)	Run 2		
			Base of Colorado (20.5')			
	21		Top of Big Clifty Fm			
			Shale, dGr, th bd, fisslike carbonaceous flakes + specks along bd, mod hd			
	22		(oil film occured on top of water in mud zone from this zone)	5.0/5.6		Core loss was ground away during drilling
	23		(Indian Springs mem)	-0.6		
	24					
	25			25.6		Reamed hole w/a 5½" RR bit and set 4" PVC casing through the upper 6" PVC casing to a depth of 24.6'. Grouted casing in 2/23/87
				Run 3		
	26					
	27			4.5/5.1		
	28					Core loss was ground away
	29			-0.6		
	30					

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG

DIVISION

INSTALLATION

SHEET 4 OF 11 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		sh (cont.)			
				30.7 / Run 4		
	31					
	32		Limestone, Gr-grBr, th bd w/shaley pts, f-m crystalline, fossiliferous, v hd, v dense.			
	33					
			Shale (as above)	7.7 / 7.7		Core loss was ground away during drilling.
	34					
	35			-2.0		
	36					
	37					
	38					
	39		Sandstone (big slifty) lyel-olive tan, v fine uniform grained, shallow ripples, friable, hard, oxidized to a depth of 64.5' (cont.)			

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 5 OF 11 SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		mGr in top 1 ft w/ calc clay inclus, dark gry	40.1		
				Run 5		
	41					
				3.2 / 3.4		
	42				Box 3 of 8	
	43		not jts are tight & mineralized	43.6 / 43.8		Full depth
				Run 6		
	44					
	45					
	46		rusty Br (mostly) high oxides		46.4	
				9.8 / 10.0		
	47				Box 4 of 8	
	48			-0.2 +0.2		
	49					
	50					

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

(TRANSLUCENT)

Hole No. [illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		SS (Rm+)			
	51					
	52					
	53			53.4		Pull depth
				53.8		
				Run 7		
	54					
	55					
	56					
	57				10.1 / 10.0	
	58		jin open		+0.1 -0.3 10.4	
	59					
	60					

PROJECT [redacted] HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS (Mon.)			
	61					
	62					
		60	Sm opens			
	63	5	rusty Br highly oxidized Lim stn			
		3		63.5		Full depth
			- Cal ss, vhard	63.8		
		15°	Lim stn - (base of oxidation	Run 8		
	64	60	along Jts is at 63.8'.		Box 5 of 8	
			— — —			
	65		Below 64.5' SS is Lt Gr; no oxidation (same as above otherwise)			
	66					
				10.3 / 10.0		
	67					
				+0.3		
	68				68.9	
	69					
		0				
	70					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES3-03

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		SS (cont.)			
	71					
	72				Box 6 of 8	
	73			73.8 Run 9		
	74		sh lens (½")			
	75					
	76					
	77				9.7 / 10.0	
	78		Base of Big Clifty SS – 78.1 Top of Reeli Creek LS (thin shaley/clay lens at contact		-0.3	
	79		Limestone lgr Br, m-c crystalline, granular, fossiliferous, occ stylolites, v hd, v dense (rgh Fract)			
	80					80.0

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

File No. WES-3215-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		LS (cont.)			
		0				
	81					
		10				
	82					
					Box	
		0			7	
	83			83.5	of	Full depth
				83.8		
				Run: 2	8	
	84					
	85					
		2				
	86					
		0				
		0	Limestone (33 scou-) but dar f-m crystalline - gram-sr w/occ shaley pts, shaley pts increase w/depth			
	87			10.0		
		2		9.7		
	88			9.3		
		2				
		1				
	89					
	90					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT

HOLE NO.

DRILLING LOG

DIVISION

INSTALLATION

SHEET 10 OF 11 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Ls (cont.)			
					91.0	
	91					
	92					
	93				Box	
				93.5	8	
	94				of	
					8	
	95					
				7.6 / 7.6		
	96					
	97					
	98		Base of Bean Rock Top of Flaser Ls - 98.2' Shale darker thicker fissile mud rich			(Lost all water at flaser contact) Chemical odor coming from sample when core was removed. (there was no water reaction when tested)
	99					
	100					

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

(TRANSLUCENT)

Hole No. WES-3-15 C

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 11 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Shale (Cont)			
	101			101.1		
			Bottom Depth- 101.1'			
	102					

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C15-80 (Beaver Creek LS)			Date well screen was set: 2/26/87
~621.2			+2.6			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen - 62.0'
			34.0			
			Bentonite Pellets			
			38.0			Teflon pipe between 44.1 to 99.5'
			Filter Pack			
			88.5			
			Well Screen			
			98.5			
			Trap			
			99.5			
			101.1 Boring Depth			

HOLE NO.

Hole No. WES-3-C17-86

DRILLING LOG	DIVISION US Army	INSTALLATION Camp Ir...	SHEET 1 OF 1 SHEETS

1. PROJECT	NWSC Groundwater Studies
2. LOCATION (Coordinates or Station)	A26 (Geologic Study)
3. DRILLING AGENCY	WES
4. HOLE NO. (As shown on drawing title and file number)	WES-3-C17-86
5. NAME OF DRILLER	Don Taylor
6. DIRECTION OF HOLE	☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	5.5'
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	145.-
10. SIZE AND TYPE OF BIT	HO w...
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: ; UNDISTURBED:
14. TOTAL NUMBER CORE BOXES	12
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED 3/14/87 ; COMPLETED 3/19/87
17. ELEVATION TOP OF HOLE	693.9
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF ~~INSPECTOR~~	Geologist Richard W. Hurt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay (CL) Br-yBr w/Gr laminations, sh bd, soft wet (Recent Rain) (Largely Residual soil)			Sampled from 0.0 to 5.5' w/8" dia folding auger.
	1					steam cleaned all tools before starting
	2					
	3					
	4					
	5		Wea SS fragments ... feet.		5.5	Refusal 5.5
	6		Sandstone, yBr, highly wea w/clay in jts(?) (soft ...) (Penn-Mansfield ...)		RR Bit from 5.5' to 12.2	Ran a 7 7/8 ... 8.1 to 12.2' + set 6" ... Casing to ... depth.
	7					
	8					
	9					
	10					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG

DIVISION

INSTALLATION

SHEET 2 OF 15 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		SS/Clay (cont			
	11					
	12			12.2 Run 1		3/16/87 Started coring w/a HQ wireline core bl. at 12.2
	13		Sandstone, mGr, fine grained occ shale pts & thin discont. lens, hd, friable			
	14					
	15			10.4/13.4		
	16		Sandstone, mGr, fine grained w/num alter wavy Blk shale pts & thin lens, hard carbonaceous flakes along bd.			
	17					
	18					
	19					

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

No. WFS-3-C17-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-	20		SS (Cont.)			
	21					
	22			22.6		
				Run 2		
	23					
	24					
	25			10.4 / 13.4		
	26		Sandstone m-dGr, f-m grained, mass, slightly friable cd			
	27					
	28					
	29					
	30		Alternating [illegible] lens of Gr [illegible] + Blk Shale (a 50-50 ratio). (Cont.)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WPC-3-C17-96

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 4 OF 15 SHEETS	
1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Carbonaceous flakes + specks along bd, hd, platey			
	31					
	32					
				33.0'		
	33		Base of Mansfield fm	Run 3		
			Top of Hardinsburg fm	33.4'		
			Shale Gn, mass, hard crumbly			
	34					
	35			4.3/4.9		
	36			-0.5		
	37		Shale [illegible] obvs [illegible] dGr			
				37.9		
	38					
				3.9/6.1		
			Shale/[illegible] Gn rarBr in b-k, mottled in some zones, mass, [illegible]	-2.2		Core loss [illegible]

PROJECT

HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 5 OF 15 SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		blocky, hard, occ s'sides dipping ~40° num micro" healed random fractures. (Shale is very similar to the Elwren. shale which normally underlies the Beech Creek LS)			
	41					
	42					
	43			43.7		
	44					
	45					
	46		Shale, dGr. (w/occ Gn + rBr streaks along bd in upper 3-4'), th bd, hard flakey, occ s'sides dipping ~40°.			
	47			7.8 / 10.0		
	48			2.2		Core loss is due to drill action
	49					
	50					

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 0 OF 15 SHEETS	
1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Shale (Cont.)			
	51					
	52					
	53					
				53.9 / Run 6		3/17/27
	54					
	55					
	56					
					9.5 / 9.5	
	57					
			Base of Hardinsburg fm. 58.0'			
	58		Top of Golconda fm. Limestone - shaley. [illegible] bd. dip ~5°			
	59					
	60					

PROJECT

HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

No. WF: -3-C-7-5.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 15 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Shaley Ls (Cont.)			
	61					
	62		Limestone, mgrBr m-c crystalline, fossiliferous, occ siltstone, v hd v dense			
	63			63.4 Run 7		
			Limestone, shaley (as above)			
	64					
	65					
	66					
			Limestone, mgrBr (as above), oolitic	5.0 / 5.0		
	67			-0.1		
	68		Base of Golconda			
			Top of Big Clifty Fm: 68.3 Shale, vdGr, th bd, platy-flaky, abunda. carbonaceous flakes & specks along bd, hd	68.4 Run 8		
	69					
				69.4		Full depth
	70					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. [redacted] 8

SHEET

.LING LOG | DIVISION | INSTALLATION

T

10. SIZE AND TYPE OF BIT

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

ON (Coordinates or Station)

12. MANUFACTURER'S DESIGNATION OF DRILL

NG AGENCY

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED

NO. (As shown on drawing title and number)

14. TOTAL NUMBER CORE BOXES

OF DRILLER

15. ELEVATION GROUND WATER

CTION OF HOLE

16. DATE HOLE | STARTED | COMPLETED

ERTICAL ☐ INCLINED _____ DEG. FROM VERT.

17. ELEVATION TOP OF HOLE

KNESS OF OVERBURDEN

18. TOTAL CORE RECOVERY FOR BORING %

TH DRILLED INTO ROCK

19. SIGNATURE OF INSPECTOR

AL DEPTH OF HOLE

ATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Shale (cont.)			
	71			1.4 / 5.5		Core between 69.8 + 73.9 (4.1') dropped out of core barrel during removal from boring
				-4.1		
	72					Ran a 5 7/8 in. RR 5.5 to 74.5, ground down [illegible]
	73					Set casing (4" PVC) to a depth of 74.5' & Grouted casing in.
					73.9 RR 5.5 74.5 Run 9	
	74					
	75					
	76					
	77		shale is fossiliferous in lower zone			
	78			9.0 / 9.3		
			Limestone, m-c Gr m-c Crystalline or shale, sds fossiliferous v hd, v dense (foil hor. bedding)	-0.3		
	79					
			num sh pts. (79.3-80.1)			

PROJECT

HOLE NO.

...IONS ARE OBSOLETE.

Page No.

DRILLING LOG

DIVISION

INSTALLATION

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM
12. MANUFACTURER'S DESIGNATION OF DR
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80					
	81		Shale, ldGr, th bd, platey-flaky, hd carbonaceous flakes + specks along bd			
	82					
	83			83.8		
	84					
	85					
	86					
	87		Shale, dgnGr in top grading to olive tan w/depth, mass, mod hd.		10.0 / 10.2	
	88					
	89		oxidized in bot zone			
	90		Top of Eq. Silt, SS - 89.4			

PROJECT

HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-3-C17-A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Sandstone, lolive tan, th bd w/shallow ripples, vf uniform grained, Lim incrusted inclus in top few feet along w/occ shaley pts.			
	91					
	92	80	tight			Lost ~ 75% of drill water at about 92.0'
		0	open			
	93					
				74.0 / Run 11		
	94					
	95					
	96					
	97	30 / 75 / 20		9.8 / 9.8		
	98					
	99	5 / 0				
	100					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Sandstone (Cont.)			
		4.2				
	101					
	102	0				
		5				
	103	0				
		5		103.8		
				Run 12		
	104					Lost all water return at beginning of Run 12
		5				
	105					
	106	10				
				10.0 / 13.2		
	107	0	Lim sh			
		0				
		20	Tuff			
	108	20		-0.2		
		5				
		5				
	109					
	110	15				

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

(TRANSLUCENT)

Hole No. WES-3-C17 ~~06~~

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		SS (cont.)			
	111	30				
		60	clay sim			
	112					
	113					
		5				
	114			114.0	Run 13	
			Lim stn, Rusty Br.			
		40				
		5	stn (blk)			
	115	3				
		0	stn			
	116					
		40				
	117	6				
					9.3 / 10.0	
	118					
		0	stn			
		0				
	119		silt stn			
		3			-0.7	
		5				
	120					

PROJECT | HOLE NO.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

No. WES-3-17-46

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120		SS (as above)			
	121	0	Stn, Bk			
		45	Blk. stn			
		5				
	122	90	stn			
		5	Lim coated			
		45				
	123	45				
				124.0		
	124			Run 14		
	125					
		0	Lim stn			
	126					
		0				
	127	0				
		10	Coarser grained, oxidized Rusty Br. (Lim stn)			
		0				
	128	0			10.0/10.0	
		5				
		0				
		5				
	129		LS, lgr Br, fossiliferous, v hd v dense, oxidized in part.			
		0	SS (as above)			
			LS. (as above)			
	130	0				

PROJECT — HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130		SS (as above			
			sd; ls high - oxidized			
	131		Top of Beech Creek - 130.8'			
			Limestone, lgr Br, m-c crystaline fossiliferous occ stylolites, v hard, v dense			Water level at 131.4' after completion of boring and removal of drill stem from Bot. (149.5')
	132					
	133		Tight — Joints are irregular rough and most are stained. Tight			
	134			134.0 Run 15		
			L Gr soft clay			
			stn open sts			
	135		sts are stained			
	136					
			Lim stn			
	137				9.5 / 10.0	
			Lim stn			
	138		Lim stn — (Base of excavation) 139.0'			
			Limestone, similar to above but dkr fine-med crystaline - occ wavy, stylo, etc.		-0.5 -0.1	
	139		stn			

PROJECT — HOLE NO.

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No. WE-[illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET 15 OF 15 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140		LS (Cont.)			
			Sh			
	141					
	142					
	143			143.0		Full drop
				144.0		
	144			Run 16		
			Sh			
	145		Sh			
	146			5.9 / 5.5		
	147		Eleven Sh inclus in bot 0.2-0.3'	+0.4		
			Bsp of Beech Creek - 147.8'			
	148		Top of Eleven Fm. Shale, dgrGn massive blocky hard, occ gr Br Cole inclus.			
	149			149.5		
	150		Bot. 149.5'			

PROJECT — HOLE NO.

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DRILLING LOG

DIVISION	
INSTALLATION	
SHEET OF SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
~696.6			Well No: WES-3-C17-16 (Beech Creek 1.5)			Date well screen was set: 3/19/87
			42.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen – 131.4
			21.0			
			Bentonite Pellets			Teflon pipe between 123.5 to 149.5
			89.0			
			Filter Pack			
			133.5			
			Well Screen			
			143.5			
			Trap			
			149.5			
			149.5 Boring Depth			

PROJECT | HOLE NO.

Hole No. WES-3-C20-R

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane Ind	SHEET 1 OF 12 SHEETS

1. PROJECT: Hydrogeologic Studies, ABG
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): 3-C20
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 0.0
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 120.0
10. SIZE AND TYPE OF BIT: HQ wireline
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 5/19/87 COMPLETED 5/23/87
17. ELEVATION TOP OF HOLE: ~ 644.9
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF ~~INSPECTOR~~ Geologist: Richard W Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Shale, olive yel-olive Gr, th bd, w/ sdy pts, platy			0.0 to 10.0' - R.R. Bit. Set 6" dia PVC surface casing. Started coring with HQ wireline at 10.0'.
	1		Note: Dozer cut next to drill site shows shale extends ~ 4.0' above boring. A 1.0' coal bed overlies the shale bed above the boring ground surface.			
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					

PROJECT | HOLE NO.

Hole No. WES-3-C20-A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3- C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Sandstone, lGr, mass, fine grained, hd, friable	Run 1		
	11					
	12					
	13					
	14			9.5/10.1		
	15		Shale, dGr, th bd, hd, platey.	-0.6		
	16		Sandstone, r-yBr, Gr + Blk, th bd, (wavey bd) w/ carbonaceous, sh + coal pts + swirls, hd, Friable			
	17					
	18					
	19					
	20					

PROJECT | HOLE NO.

WES-3-C20-82

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3.- C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont.)	20.1 / Run 2		
	21					
	22					
	23					
	24			9.6 / 9.9		
	25			-0.3		
	26		(Base of Penn Sediments)			
			(Top of Miss Sediments) (Golconda/Haney Fm)			26.7'
	27		Shaley Limestone – Limey Shale, m-dGr, th bd, hd, fossiliferous			
	28					
	29					
	30			30.0		

PROJECT | HOLE NO.

Holbrook WRC-3-C20-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number) 3 - C20	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Shaley Ls (cont.)	Run3		
			Shale, vd Gr, th bd platey			
	31		Limestone, l-m grBr, m-c crystaline, fossiliferous, v hd, v den			
	32					
	33					
				9.0 / 9.0		
	34					
	35					
	36		Limey Sh (as above)			
	37					
	38					
			(Base of Gatconda/Honey)	39.0		39.0'
	39		(Top of Big Clifty fm) (Indian springs mem)	Run4		
			Shale, vd Gr-Blk, th bd carbonaceous platey-flaky			
	40					

PROJECT | HOLE NO.

Hole No. WES-3-C20-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3- C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Shale (cont.)			
	41			4.1/4.1		
	42					
	43			43.1		
				Run 5		
	44					
	45					
	46			9.3/10.0		
	47			-0.7		
	48					
	49					
	50					

HOLE NO.

Hole No. WES-3-C20-DC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number) 3 - C20	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Shale (cont.)			
	51					
	52					
	53			53.1 Run 6		
	54					
	55		alter ss lenses			
	56		Shale becomes olive Gr, mass, oxidized in bot 1½'	10.0 / 10.1		
	57			-0.1		
	58					
	59		(Base of Indian Springs) (Top of Bgclift, SS) (Cont.)			59.2'
	60					

HOLE NO.

WES-3-C20-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Sandstone, olive Yel-Br, th bd-mass, shallow ripples, oxidized, hd, friable			
	61					
	62					
	63			63.2 Run 7		
	64					
	65					
	66			10.0/10.0		
	67					
	68					
	69					
	70					

PROJECT | HOLE NO.

Hole No. WES-3-C20-B

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number) 3-C20	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Sandstone (cont.)			
	71					
	72					
	73			73.2 / Run 8		
	74					
	75					
	76			10.0 / 10.0		
	77					
	78					
	79					
	80					

HOLE NO.

Hole No. WES-3-C20-B

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		SS (Cont.)			
	81					
	82					
	83			83.2		
				Run 9		
	84					
	85					
	86					
				10.0 / 10.0		
	87					
	88					
	89					
	90					

Hole no. WES-3-C20-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		Sandstone (cont.)			
	91					
	92					
	93			93.2		
				Run 10		
	94					
	95					
	96					
				10.0 / 10.0		
	97					
	98					
	99					
	100		(Base of Big Cliff fm) / (Top of Beach Rock fm)			99.8'

HOLE NO.

WB-3-C20-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Limestone, 1-m grBr, m crystalline, fossiliferous, v hd, vdcn, occ stylolites			
	101					
			Solutioning on Ls at above contact.			Base of Oxidation ~102'
	102					
	103			103.2 / Run 11		
	104					
	105					
	106			9.3 / 9.3		
	107					
			Ls changes to dGr, f-m crystalline occ wavy shaley pts			
	108					
	109					
	110					

PROJECT | HOLE NO.

Hole No. WES-3-C20-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 12 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3-C20	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		LS (cont.)			
	111					
	112			112.5	Run 12	
	113					
	114					
	115			6.3 / 6.3		
	116					
	117					
	118		(Base of Beach Creek fm)			118.6'
			(Top of Ellwren fm)	118.8	Run 13	
	119		Shale, Gn, mass	0.9 / 1.2		
	120		Tot. Depth - 120.0'	-0.3		

HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-CLO-86 (Beach Creek Ls)			Date well screen was set: 5/21/87
~647.4			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen – 89.0'
			56.0			
			Bentonite Pellets			Teflon Pipe – 83.0 – 119.0'
			59.5			
			Filter Pack			
			108.0			
			Well Screen			
			118.0			
			Trap			
			119.0			
			120.0 Boring Depth			

PROJECT | HOLE NO.

DRILLING LOG	DIVISION US Navy	INSTALLATION Nwsc Crane In	SHEET 1 OF 8 SHEETS

1. PROJECT: Hydrogeologic Studies
2. LOCATION (Coordinates or Station): ABG (Johnson Hollow)
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-3-C25-86
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 8.0'
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 70.7'
10. SIZE AND TYPE OF BIT: HQ wireline
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 6/17/87 COMPLETED 6/18/87
17. ELEVATION TOP OF HOLE: 595.0'
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Sandy silt - Silty Sand (ML-SM), yBr-rBr, w/ num oxidized SS frags, cobbles & pebbles, mod soft, moist. (Alluvium)			Drilled 0.0 to 10.5' w/ 7" folding Auger
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8		Base of Valley Fill 8.0'			
	9		Shale olive - olive gray, mass, v firm slightly moist weathered (Indian springs member of Big Clifty fm)			
	10		Base of Shale 10.0'			

PROJECT | HOLE NO.

ENG FORM 1836, 1 DEC 68, WHICH IS OBSOLETE

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		(Top of Big Clifty SS – 10.0')			
				10.5' Run 1		Started coring w/ HQ wireline at 10.5'.
	11	0	Sandstone, lyel-olive Tan v fine uniform grained, th bd with shallow ripples mod hard, friable, oxidized w/ Lim stn along Jts.			
		0				
		0				
	12	0				
		0				
	13	0				
	14					
		0				
	15	0		9.2/10.0		
		0				
		0				
		99				
	16	0				
		10				
		77		-0.7		
	17	32				
	18	40				
	19					
	20	0				

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 3 OF 8 SHEETS	
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	
5. NAME OF DRILLER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED / COMPLETED
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING %	
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont.)	20.5		
				Run 2		
	21	0				
		0				
	22				22.1	
		0				
	23					
		0			Box	
		60				
	24				2	
		45			of	
				9.7 / 10.0	6	
	25					
		0		-0.3		
	26					
	27					
	28	30				
		30				
	29					
	30					

PROJECT

HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		SS (Cont.)			
				30.5		
				Run 3		
	31					
	32					
		39				
	33					
	34				34.3	
		0	Calcareous SS	10.1 / 10.2		
	35	0			Box	
				-0.1		
	36	5			3	
	37				of	
					6	
	38					
	39					
		0				
	40	0				

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (Cont)			
				40.7 / Run 4		
	41					
	42					
	43	20				Lost all drill water at ~42.6'
	44					
		0				
	45			10.2 / 10.2	45.7	
	46				Box-	
	47				4	
		0				
		2			of	
		0				
	48				6	
			Stoing pass in bot from front of ss.			
	49	0				
	50	0				

PROJECT | HOLE NO.

ENG FORM 1836-1 PREVIOUS EDITIONS ARE OBSOLETE

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50	20 / 10	SS (Cont.)			
				50.9		
	51	0		Run 5		
		0	Base of Big Cliffy SS - 51.6'			
			Top of Beech Creek Ls			
	52	0	Limestone, l-m gr Br, m-c crystalline, fossiliferous, v hard, v dense, occ stylolites.			
	53					
	54					
	55	0		10.1 / 10.1		
	56					
					56.9	
	57				Box	
	58	0	Ls becomes d Gr below ~58'		5	
	59	0 / 5			of 6	
	60	0				

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 7 OF 8 SHEETS	
1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Ls (cont)			
				61.0		
	61			Run 6		
	62					
	63					
	64					
	65		see wavy shaley pts in lower zone			
	66					
	67					
	68					
	69					
	70					

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Base of Beech Creek Ls - 70.5			
			Top of Elwren Shale, dGn			
			Bottom Depth - 70.7'			

END FORM

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C25-86 (Beech Creek Ls)			Date well screen was set: 6/18/86
597.5			+2.5			
595.0			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting screen - 44.4
			7.5			
			Bentonite Pellets			
			10.5			
						Teflon Pipe - 39.4 to 70.7'
			Filter Pack			
			59.7			
			Well Screen			
			69.7			
			Trap			
			70.7 ?			
			70.7 Boring Depth			

HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC Crane In	SHEET 1 OF 11 SHEETS

1. PROJECT: Hydrogeologic Studies
2. LOCATION (Coordinates or Station): A86
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-3-C26-86
5. NAME OF DRILLER: Don Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 0.0
8. DEPTH DRILLED INTO ROCK: 105.7'
9. TOTAL DEPTH OF HOLE: 105.7'
10. SIZE AND TYPE OF BIT: HQ Wire line Core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: ; UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 7/28/87; COMPLETED 8/3/87
17. ELEVATION TOP OF HOLE: 638.6
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Shale / Clayshale, olive Gr w/rusty Br Lm stn, th bd, very firm (wea), occ carbonaceous streaks (Hardinsburg Fm)			Split spoon spl's, from 0.0 to 13.5. Dozer cut down ~4' from ori surface in leveling drill site.
	1			1.5		
	2					
	3			3.0		
	4			4.5		
	5					
	6			6.0		
	7			7.5		
	8					
	9			9.0		
	10					

PROJECT | HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Shale (Cont.)	10.5		
	11					
	12			12.0		
	13					Ran 6 3/4" RR Bit to 14.2 & set 6" pvc casing to 14.2'
			∴ Base of Hardinsburg Sh	13.5		
			Top of Cokerdale/Hanna Ls (mississippian)	RR Bit		
	14		Limestone yBr & highly wea in top 1.3', grades into lgr Br, oxidized, med crystalline fossiliferous, v hard, v dense, Lim stn & solutioning along jts & bedding	14.2 Run 1		Started Coring w/HQ wireline rigging.
	15					
	16			7.1 / 9.5		
	17					
	18			-2.4		
	19		Drill action indicated soft zone between 18.5' & 20.5'; possibly highly wea shaley zone or cavity.			
	20					

PROJECT | HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Ls (Cont.			
	21					
	22					
	23			23.7		
	24			Run 2 1.8/2.1		
	25		Base of Colorado/Hona Top of Indian Spring Sh - 25.0' (Big Cliffy fm)	-0.3		
	26		Shale Blk-vd Gr, th bd, platey, hard, Carbonaceous flakes along bedding,	25.8 Run 3 0.8/1.0 -0.2 26.8		Blocked
	27			RR 8.1		Reamed hole to 28.1' + set 4" dia PVC casing thr the 6" upper casing.
	28			28.1 Run 4		
	29			5.0/5.2 -0.2		
	30					

PROJECT | HOLE NO.

Hole No. WES-3-026-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 11 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Shale (cont.)			
	31					
	32					
	33			33.3 Run 5		
	34					
	35					
	36			6.1/9.6 -3.5		Core was stuck in inner bl. & had to be dug out. Core loss due to mech reasons.
	37					
	38					
	39					
	40					

PROJECT | HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Shale (cont.)			
	41					
	42			42.9		
	43		Shale/clayshale, olive-olive Gr, mass, wea, w/lim stn, occ fossils	Run 6		
	44					
	45			10.1/10.1		
			Base of Indian Spring Sh			
	46		Top of Big Clifty SS - 45.8			
	47		Sandstone, olive Gr - Tan, th bd to mass, v fine grained, hard, friable, shallow ripples, oxidized.			Lost all drill water Return in sandstone
		5	stn num wavey shaley pts from 45.8 to 49.7'.			
	48					
	49					
	50					

PROJECT | HOLE NO.

Hole No. WES-3-026-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Sandstone (cont)			
	51					
	52	15				
				53.0		
	53			Run 7		
	54					
	55					
		10				
	56	0		10.0 / 10.0		
	57					
	58					
	59					
	60					

PROJECT | HOLE NO.

Hole No. WES-3-C26-26

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60	70/	Sandstone (cont)			
	61					
	62	10				
	63			63.0 Run 8		
	64					
	65					
	66			9.6 / 9.6		
	67					
		0				
	68					
	69					
		60/				
	70	3				

PROJECT | HOLE NO.

Hole No. WES-3-226-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70	45	stn SS (Cont.)			
	71					
	72			72.6 / Run 9		
	73	5				
	74		Rusty Br f-m grained Cross bedded			
	75	30				
		5	Jts are tin stn'd	9.5 / 9.5		
	76					
	77	45 / 30				
	78					
	79					
	80					

PROJECT | HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		SS (Cont.)			
	81					
	82			82.1 Run 10		
			← Base of major oxidation 82.5'			
	83					
			Base of Big Cliff SS			
			Top of Beech Creek Ls - 83.6			
	84		Limestone, lgr Br, mod crystalline, fossiliferous, v hard, v dense, occ stylolites			84.1 ~ Base of all oxidation
	85			6.9 / 7.0		
				>0.1		
	86					
	87					
	88					
	89			89.0 - 89.1 Run 11		Pull depth
	90					

PROJECT HOLE NO.

Hole No. WES-3-226-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90		LS (cont.)			
	91			4.2/4.1 +0.1		
	92					
	93			93.2 Run 12		Flange
	94		Limestone (as above) but dGr, f-m crystaline, occ to num wavy shaley pts.			
	95					
	96			10.0/10.0		
	97					
	98					
	99					
	101					

PROJECT | HOLE NO.

Hole No. WES-3-C26-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 11 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Limestone (cont.)			
	101					
	102					
	103			103.2		
				Run 13		
			Base of Beaufi Creek Ls			
	104		Top of Elsworth Sh - 103.9			
			Shale, dGn, mass hard, occ pyrite nodules	2.5 / 2.5'		
	105			105.7'		
	106		Bot Depth - 105.7'			

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-3-C26-86 (Beech Creek LS)			Date well screen was set: 8/3/87
641.1			+2.5			
638.6			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen - 78.0
			42.0'			
			Bentonite Pellets			Teflon Pipe from 73.7' to 105.0'
			46.0			
			Filter Pack			
			94.0'			
			Well Screen			
			104.0.			
			Trap			
			105.0			
			105.7 . Boring Depth			

PROJECT HOLE NO.

Hole No. WES-3-C27-86

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NWSC	SHEET 1 OF 8 SHEETS

1. PROJECT Hydrogeologic Studies ABB	10. SIZE AND TYPE OF BIT HQ Wireline Core
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) C27	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 8/12/87 COMPLETED 8/13/87
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE 602.14
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 73.3'	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, yBr, sandy, w/ss frags, v firm (CL)			Sampled from 0.0 to 17.7' w/a 3" dia split spoon (pushed downward rather than driving) Cleaned boring w/a 8" dia flight auger. Set 6" dia PVC Casing to 17.7' Started Coring w/a HQ wireline rigging at 17.8'
	1					
	2		Clay, (CH) yTan + lGr (mottled) w/red + blk specks, occ SS frags. v firm. stiff, (wea. Indian Springs Shale mem.)			
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					

PROJECT | HOLE NO.

Hole No. WES-3-227-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10		Clay (wea shale) (Cont.)			
	11					
	12					
	13					
	14					
	15					
	16		Sandy toward bot. w/ num. manga inclus (balls)			
	17					
	18	40 / 10	Sandstone (Big Clifty fm), yel-olive Tan, mass, highly oxidized, friable, highly jtd w/ lim + clay along jts.	17.8 Run 1		
	19	10 / 60 / 15		5.7 / 5.7		Lost all drill water return in first run.
	20	15				

PROJECT | HOLE NO.

Hole No. WES-3-C27-DC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20	30 60 30	Sandstone (cont.)			
	21	10 10 50 30				
	22	5 50 5				
	23	10 5 80 5		23.4 / Run 2		
	24	5 10				
	25	0 30 60 20				
	26	80 5		9.5 / 10.0		
	27	30 5 20 10		-0.5		
	28	5 5 5				
	29					

Hole No. WES-3-C27-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30	5	Sandstone (cont.)			
		0				
		0				
	31	5				
		5				
		30				
	32					
	33	20				
		5		33.4 / Run 3		
		10				
	34	10				
	35	5				
	36			10.0 / 10.0		
	37					
	38					
		20				
		20				
	39	20				
		10				
		30				
		90				
		60				
	40	2				

PROJECT | HOLE NO.

Hole No. WES-3-C27-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40	15	Sandstone (cont.)			
		10				
		10				
		10				
	41	10				
		5				
	42	5				
		30				
	43	0				
				43.4 / Run 4		
		0				
	44	40				
		10				
		70				
	45	0				
		0				
		5				
	46	5				
		30		9.0 / 10.0		
	47	5				
		0		1.0		
		40 / 5				
	48	45 / 10				
		30				
	49	60				
		10				
		60				

Hole No. WES-3-C27-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 8 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50	S	Sandstone (cont.)			
	51	85 85				
	52					
	53			53.4' Runs		
	54					
	55					
	56		— Ton-Br sdy clay in cavity (Core loss zone)			
	57			4.2/7.2		
	58	S	(Beech Creek fm - 58.1)			
		d	Limestone, dGr + Br, f-m crystalline, fossiliferous v hd, v dense, oxidized in top zone occ stylolites	-3.0		
		d				
		d				

PROJECT | HOLE NO.

Hole No. WES-3-C27-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Ls (cont.)			
				60.6		
				Run 6		
	61					
			Base of oxidation (61.6')			
	62					
				4.6 / 5.2		
	63			-0.6		
	64		num shaley pts in bot. zone			
	65					
				65.8		
	66			Run 7		
	67					
				3.5 / 3.8		
	68			-0.3		
	69					
				69.6		
				Run 8		
	70					

PROJECT HOLE NO.

Hole No. WES-3-C27-BC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 8 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Base of Beech Creek fm	70.4'		
			Top of Eheron fm			
	71		shale, dl grGn, mass v firm-hd, w/r Br mottling in bot ft.			
	72					
	73					
			Bot. Depth - 73.3'			
	74					
	75					

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
604.64			Well No: WES-3-C27-86 (Beech Creek Ls)			Date well screen was set: 8/14/87
			+2.5			
			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting Screen – 55.4'
			15.0			
			Bentonite Pellets			
			18.0			
			Filter Pack			Tefla. Pipe – 50.5 to 71.5'
			60.5			
			Well Screen			
			70.5			
			Trap			
			71.5			
			73.3 Boring Depth			

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION US. Navy	INSTALLATION NWSC	SHEET 1 OF 27 SHEETS

1. PROJECT Hydrocoalosie Studies, A 86	10. SIZE AND TYPE OF BIT HQ Wire line Core
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-3-C30-86	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 9/2/87 — COMPLETED 9/15/87
	17. ELEVATION TOP OF HOLE 777.21
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR Geologist R. W. Hunt
9. TOTAL DEPTH OF HOLE 263.6	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Residual Soil, silty clay & clayey, sandy silt with weathered sandstone frags.			Ran 7 3/4" dia R.R. Bit to 11.4' and set 6" dia PVC Surface Casing.
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10					
	11		Top Rock -	11.4		
			Sandstone, yel-rusty Br, oxidized, fine grained, shallow cross bd, hard, friable.	Run 1		Started Coring w/HQ wireline rigging at 11.4'
	12					
	13					
	14					
	15			5.6 / 7.1		
	16			-7.5 -1.4		
	17					
	18		Sandstone similar to above, but with num dGr thin shale lens. bd. dip ~3°.	18.5 Run 2		18.4 - Pull Depth
	19					
	20					

PROJECT | HOLE NO.

Hole No. WES-3-C80-87

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20					
	21			4.8 / 4.7		
	22			22.1		
	23			23.2 Run 3		
	24		no apparent oxidation below ~ 23.8.			
	25					
	26		Shale, dGr, th bd, platey, hd.	9.9 / 9.9		
	27		Coal, Blk, blocky hd.			
	28		Siltstone - Claystone, olive gray, mass, hd, blocky, numi carbonaceous leaf imprints, etc.			
	29					
	30					

PROJECT | HOLE NO.

Hole No. AVES-3-C39-DC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	30		Siltstone (cont)			
	31					
	32					
	33			33.1		
				Run 4		
	34					
			Shale, Blk, th bd, indurated, blocky, carbonaceous, occ dark hd claystone nodules.			
	35			9.0 / 10.0		
	36					
				.10		
	37			.0.5		
	38					
	39					
	40					

PROJECT | HOLE NO.

Hole No. W ES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 27 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Shale, (Cont)			
	41					
	42			42.6		Pull Depth
	43			43.1 R4n5		
	44		Sandy Siltstone Gr mass, becoming th bd w/ depth, hd			
	45					
	46			10.0 / 9.5		
	47			46.5		
	48					
	49					
	50					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50		Siltstone (cont)			
	51					
	52					
			Sandstone, 1-m Gr, v fine, w/occ to num Blk wavy carbonaceous shale pts + thin lens, scattered coal pts, hd, friable.	52.6 / Run 6		
	53					
	54					
	55					
	56			9.7 / 10.2		
	57			~~0.5~~ 0.2		
	58					
	59					
	60		Shale, Blk, silty, th bd, indurated.			

PROJECT | HOLE NO.

Hole No. WFS-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 27 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Shale (cont.)			
	61		Claystone, m-olive, th bd, mass, soapy texture, crumbly, with slickensides.			
	62			62.5 / 62.8 Run 7		Full depth
	63					
	64		Shale blk-vdGr, th bd, indurated hd, carbonaceous, occ d olive hd siltstone-claystone nodules			
	65					
	66			10.3 / 10.0 +0.3		
	67					
	68					
	69					
	70					

PROJECT | HOLE NO.

Hole No. WES-3-C30-BC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 8 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	70		Shale (cont)			
	71					
	72					
				72.8		
				Run 8		
	73					
	74					
	75					
	76			9.7 / 10.0		
	77					
	78			.03 / .01		
	79					
	80					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Shale (cont.)			
	81					
	82			82.6 / 82.8 Run 9		Pull depth
	83					
	84					
	85					
	86			10.2 / 10.0		
	87		Sandstone, dgrBr, shaly, (clastic?), contains thin (sh) shaley swirls and wavy pts, hd, partly oxidized,	10.2		
	88					
	89					
	90					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90					
			Sandstone, clastic, shaley, lGr + Blk, wavy th bd, carbonaceous, hd.			
	91					
	92					
				92.8		
				Run 10		
	93					
	94					
	95					
	96			9.8 / 10.0		
			Coal, Blk, blocky, hd			
	97					
			shale, vdGr-Blk, th bd, platey, carbonaceous, hd	-0.2		
	98					
	99					
	100					

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 11 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Shale (cont.)			
	101					
	102			102.6 / 102.8 Run 11		pull depth
	103					
	104					
			Coal, Blk, blocky, hd			
	105		Sandstone, lGr, mass, v fine, carbonaceous, hd, friable			
			Siltstone, lGr-olive Gr, mass-th bd, num carbonaceous leaf imprints-etc, hd, blocky-crumbly			
	106					
	107				10.2 / 10.0	
	108				+0.2	
	109					
	110					

PROJECT | HOLE NO.

Hole No. WES-3-C30-B6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	110		Siltstone (Cont.)			
	111					
	112		Sandstone, lGr with num vdGr wavey shaley pts, v fine grained hd friable, carbonaceous in lower half.	112.8		
				Run 12		
	113					
	114					
	115					
	116			10.2 / 10.2		
	117					
	118					
	119		Sandstone lGr w/yel tan oxidized zones, th bd - mass, fine, shallow cross-bd, hd, friable			
	120					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 13 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120		Sandstone (cont.)			
	121					
	122					Penn Sediments
			Base of Pennsylvanian at 123.0'.	123.0		— Unconformity - 123.0'
	123		Limestone (Glen Dean) Gr fine crystaline oolitic, v hd, v dun. (Solution surface on top) (Base of Glen Dean fm - 124.2')	Run 13		Miss- Sediments
	124		Top of Hardinsburg fm			
	125		Shale, dGr, th bd, silty, hd, platey-flakey.			
	126			7.5/7.5		
	127					
	128		wavy siltstone + sh laminations			
	129					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	130		Shale (cont.)	130.5 Run 14		
	131					
	132			0.7 / 2.6		131.9 - Pull depth
				1.9 - 0.7		
	133			133.1 Run 15		133.1 + 1.2 = 131.9
	134		Sandstone, f-m Gr w/oxidized yel-tan zones, mass, v fine, cross-bedded, hd, friable.			
	135					
	136			9.0 / 8.0		
	137			1.2 + 1.2		
	138					
	139					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 15 OF 27 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140		SS (Cont.)			
				140.9		pull depth
	141			141.1		
				Run 16		
	142					
	143					
	144					
	145			10.2 / 10.0		
	146		num Blk wavey Carbonaceous sh pts + thin lens.	+0.2		
	147					
	148					
	149					
	150		Shale, dGr w/silter			

PROJECT | HOLE NO.

Hole No. ~ES-3-C30-C

DRILLING LOG	DIVISION	INSTALLATION	SHEET 16 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	150		lGr SS lens			
	151		Sandstone, lGr (similar to above	151.1 Run 17		
	152					
	153		Shale, w/alter sandstone lens (as above			
	154		Sandstone, lGr, w/num wavy dk gray shaley pts hd, friable	6.9 / 7.4		
	155		Shale, vd Gr, th bd, w/occ thin lGr SS lens, plaky, hd, occ pyrite nodule	~~.05~~ -0.4		
	156					
	157					
	158					
			shale, d Gn in top few feet, grading to vd gn Gr toward bot, mass + blocky in top zone; th bd + flakey in bot zone, num slickensides, hd	158.5 Run 18		158.4 - Pull depth
	159					
	160					

PROJECT | HOLE NO.

Hole No. WES-3-C30-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 17 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160		Shale (Cont			
	161					
	162			6.3 / 10.1		
	163			~~3.8~~ +0.1		
	164			164.7		Pull depth
	165					
	166					
	167					168.6 − 3.9 = 164.7
	168					
			Base of Hardinsburg fm	168.6		
	169		Top of Golconda / Haney fm - 168.6'. Shaley, fossiliferous limestone - limey shale, th bd, dGr, w/occ 1 Gr dense Ls	Run 19		
	170					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 18 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED: — COMPLETED:
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	170		lens & thin layers, hd.			
	171			8.5 / 5.0		
	172			~~+3.5~~ +3.9		
	173		Shale, vd Gr, th bd, platey	173.2 / 173.6 Full 20		Full Depth
	174					
	175		Limestone, l-m grBr, m-c crystalline, w/ fossils, v dense, v hd.			
	176			10.2 / 9.8		
	177			+0.4		
	178					
	179					
	180					

HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 19 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	180					
			Shaley Ls (as above)			
	181					
			Crystaline Limestone (as above)			
	182					
	183		Base of Colorado / Honey	183.4 Run 21		
			Top of Indian Springs Sh (Big Clifty mem.) - 1833'			
	184		Shale, vdGr-Blk, th bd, carbonaceous, plaky - flaky, hd.			
	185			3.5/4.2		
	186			-0.7 -0.3		
	187			187.2		Pull depth
				187.6 Run 22		
	188					
	189			6.2/5.8		
				4.4		
	190					

PROJECT | HOLE NO.

Hole No. WES-3-C30-BC

DRILLING LOG	DIVISION	INSTALLATION	SHEET 20 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	190		Shale (cont.)			
	191					
	192					
	193			193.4 / Run 23		
	194					
	195					
	196			9.7 / 9.7		
	197					
	198					
	199		Shale, becomes med olive Gr, mass, & crumbly below 199.1'			
	200.1					

PROJECT | HOLE NO.

Hole No. WES-3-C30-06

DRILLING LOG	DIVISION	INSTALLATION	SHEET 21 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	200		Shale (Cont.)			
	201					
			Base of Indian Springs Sh			
	202		Top of Big Clifty SS - 201.9'			
	203		Sandstone, 1-m Gr, mass w/shallow ripples, vF-F grained, hd, Friable.	203.1 / Run 24		
	204					
	205					
	206			10.0 / 10.1		
	207			10.1		
	208					
	209					
	210					

PROJECT | HOLE NO.

Hole No. WES-3-C30-R6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 22 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	210		Sandstone (cont.)			
	211					
	212					
	213			213.2 / Run 25		213.1 - Pull depth
	214					
	215					
	216			10.3 / 10.2		
	217					
	218			+0.1		
	219					
	220					

PROJECT | HOLE NO.

Hole No. WES-3 C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 23 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	220		Sandstone (cont.)			
	221					
	222					
	223			223.4 / Run 26		
	224					
	225					
	226			10.0 / 10.0		
	227					
	228					
	229					
	230					

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 24 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	230		Sandstone (cont.)			
	231					
	232					
	233			233.4		
				Run 27		
	234					
	235					
	236					
				9.6 / 10.0		
	237					
	238			0.4		
	239					
	240					

PROJECT | HOLE NO.

Hole No. W-ES-3-C30-96

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 25 OF 27 SHEETS	
1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	240		Sandstone (cont)			
	241		Conglomeritic in bot. 0.2'			
			Base of Big Mitty SS.			
	242		Top of Beech Creek Fm 241.8'			
			Limestone, l-m grBr, m-c crystaline, fossiliferous, occ stylolites.			
	243			243.4 / Run 28		
	244					
	245					
	246			10.2 / 10.2		
	247					
	248					
	249					
	250		Limestone (similar to above, but dGr,			

PROJECT | HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 26 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3. DRILLING AGENCY	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4. HOLE NO. (As shown on drawing title and file number)	14. TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	250		f-m Crystalline, occ to num wavy blk shaly pts.			
	251					
	252					
	253			253.6		
				Run 29		
	254					
	255					
	256					
				9.9/10.0'		
	257					
	258			-0.1		
	259					
			rounded inclus. of Elwren Shale in bot. 0.3'			
	260		Base of Beech Creek - 260.0'			

HOLE NO.

Hole No. WES-3-C30-86

DRILLING LOG	DIVISION	INSTALLATION	SHEET 27 OF 27 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	260		Top Eisren Shale 260.0'			
			dGn-grGn, mass, hard.			
	261					
	262					
	263			263.6		
			Bottom Depth 263.6'			
	264					
	265					

PROJECT | HOLE NO.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No.: WES-3-C30-86 (Beech Creek Ls.)			Date well screen was set: 9/17/87
779.71			+2.5'			
777.21			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen - ?
			~~Bentonite Pellets~~ None			
			188.0			
			Filter Pack (Pool filter Sand)			Teflon Pipe set between 210.1 to 261.5'
			250.5			Note: First attempt to set well was a failure - hole caved before sand was set. The entire riser pipe and screen was drilled out w/a R.R. bit. A second well screen and riser pipe assembly was set in the same boring.
			Well Screen			
			260.5			
			Trap			
			261.5			
			263.6 Boring Depth			

APPENDIX A.2

OLD RIFLE RANGE

Hole No. WES-6-11C-90

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC Crane In	SHEET 1 OF 4

1. PROJECT Hydrogeologic Studies Old Rifle Rg. Dam Site	10. SIZE AND TYPE OF BIT HQ wireline Core
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-6-11C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 3/7/90 — COMPLETED 3/8/90
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE TOC = 502.51
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 61.1	19. SIGNATURE OF INSPECTOR Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		silty clay, Br, soft, moist			0.0 to 13.5' drilled w/auger
			(2.0')			
	2		silty clay, y Tan, soft becoming v moist			
			(4.0')			
	4		silty-pebbly clay, y tan, ss pebbles, v soft, wet.			
	6		(6.5')			
			silty clay, y tan + Gr mottled, lim stn, v soft, moist			
	8					
	10					
	12					
				13.5'		set 6" casing to 13.5
	14			R.P. 0.1'		
			(15.3')	15.3		
	16		silty-sdy clay w/ ss cobble + boulder size frags (stream deposits), d Gr + d Gn color	Run 1		
	18			2.2/7.6		
				-5.4'		Lost ~70% water return
	20					

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Hole No. WES-6-11C-

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-11C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20					
	22					
	24		(24.1') (Big Cliffy ss) Sandstone, l tan Gr, th bd, rippled, vf, homo, sli friable, oxid in top 2'.	22.9' / Run 2		
	26					Losing ~20% wash return
	28			8.8 / 10.0		
				(-1.2')		
	30		Occ small pyrite nodules.	-1.0'		
	32			32.9' / Run 3		32.7' — pull depth
	34					
	36			9.8 / 9.6		
	38			+0.2		
	40		(Base Big Cliffy Fm) (39.6') (Top Beech Creek Ls)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-11C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-11C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Limestone, l-m gr Br, mass, m-c crystalline, fossiliferous, occ stylolites, hd dense.			
	42			42.5' Run 4		
	44					
	46		(46.0') Ls (as above) but d Gr, f crystalline, occ wavy shly pts.	10.2/10.2		
	48					
	50					Still Losing ~ 20% water Return
	52			52.7' Run 5		
	54			5.4/5.4		
	56		(Base Beach Creek Ls) (56.2') (Top Elwren Fm) Shale, d Gn, mass, occ ls nodules in top, hd, slickensides along jts.			
	58			58.1 Run 6 2.5/3.0 -0.5'		
	60					

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Hole No. WES-6-HC-9

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-HC-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Sh (cont.)	61.1		
			Bot. Depth- 61.1'			
	62					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-11C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-11C-90			Date well screen was set: 3/8/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (see Note)			Water level just Prior to setting screen -
			29.0			
			Bentonite Pellets			
			32.0			set surface casing to 13.5'
			Filter Pack			Note; 0.0 to 13.0 - Grout; 13.0 to 15.0 - Bentonite; 15.0 to 29.0 - Sand
			36.2			
			Well Screen			
			56.2			
			~~Trap~~			
			61.1 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS
1. PROJECT		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)	WES-6-11CP2-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED / COMPLETED
		17. ELEVATION TOP OF HOLE	
7. THICKNESS OF OVERBURDEN		18. TOTAL CORE RECOVERY FOR BORING %	
8. DEPTH DRILLED INTO ROCK		19. SIGNATURE OF INSPECTOR	
9. TOTAL DEPTH OF HOLE			

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-11CP2-90			Date well screen was set: 3/8/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen. –
			13.0			
			Bentonite Pellets			
			15.0			set 4" Surface casing
			Filter Pack			
			20.0			
			Well Screen			
			30.0			
			~~Trap~~			
			30.0 Boring Depth			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-6-12C

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC Crane In	SHEET OF
1. PROJECT Hydrogeologic Studies (Old Rifle Rg) Demo Site		10. SIZE AND TYPE OF BIT HQ wireline	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY WES		12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500	
4. HOLE NO. (As shown on drawing title and file number) WES-6-12C-90		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 3/9/90 / COMPLETED 3/12/90
7. THICKNESS OF OVERBURDEN 8.5'		17. ELEVATION TOP OF HOLE TOC = 522.70	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	
9. TOTAL DEPTH OF HOLE 82.8		19. SIGNATURE OF ~~INSPECTOR~~ GEOLOGIST Richard W. Hunt	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, Br-lBr, w/ num small ss frags			0.0 - 4.4' Drilled w/ Auger
	2					
	4		(4.4')	4.4		Set 6" pvc casing to 4.4' (Refusal)
			silty clay + ss frags + ss blocks.			Drilled 4.4 to 11.8 w/ R. P. Bit.
	6			R.		
				R.		
	8		(8.5)	Bit		
			(Coleanda fm) Limey shale/shaley limestone, th bd, d Gr, fossiliferous.			
	10					
				11.8		
	12			Run 1		Started coring w/ HQ wireline
				2.8/3.1		
	14			-0.3		
				14.9		
				Run 2		
	16		(16.4')			
			(Indian springs member) shale, d Gn, mass-th bd hd.	4.5/5.0		
	18			-0.5		
			sh + ls conglomerate (d Gn sh w/ m Gr ls angular inclus) (19.9')	19.9'		
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-RC-5

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-RC-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		(Top Big Clifty SS 19.5')	Run 3		
			Alternating silty vf gr Gr SS + d olive Gr sh lens.	2.6/2.9		
	22			-0.3		3-10-90 Reamed hole + set 4" pvc casing to 22.8'
				22.8'		
				Run 4		3/12/90
	24					
			25.4'			
	26		Sandstone, l olive Gr, mass, rippled, vf, homo, sli friable, sli oxid to 33.8'	9.4/10.0		
	28			~~0.6~~ -0.5		
	30					
	32			32.8'		32.7 Full depth
			(L Gr below 33.8') not oxidized	Run 5		
	34					(No Jts)
	36			9.9/10.0		
	38			~~-0.1~~ +0.1		
	40					

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PROJECT | HOLE NO.

Hole No. WES-6-12C-9

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-12C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (cont.)			
	42			42.8		42.6 Pull depth
				Run 6		
	44					
	46			10.1/10.0		
	48			+0.1		
				+0.2		Lost ~ 40% water return at ~ 48'
	50					
	52			52.6		52.7 Pull depth
				Run 7		
	54					Losing ~ 40-50% water return
	56			10.1/10.0		
	58			+0.1		
	60		(Base of big cliff in SS) (59.7') (TOP Beech Creek Ls)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-120-

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEET

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-120-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Ls, lt-m grBr, m-c crystalline, fossiliferous, occ stylolites, hd, den			
	62		(open)	62.8 Run 7		
	64					
	66		66.0' Ls (as above) but dGr, f-m crystalline, occ shly pts. (wavy)	9.7 / 10.0 9.7		40-50% water return
	68					
	70					
	72			72.5 / 77.8 Run 8		Pull depth - (based on core characteristics)
	74			-0.3 Blight Fracture		40-50% water return
	76		(Base Beach Creek Ls) 76.5' (Top Elwren Fm) Shale, d Gn, mass, hd, Ls nodules in top ft.	10.0 / 10.0		
	78					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE N

Hole No. WES-6-12C-9

DRILLING LOG	DIVISION	INSTALLATION	SHEET of 5

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-12C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80					
	82			82.8		
	84		Bot. Depth - 82.8'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-12C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-12C-90			Date well screen was set: 3/12/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting screen. – 6" PVC Casing to 22.8'
			42.0			
			Bentonite Pellets			Note: 0.0 to 22.0' - Grout; 22.0 to 25.0' - Bentonite; 25.0 to 42.0' - Sand
			45.0			
			Filter Pack			
			56.5			
			Well Screen			
			76.5			
			~~Trap~~			
			82.8 Boring Depth			

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PROJECT | HOLE NO.

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Hole No. WES-6-13C-9

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NWSC Crane In	SHEET 1 OF 4 SHEET

1. PROJECT: Hydrogeologic Studies Demo Site.
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-6-13C-90
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 62.9'
10. SIZE AND TYPE OF BIT: HQ wireline
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES: 4
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 5/10/90 COMPLETED 5/19/90
17. ELEVATION TOP OF HOLE: TOC = 507.66
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF ~~INSPECTOR~~ Geologist: Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		silty clay, dBr in top 2' changing to tan Br w/Gr mottling w/depth, soft, moist,			Drilled 0.0 to 22.5 w/ auger
	2					
	4					
	6		v moist below ~6'			
	8					
	10		silty clay becomes v soft & wet below ~ 11.0'			
	12					
	14					
	16					
	18		(18.0') silty clay, dGr, sli sdy, v soft, wet			
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-18C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-18C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Silty Clay (cont), becomes more sdy, firm & less wet below ~20.0'			
	22		Base of Alluvium (22.5')	22.5		Set 4" PVC casing to 22.5'
				22.8 Run 1		R.R.G.I. Started coring w/ HQ wireline at 22.8'
	24		Big cliffy wea SS?			
	26		? Core Ground away, probably Conglomeritic & clayey SS, may be stream deposit	3.5/7.9 -4.4		~50% water return
	28		SS Conglomerate, angular-sub rounded frags, oxid. (Big cliffy fm) Sandstone, l olive Gr, th bd, vf-f, sli fri, w/ alter shly pts, bd ~ hor to 20° dip.			
	30			30.7 Run 2		
	32		Lim stn frags, oxidized	2.3/3.3 -1.0		~50% water return
	34		? core loss	34.0 Run 3		
	36		(35.1) Sandstone similar to above w/o shly pts.	7.6/8.9 -1.3		Lost all water return at ~36.5'
	38		oxid; lim stn 37.9 ? core loss (Bot. Big cliffy fm) (39.2')			
	40		(Top Beech Creek fm) Limestone (cont.)			

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Hole No. WES-6-13C

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-13C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Limestone, lgt Br, m-c crystalline, mass, hd, dense, fossiliferous, occ, stylolites			
	42	10				
		0		42.9		
				Run 4		Ran out of water
	44	0	(44.0')			
		0	Ls, changes to dGr, f crystalline w/occ wavey, shaley pts, fossiliferous			
	46	0				
		0		10.0/10.0		
		0				
	48	3				
		0				
	50	0				
	52	0				
				52.9		Flange
						5/19/90
	54	0	(Base Beech Creek Ls) (54.5') (Top Elmren fm)			
			Shale, dGn, th bd, soft, crumbly			
	56			10.0/10.0		
			(58.0')			
	58		Shale, m-d Gn, th bd, w/alter vf silty sandstone pts spaced ~1/8" apart, ~hor bd, hard			
	60					

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PROJECT | HOLE NO.

Hole No. WES-6-13C-9

DRILLING LOG	DIVISION	INSTALLATION	SHEET of 4

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-13C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Sh (cont.)			
	62			62.9		
			Bot. Depth -62.9'			
	64					
	66					
	68					
	70					

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Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-13C-90
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-13C-90			Date well screen was set: 5/19/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (see Note)			Water level just Prior to setting screen -
			28.0			
			Bentonite Pellets			4" PVC Casing to 22.5'
			30.0			Note: 0.0 to 20.0 - Grout; 20.0 to 22.5 - Bent.; 22.5 to 28.0 - Sand
			Filter Pack			
			35.0			
			Well Screen			
			55.0			
			~~Trap~~			
			62.9' Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT | HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-13CP2-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-13CP2-90			Date well screen was set: 5/19/90
			+2.5			
			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting screen. –
			13.0			
			Bentonite Pellets			Set 4" Surface Casing
			15.0			
			Filter Pack			
			20.0			
			Well Screen			
			30.0			
			~~Trap~~			
			30.0 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-140-

DRILLING LOG	DIVISION U.S. Army	INSTALLATION Nwsc Crane In	SHEET 1 OF 3 SHEETS

1. PROJECT Hydrogeologic Studies (Old Ette Rg.) Domo Site
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY WES
4. HOLE NO. (As shown on drawing title and file number) WES-6-140-90
5. NAME OF DRILLER Don Taylor
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 52.7'
10. SIZE AND TYPE OF BIT HQ wireline core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 5/28/90 | COMPLETED 5/29/90
17. ELEVATION TOP OF HOLE TOC = 510.53
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, dBr, soft, moist			0.0-13.0 drilled w/ Auger
			1.0'			
	2		Silty-sdy clay, w/ SS grit + frags, v soft, v moist becoming wet-saturated below ~3.0'			
	4					(water 1½-2' from surface in auger hole)
	6		Pebbley clay (similar to above) (6.5')			
			Silty clay, y-tan w/ gray mottling, sli sdy, soft, moist, occ SS frags.			
	8					
	10					
			11.5			
	12		y-org vf sand (wea Big Cliffy SS) Soft, moist	13.0		Set 4" PVC casing to 13.0' Refusal
				Run 1		5/29/90 Started coring w/ HQ wireline at 13.0
	14		?			
			14.5			
	16		(Big Cliffy fm) Sandstone, y-tan, mass, vf-f, homo, oxid, sli friable.	8.1/9.6		
	18			-1.5'		
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-1KC-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 3

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-1KC-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont			
	22			22.6		
			SS is less oxidized below ~22.0'	Run 2		
	24					
	26		occ zones w/ silty shly pts, (rippled)	9.8/10.1		
	28			-0.3		
	30		(Base Big cliffy SS) 31.6'			Lost all water return at ~ 31.6'
			(Top Beech Creek Ls)			
	32		open at Limestone	32.7		Flange
			Limestone, lgr Br, m-c crystalline, fossiliferous, occ stylolites, hd, den	Run 3		
	34			22/2.2		
				34.9		
				Run 4		
	36					
	38		37.8'	7.6/7.8		
			Ls (as above) but dkr, f crystalline, occ many shaly pts.	-0.2		
	40					

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PROJECT | HOLE NO.

Hole No. WES-6-14C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 3 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-14C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Ls cont			
	42			42.7		42.5 _ drill depth
				Run 5		Note: Core loss carried below to top of sh.
	44			4.6 / 4.9		
	46			-0.3		
90.1' Ls-47.1			(Base Beech Creek Ls) (47.1') (Top Ehwren Fm)	47.1 / 47.6		drill depth Out of water
	48		Shale, dk gn massive bd fissile tendency. (soft sh) (core loss ground away)	Run 6 4.6 / 5.1		
	50			-0.5		
			51.3' sh becomes m-dk gn, hard, w/occ silty-sdy pts.			
	52			52.7		
			Bot Depth - 52.7'			
	54					
	56					
	58					
	60					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-14CPZ-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No. WES-6-14CPZ-90			Date well screen was set: 5/25/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			8.0'			
			Bentonite Pellets			Set 4" Surface casing.
			10.0			
			Filter Pack			
			15.0			
			Well Screen			
			25.0			
			~~Trap~~			
			25.0 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-14C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-14C-90			Date well screen was set: 5/24/90
			+2.5			
			0.0 Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting screen. -
			23.0			Casing to 13.0'
			Bentonite Pellets			
			25.0			Note: 0.0 to 13.0' Grout. 13.0 to 15.0' Bentonite. 15.0 to 23.0' Sand
			Filter Pack			
			28.0			
			Well Screen			
			48.0			
			~~Trap~~			
			52.7 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-18C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-18C-90			Date well screen was set: 6/14/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting screen. –
			31.0			4" Casing to 22.6'
			Bentonite Pellets			
			34.0			Note: 0.0 to 22.0 - Grout; 22.0 to 24.0 - Bent.; 24.0 to 31.0 - sand.
			Filter Pack			
			39.2			
			Well Screen			
			59.2			
			~~Trap~~			
			62.4 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NWSC, Crane In	SHEET 1 OF 4 SHEETS

1. PROJECT Hydrogeologic Studies (Old Ditto Rg) Demo Area	10. SIZE AND TYPE OF BIT HQ wireline Core
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-6-MC-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 1.5'	16. DATE HOLE — STARTED 5/25/90 — COMPLETED 5/26/90
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE TOC - 513.95
9. TOTAL DEPTH OF HOLE 62.2'	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, Si, soft moist 1.5'			Auger 0.0-1.5'
	2		(Big clifty SS)			R.R.B.t to 9.7 Set 6" Casing 2.5'
	4			R.P.		
				B.1		
	6		Sandstone, y tan, mass, thi bd, rippled, vf, homo, sli friable, highly oxid.			
	8			9.7		set 4" casing to 9.7'.
	10			Run 1		
	12					
	14			10.2/10.3		Breaks along bed (~ hor) are probably dissolution + sh spins.
				0.1		
	16					
	18					
	20			20.0'		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-15C-90

DRILLING LOG

DIVISION	
INSTALLATION	SHEET OF
1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-15C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont.)	Run 2		5/26/90
				2.2		
	22		Below ~20.0' there are many rounded dim nodules 1/8-1/4" dia. (oxid Pyrite)	22.2		
				Run 3		
	24					
	26			9.9/10.0		
				-0.1		
	28					
	30					
			Below ~30' is not oxid, 1 olive tan buff ss, w/pyrite nodules (as above)	32.2		
	32			Run 4		
			occ shly pts			
	34					
	36					
			shly pts	9.8/10.0		
	38			-0.2		
			(Base Big cliffy SS) 39.2' (Top Beech Creek LS)			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-15C

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEET

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-15C-90
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		(open hole)			Lost all water rets at 40.3'
			Limestone, lgrBr, mass m-c crystalline, fossiliferous, occ stylolites, hd, den.			
	42			42.2 / Run 5		42.0' Full depth
	44					
			45.5			
	46		Ls (as above) but dGr, f-m crystalline, occ shly pts	10.2 / 10.0		No Return
				10.2		
	48					
	50					(Ran out of water at ~ 49.0')
	52			52.2 / Run 6		
	54			3.8 / 3.8		
			(rounded inclus of Ehrenburg) (sh in bot 0.2-0.3' Ls)			
			(Bot Beech Creek Ls) (56.0')	56.0'		Blocked
	56		(Top Ehrenburg fm) Shale, dGn hard, crumbly, fissile, soft.			
	58		Burrowed hard mottled GnG Sh + siltstone	6.2 / 6.2		
			--- 59.5			
	60					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE

Hole No. WES - 6-15C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-15C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Shly silstone/sandstone, lgr + Gn, thin bd, hd, burrowed			
	62			67.2'		
			Bot. Depth - 67.2'			
	64					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-15C-90
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-15C-90			Date well screen was set: 5/26/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting screen. -
			28.0			
			Bentonite Pellets			Set 4" casing to 9.7'
			30.0			
			Filter Pack			Note: 0.0 to 9.0 - Grout; 9.0 to 11.0 Bent.; 11.0 to 28.0' Sand
			36.0			
			Well Screen			
			56.0			
			~~Trap~~			
			62.2' Boring Depth			

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

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Hole No. WES-6-16C

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NUSC Crane In	SHEET 1 OF 5 SHEET

1. PROJECT Hydrogeologic Studies (old Rifle Rg), Demo Site	10. SIZE AND TYPE OF BIT HQ Wireline
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-6-16C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 8.3'	16. DATE HOLE — STARTED 5/31/90 — COMPLETED 6/4/90
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE TOC = 32.96
9. TOTAL DEPTH OF HOLE 88.5'	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		silty clay, yl brn, soft-mod soft, moist, occ SS frags			0.0 to 8.3 - Auger
	2					
	4					
	6		becomes more sdy + w/ increase in SS frags below ~5'.			Set 6" PVC Casing to 8.3'
	8			8.3'		Refusal
	10		(Golconda Fm) Limey shale w/ shly-crystalline Ls lens + interbeds, dGr, fossiliferous	R.R. 8.4		8.3-12.0' drilled w/ R.R. bit.
	12			12.0'		
				Run 1		Started Coring w/ HQ Wireline at 12.0
	14			1.2/5.7		
	16		? Core loss ground away (limey sh)?	-4.5		Lost all water return at ~ 14.5
				17.7		
	18		(Base Golconda Ls) 18.8' (Top Inkom springs member) Shale, dgn Gr, th bd	Run 2 0.3/0.3 (0.2) Run 3 1.0/0 19.4 Run 4 1.1/1.1		No return; blocking off
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-160-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-160-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Sh, (cont.)	20.5 / Run 5		
				1.9 / 2.4		Reamed hole & set 4" Casing to 22.9', let set for 24 hrs
	22			-0.5 / 22.9		
			(Crumbly in bot 3')	Run 6		6/2/90
	24					
			(Base Indian Spr) (25.9')			
	26		(Top Big Clifty ss)			~ 100% return
			Sandstone, lgrGn, thbd, rippled, occ to mum lGr sh/shly pts, occ tan Gr hd nodules in top 2'	9.1 / 10.0		
	28		sh vf, sli friable	-0.6		
			Limestn (oxid)	-0.4		
	30		30.9'			
	32		Sandstone, lgnGr, th bd-mass, rippled, vf, friable, occ granular pyrite nodules 1/8 to 1/2" size. (SS similar to above but w/o shly pts)	32.9 / Run 7		32.7 - Pulldepth
	34					
	36			10.2 / 10.0		~ 90-95% return
	38			+0.2		
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-16C-1

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-16C-4U	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		55 (cont.)			
			Jts are fresh			
	42			42.9		
				Run 8		
	44					
	46			9.7 / 10.0		~90-95% Return
	48					
	50					
	52			52.9		52.6' Pull depth
			52.0 - 60.4' - occ vdGr shly pts along ripples	Run 9		
	54					
			Jts shown are along bd + are Fresh breaks.			
	56			10.1 / 9.9		
	58			+2.2 +6.3		
	60					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-4 MC-9

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS (Cont.)			
	62			62.8 Run 10		67.7 Pull depth
	64					
	66			10.2/10.1		Losing ~50-60%
	68		Base Big Cliff Ss (67.7') Top Beech Creek Ls. Limestone, lgr-Br, mass, m-c crystalline, fossiliferous, occ stylolites, hd, den			
	70					
	72		72.1 Ls (as above) but dGr, f-m crystalline, occ wavy shly pts.	72.9 Run 11		Lost all drill water at beginning of run 11
	74					
	76			5.8/6.1		
	78			79.0 Run 12		78.2' Pull depth
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-16C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-16C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Ls (cont.)	4.2/3.9 +0.3		No return
	82			82.9		
			Base Beech Creek Ls 83.8' Top Ellwen Fm	Run 13		6/4/90
	84		Shale, dGn, mass, hard.	4.6/5.6		No Return
	86			-0.1		
	88		Core left in hole?	88.5'		
	90		Bot depth - 88.5'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-16C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-16C-90			Date well screen was set: 6/4/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting Screen -
			52.0			6" Casing to 8.3' 4" " " 22.9'
			Bentonite Pellets			
			55.0			Note: 0.0 to 24.0' - Grout 24.0 to 26.0' - Bent. 26.0 to 52.0' - Sand
			Filter Pack			
			63.8			
			Well Screen			
			83.8			
			~~Trap~~			
			88.5 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-18c-9

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION Nuse Crane In	SHEET 1 OF 4 SHEETS

1. PROJECT Hydrogeologic Studies, Old Rifle Rg. Demo, site	10. SIZE AND TYPE OF BIT HQ Wireline Core
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-6-18c-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Dan Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 6/13/90 — COMPLETED 6/14/90
7. THICKNESS OF OVERBURDEN 23.3	17. ELEVATION TOP OF HOLE TOC = 507.74
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 62.4'	19. SIGNATURE OF ~~INSPECTOR~~ Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay - dBr, changing to tan w/depth, moist soft, w/ss frags.			Augered 0.0 to 13.5'
	2					
	4		(5.0')			
			Silty Clay, mGr, v soft v moist-wet.			
	6					
	8		Clay becomes v soft & hole continued to squeeze in starting at ~ 6.0'			
	10					Note: After augering to 13.5', put in 6" PVC casing and was able to push the casing down to 22.3', using hydralics on kelly, and w/o pre-drilling. Cleaned inside of casing out w/ R.R. bit and started coring at 23.3'
	12					
	14					
	16					
	18					
	20		~20.0'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT

Hole No. WES-6

DRILLING LOG	DIVISION	INSTALLATION	SHEET of 4

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-18C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Sand, clayey, dark-gn Gr, v fine			
	22					
			Top Rk (Big Cliffy SS)	23.3		
				Run 1		6/14/90 Started coring w/ HQ wireline at 23.3
	24		Sandstone, Gn in top 2-3' becoming lGr below, mass, vf-f, homo, friable, num pyrite nodules			
	26					
				8.2/9.1		
	28					
				-0.9		
	30					
	32			32.4		
				Run 2		
	34					
	36			9.9/10.0		
				-0.1		
	38					
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-6-18C

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEET

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-18C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Sandstone (Cont.)			
	42			42.4		
				Run 3		
			Conglomerate in Bot 0.1'			
			Base Big Cliffy SS 43.4			
			(Top Beech Creek Ls)			
	44		Limestone, lgrbr mass, m-c crystalline, fossiliferous, occ stylolites, hd, dun			
	46					
				9.9 / 10.0		90-95% water return
	48					
			49.3'	-0.1		
	50		Ls (as above) but m-d Gr. f-m cryst; occ wavy shly pts.			
	52			52.4		52.3' pull depth
				Run 4		
	54					Carry 0.1' core loss down to top Elwren from Run 3
	56			9.8 / 10.0		
	58					
			Bot. Beech Creek Ls 59.2'	-0.2		
			(Top Elwren Fm)			
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-

DRILLING LOG	DIVISION	INSTALLATION	SHT OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-18C-90	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Shale, dGn, th bd, ha			
	62			62.4		
			Bot. Depth - 62.4			
	64					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-18PZ-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-18PZ-90			Date well screen was set: 6/15/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting Screen. –
			18.0			
			Bentonite Pellets			4" Casing set to 19.0'
			20.0			
			Filter Pack			
			23.0			
			Well Screen			
			33.0			
			~~Trap~~			
			33.0 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-18C-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-18C-90			Date well screen was set: 6/14/90
			+2.5			
			0.0' Ground surface			
			~~Grout mixture~~ (See Note)			Water level just Prior to setting screen. –
			31.0			4" Casing to 22.6'
			Bentonite Pellets			Note: 0.0 to 22.0 - Grout; 22.0 to 24.0 - Bent.; 24.0 to 31.0' sand.
			34.0			
			Filter Pack			
			39.2			
			Well Screen			
			59.2			
			~~Trap~~			
			62.4 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

APPENDIX A.3

DEMOLITION RANGE

Hole No. WES-6-2C-8

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane In	SHEET 1 OF 4 SHEETS

1. PROJECT Hydrogeologic Studies of Demo. Area	10. SIZE AND TYPE OF BIT HQ wireline
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-2C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Don Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 12/5/89 COMPLETED 12/7/89
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE TOC = 513.57
9. TOTAL DEPTH OF HOLE 73.8'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay, Br - tan, firm, moist			12" dia flight Auger from 0.0 to 8.7'
	2					
	4		(4.7')			
			(Indian spgs mem) Shale / clayshale, m olive - olive Gr, firm, sli moist - dry			
	6					Refusal to Auger at 8.7'
	8			8.7'		Set 8" dia PVC Casing to 8.7' + Grouted to surface.
	10		contains Ls lens + or nodules w/sh lens + pts, v hd			R.R. Bit from 8.7 - 12.0'
	12			12.0'		
			(Base of Indian Spgs) 12.0' (Top Big Clifty SS)	Run 1		
	14		Sandstone, / olive to olive tan, th bd, rippled, v fine, hom, sli friable, rounded gtz grains, oxidized (olive Gr shale pts in top 1.8'.)			
	16			8.4 (Recovery) / 9.2 (Run)		
	18			-0.8' (Core loss)		
	20					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.

Hole No. WES-6-2

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SH

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		SS (cont.)			
				21.2		
				Run 2		
	22			2.6/2.6		
				23.8		
	24			Run 3		
	26	30				
				10.0/10.0		
	28		occ small pyrite nodules			
	30		(Bd Jts shown are probably largely drill action induced)? no stn			
	32					
				33.8		
	34			Run 4		
	36					
				10.0/10.0		
	38	0	Jt is lim stn			
		10				
	40		Bot oxidation at 39.8'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-6-2C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (cont.), but not oxid, lgr. acc pyrite nodules are generally ≤ 1/8" dia but few are > 1" dia, + have sugary texture.			
	42					
				43.8 Run 5		
	44					
	46					
			SS becomes slightly coarser in bot few ft.	10.0 / 10.0		
	48					
			1/2" to 1" conglomeritic zone at bot. contact. The contact is tight + has a stylolitic appearance.			
	50		Base of Big Chiffy fm (5.0') (Top Beech Creek fm)			
			Limestone, l-m gr Br, m-c crystalline, v hd + v dense, fossiliferous, occ stylolites			
	52					
				53.8 Run 6		12/7/89
	54					
	56					
				10.0 / 10.0		
	58		LS is m-d Gr + finer grained than above, occ wavy shly pts			
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT | HOLE NO.

Hole No. WES-6-7

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 S.

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		LS (Cont.)			
	62					
				63.2		
	64			Run 7		
				3.3/3.3		
	66					
			(Base Beech Creek fm)	67.1'		Blocked
			(Top Ellwren fm)	Run 8		
	68		Shale, m-d Gn, mass, hd, s'sides			
				6.7/6.7		
	70					
	72					
			Th bd, w/alter rpted vf sdy-silty pts.	73.8		
	74		Bot. Depth- 73.8'			
	76					
	78					
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-2C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-2C-89			Date well screen was set: 12/7/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			42.0			
			Bentonite Pellets			6" Casing to 8.7'
			45.0			
			Filter Pack			
			47.1			
			Well Screen			
			67.1			
			~~Trap~~			Note: 70.0 to 73.8' Bentonite Pellets: 67.1' to 70.0'. Sand
			73.8 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

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Hole No. WES-6-3C-89

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NASC, Crane, In	SHEET 1 OF 5 SHEETS

1. PROJECT: Hydrogeologic Studies, Demo Site
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-6-3C-89
5. NAME OF DRILLER: Don Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 91.8'
10. SIZE AND TYPE OF BIT: HQ Wireline Core
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 12/9/89 | COMPLETED 12/13/89
17. ELEVATION TOP OF HOLE: TOC = 507.45
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, ytan, w/ SS frags, soft, v moist-wet			0.0-12.6' Auger
	2					
	4					Note: Hit refusal (?) at 12.6'; however was able to push 6" PVC casing to 14.3'; 6" casing is ~ 1/2' below surface; Grouted 8" dia casing outside 6" casing to a depth of 6' & w/a 1' stick-up above ground.
	6		7.5			
	8		Silty clay, olive Br, soft-v moist w/ fossil inclus, limey			
	10		Note: in RR Bit boring for 6-3CP2, hit crystaline Ls at 8.7-13.5' & 14.2-15.'			Cleaned hole w/ R.R. Bit.
	12		Zone is solutioned & was portion of Golconda Ls fm			
	14			14.3		
				Run 1		Started coring w/ HQ wireline at 14.3'.
	16		Limey shale in Bot zone.	5.7/8.7		Core Recovery / Core Run
	18			-3.0/-2.8		core Loss/gain
	20		(~ Bot Golconda) (19.5') (Top Indian spgs member)			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.

Hole No. WES-6-5

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SH

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		(Cont.)			
			Shale, vdGr, th bd, fissile, m hd-soft,			
	22					
				23.0		22.8 — Pull depth
				Run 2		
	24					
			Shale is grGn, mass, crumbly	5.0 / 4.8		
	26					
				27.8		
	28			Run 3		
			m gGn shaley LS Conglo			
			(Bot Indian Spgs) 29.7			
	30		(Top Big Clifty SS)	5.0 / 5.2		No water loss
			Sandstone, lGr w/ Gn tint, th bd-mass, rippled, vf, homo, (shly pts in top 2-3') sli friable.	-0.2		
	32					
				33.0		
				Run 4		
	34					
	36					
				9.7 / 10.0		
			oxidized, Lim aben jts			
	38			-0.3		
	40		SS color is mGn			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-3C-09

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3C-09	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		SS (Cont.) - mgn color			
	42			43.0 Run 5		
	44		mum ~ hor breaks in core along bd; appear to be drill breaks. Core is friable			
	46			9.5/10.0		
	48			-0.5		
	50					
	52			53.0 Run 6		
	54					
	56			9.5/10.0		
	58			-0.5		
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-3-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 of 5

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-3-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS (Cont.)			
	62					
				63.0 Run 7		
	64					
	66					Lost water at ~66.0' but ~ 50 to 70% returns later
	68			9.9 / 10.0		
	70					
			(Bot. Big Clifty SS) 71.0' (Top Beech Creek Ls)			
	72		Limestone, l-m gr Br, mass, m-c crystaline, fossiliferous, v hd, v dense occ stylolites	73.0 Run 8		Lost all water return for good at ~72.0' 72.9 pull depth
	74					
	76					
			Ls changes to dGr, f crystaline	10.1 / 10.0		
	78			+0.1		
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT | HOLE NO.

Hole No. WES-6-3C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Ls (Cont.)			
	82			83.0		
				Run 9		
	84			3.8/3.8		
	86		(Bot Beech Creek Ls)	86.8		Blocked
			(Top Elwren Fm)	Run 10		
	88		Shale, d Gn, thbd, occ silty pts + pyrite nodules, hd	4.3/5.0		
	90		r Br/Gn mottling in bot ft.	-0.7		
				91.8		
	92		Bot Depth 91.8'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE — PROJECT — HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3CP2-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-3CP2-89			Date well screen was set: 12/15/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen. -
			8.0			
			Bentonite Pellets			
			9.0			6" Surface Casing
			Filter Pack			
			10.0			
			Well Screen			
			20.0			
			~~Trap~~			
			20.0 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-3C-89			Date well screen was set: 12/14/89
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			25.0			
			Bentonite Pellets			6" Surface Casing
			28.0			
			Filter Pack			
			66.8			
			Well Screen			
			86.8			
			~~Trap~~			
			91.8 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NWSC, Crane In	SHEET 1 OF 6

1. PROJECT: Hydrogeologic Studies, Demo site
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-6-9C-89
5. NAME OF DRILLER: Don Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 8.8'
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 103.3'
10. SIZE AND TYPE OF BIT: HQ wireline co
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER: TOC: 520.70
16. DATE HOLE: STARTED 1/17/90 COMPLETED 1/22/90
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Richard W. Hunt, Geologist

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, y-tan, soft, v moist			0.0 - 10.0' Auger
	2					
	4					
	6		Silty Clay, olive-Tan, w/ss frags, soft, v moist			
	8					Set 6" dia. Surface casing to 10.0
			8.8' Limey Shale, m-dGr, fossils, dry (Golconda fm)			
	10		Limestone, lGr Br m-c crystalline, fossil, v hd, v den	10.0 Run 1		Started coring w/ HQ wire line at 10.0'
	12					
	14		Shaley Ls - Limey Sh, m-d Gr th bd, hd, fossiliferous; soft clay + oxid along dts.	4.2/6.6 -2.4'		Core Recovery / Core Run; Core Loss/Core gain
	16			16.6 Run 2		
	18			4.4/6.6 -2.2'		
	20					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-4C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 6 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-4C-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		shly Ls (cont.)			
	22					
				23.2		
			Crystalino Ls (Casaba)	Run 3		1/18/90
	24		Solu in top ½ ft + oxid	3.4/3.8 -0.4'		
			(Becomes shly in bot ½)	0.0		
	26		(Base Colorado fm) (26.4') (Top Indian spgs mem)	27.0'		26.6' (Run 4) Pull depth
			Shale vd Gr, th bd, fissile hd, fossils in top 2.0'	Run 4		
	28			3.1/4.5		29.7 (Run 5) - Run depth
	30			-1.4' +0.4		
				31.5		
	32			Run 5 3.5/4.8 +1.8		Reamed hole & set 4" PVC Casing to 33.2'
				33.2		
				Run 6		1/20/90
	34					
	36			8.3/9.3		
	38		Below ~ 37.5' shale is d olive Gr & soft.	-1.0'		
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-6-4

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF 6 SH

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-3C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		(sh, cont.)			
	42		(Bot. Ind spra) (42.5') (TOP Big Clifty ss)	42.5 Run 7		
	44		Sandstone, lgnGr, th bd w/num olive gr shaley pts, rippled, vf grained, pyrite inclus			
	46		olive Gr sh	8.9 / 9.3		no water loss
	48		olive Gr sh	-0.4		
			Sandstone (similar to above) lGr, th bd, rippled, v f, homo, sli friable, hd	-0.1		
	50					
	52			51.2 Run 8		51.5 / Run 8 Pull depth
	54		(very few to no jts)			
	56			10.1 / 10.4		
				-0.3		
	58			+0.3		
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-6-4C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-4C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS (cont)			
						6/6 Run 9 – Pull depth
	62	0		62.2 Run 9		
		0				
	64					
		0				
		0				
	66					
		0				
		5/4				
		0		10.2 / 10.2		
	68			+0/6		
	70					
						71.8' Run 10 – Pull depth
	72			72.4 Run 10		
		0				
		0				
		5				
	74					
		0				
	76					
				10.3 / 10.0		
		0				
		10				
		5				
	78	0		+0/3		
		0				
		10	SS is calcareous + v hd below ~ 79.0'	+0/6		
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.

Hole No. WES-6-90

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 6

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-MC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Bot Big Clifty ss (80.9) (Top Beech Creek Ls)			Lost all water return at ~81.0'
	82		Limestone, l-m gr Br, m crystalline, fossiliferous, v hd, v dens, occ stylolites	82.4 Run 11		82.4 Run 11 pull depth 1/22/90
	84					
	86					
	88		Ls is m-d Gr, f-m crystaline, occ shly pts.	10.4/10.1		
	90					No water return
	92			92.5 Run 12		
	94			4.4/4.4		
	96			96.9 Run 13		
	98		(Bot Beech Creek Ls) 97.4 (Top Ellerson fm) Shale, d gr Gn, th bd hd.			
	100					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT | HOLE NO.

Hole No. w ES-6-4C-87

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF 6 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		Sh (cont.)			
				6.4 / 6.4		
	102					
				103.3		
	104		Bot. Depth = 103.3'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-4CPZ-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-4C-89			Date well screen was set: 1/23/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			9.0			
			Bentonite Pellets			6" Surface casing to 9.0'
			10.0			
			Filter Pack			
			17.0			
			Well Screen			
			27.0			
			~~Trap~~			
			27.0 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-4C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-4C-89			Date well screen was set: 1/22/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen -
			38.0			
			Bentonite Pellets			6" Surface Casing
			42.5			4" Casing to 33.2'
			Filter Pack			
			78.0			
			Well Screen			
			98.0			
			~~Trap~~			
			103.3 Boring Depth			

PROJECT — HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No. WES-6-SC-89

DRILLING LOG	DIVISION U.S Navy	INSTALLATION Naval Crane In.	SHEET 5 OF 5 SHS
1. PROJECT Hydrogeologic Studies, Demo Area		10. SIZE AND TYPE OF BIT HQ wireline	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY WES		12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500	
4. HOLE NO. (As shown on drawing title and file number) WES-6-SC-89		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER Dan Taylor		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN 6.4 ft		16. DATE HOLE	STARTED 1/24/90 / COMPLETED 1/25/90
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE TOC = 506.93	
9. TOTAL DEPTH OF HOLE 86.4 ft		18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR Geologist Richard W. Hunt	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, y brn, w/ SS frags, soft, moist - v moist.			Augered from 0.0 to 13.6'
	2					
	4					
	6		6.4'			
	8		Clay / Clayshale (Residual weathered Galveston / Haney fm), d olive-olive Br, hard, dry, Calcareous, w/ fossils + fossil frags			
	10					
	12					Set 6" PVC casing to 13.6 + Grouted
			13.5'	13.6		
	14		(Indian Springs mem) Shale, d Gr, th bd fissile, soft-mod firm, lim stn along fractures in top 2-3'.	Run 1 3.1/4.6 (1.5')		Started coring w/ HQ wireline at 13.6'
	16					
	18			18.2 Run 2		
	20					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT

Hole No. WES-6-SC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 3 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-SC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Sh (cont.)			
				4.4/5.5		
	22			(-1.1)		
				23.7		
	24			Run 3		
			Shale/claystone m-d Gn, mass w/num irregular shaped LS(?) nodules (conglomeritic effect)			
	26			8.4/9.5		
	28		th bd w/occ ss lens. (Bot. Ind. spts) (285)	(-1.1)		
	30		(Top Big Clifty SS) Sandstone, lgr, Vf, w/num grGn Sh lens + pts, rippled hd, sli friable			
	32			32.1		32.1 - full depth
				33.2		
				Run 4		
	34					
			olive sh			
	36		Sandstone lGr th bd, rippled, Vf, homo, rounded qtz sd, sli friable, sli oxid between 34.0 + 43.2'	9.6/8.7		
	38			(+0.9)		
				+0.2 / +1.1		
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. WES-6-5

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF 5 SH

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-SC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Sandstone (cont.)			
	42			41.9 / Run 5		41.7 – Pull depth
	44					
	46			10.3 / 10.3 (+0.2)		
	48					
	50					
	52			52.2 / Run 6		52.0 – Pull depth
	54					
	56			10.4 / 10.2 (~~+0.2~~)		
	58					
	60					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

Hole No. wES-6-SC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) wES-6-SC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		SS (cont			
	62		SS, (as above) but calcareous + hd. (not friable)	62.4 Run 7		
	64		(Base of Big Cliffy) 65.2' (Top Beech Creek) (solution contact)			
		30	Limestone, mgrBr, mass, m-c crystaline fossiliferous, v hd, vden, occ stylolites	9.9/10.1		
	66					
	68			(-0.2)		
	70					
	72			72.5 Run 8		
	74					
	76		Ls changes to dGr, f crystaline, occ shly pts.	10.1/10.2		
	78			(-0.1)		
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-SC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 of 5

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-SC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Ls (cont.) 80.4			
			(Top Elkton fm)			
			Shale, dgrGn, thbd-mass, hard			
	82			82.7		
				Run 9		
	84			3.6 / 3.7		
				-0.1		
	86			86.4		
			Bot. Depth - 86.4 ft.			
	88					
	90					

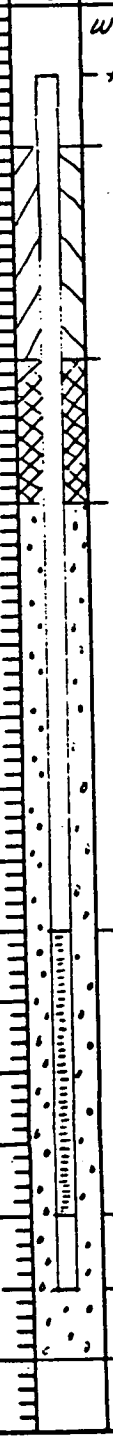
ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-SC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-SC-89			Date well screen was set: 1/25/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen. -
			25.0			
			Bentonite Pellets			
			29.0			
						8" casing to 13.6'
			Filter Pack			
			60.4			
			Well Screen			
			80.4			
			~~Trap~~			
			86.4 Boring Depth			



ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT | HOLE NO.

Hole No. WES-6-6

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC Crane In	SHEET 4 OF 4 SHEETS

1. PROJECT: Hydrogeologic Studies, Demo Site
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-6-GC-89
5. NAME OF DRILLER: Dan Taylor
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 23.5' (?)
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 75.4'
10. SIZE AND TYPE OF BIT: HQ Wireline
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 1/26/90 COMPLETED 1/29/90
17. ELEVATION TOP OF HOLE: TOC = 512.19
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Richard Wilhelm Geologist

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, Br in top, becoming y Br below ~1.0', ss frags, moist, soft			0.0 to 23.5' drilled with Auger.
	2					
	4					
	6					
	8					Note: Outcrop in slope above boring surface elev. consists of thinly bd platy ss w/ plant castings & ripple marks. (Penn Sediments)
	10		Becomes more moist below ~10'.			
	12		Silty-sdy clay. y Br, Red + Gr mott, soft, v moist			
	14					
	16		Silty clay, rusty oliv Br, sdy w/ num. ss frags (Pebbly size) blk staining, dryer than above			
	18					
	20		Silty-clayey v f Sand			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-GC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-GC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		yBr + lGr mottled, very soft, v moist.			
	22					Set 8" dia. PVC Casing to 23.5'
				23.5		
				Run 1		Started Coring w/ HQ wireline at 23.5'. (Very little to No water loss during complete drilling of Boring.)
	24		Core recovered is 1.0' of fine, oxidized SS in th lens + frags.			
	26		Core loss is probably wea platey SS as seen in outcrop above boring location (Sheet 1)			
				1.0 / 9.6		
	28					Core ground away during drilling; very easy advancement
				(-8.6')		
	30					
			(32.1')			
	32		Shale / clayshale, m Gr, mass, soft-mod firm.			- contact w/ clayshale determined from drill action
				33.1		
				Run 2		
	34					
			- lGr vf SS, pyrite nodules			
	36					
			- lGr vf SS (37.8')			
	38		Sandstone, lGr, th bd - mass, vf, cross bd + swirled bd, occ dGr shly pts + pyrite nodules, contains Blk	-5.8 / 7.1		
				-1.3		
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE — PROJECT — HOLE NO.

Hole No. WES-6-6

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF 4

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-6C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Carbonaceous flakes, hard.	40.2 Run 3		
				2.2/2.9 (-0.7)		
	42			43.1 Run 4		43.0 — Pull depth
	44					
	46			6.1/6.0 (+0.1)		
	48			49.1 Run 5		
	50			3.7/4.0		
	52		Below 51.6', abundant Carbonaceous Shaley Swirls & flakes	-0.3 53.1 Run 6		
	54					
	56		abundant pyrite inclus unconformity (56.3') (Beach Creek Fm)	9.5/9.6		PENN ~~~~ Miss
	58		Limestone, lt-br, m-c crystalline, v hd, v den, occ stylolites	-0.1		
	60		LS changes to dbr finely crystalline (as above)			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-GC-09

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-GC-09	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Ls (cont.)			
	62			62.7		62.6 - Pull depth
				Run 7		
	64					
				5.5 / 5.4		
	66			+0.1		
	68			68.1		
				Run 8		
			(Base of Beach Creek) (69.4')			
			(Top Ehren fm)			
	70		Shale dGn	4.7 / 4.8		
				-0.1		
	72			72.9		72.8 Pull depth
				Run 9		
	74			2.6 / 2.5		
				+0.1		
				75.4		
	76		Bot. Depth - 75.4			
	78					
	80					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WGS-6-GCP2-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED — COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WGS-6-GCP2-89			Date well screen was set: 1/30/89
			+2.5			
			0.0 Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			12.0			
			Bentonite Pellets			
			15.0			Surface casing to 10.0
			Filter Pack			
			22.5			
			Well Screen			
			32.5			
			~~FRP~~			
			32.5 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-6C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-6C-89			Date well screen was set: 1/29/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen -
			33.0			
			Bentonite Pellets			
			38.0			8" Casing to 23.5'
			Filter Pack			
			49.4			
			Well Screen			
			69.4			
			~~Trap~~			
			75.4' Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane In	SHEET 1 OF 5

1. PROJECT Hydrogeologic Studies, Demo Site	10. SIZE AND TYPE OF BIT HQ wireline Co
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-6-TC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Don Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 2/2/90 COMPLETED 2/6/90
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE TOC = 513.260
9. TOTAL DEPTH OF HOLE 87.5	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty Clay, Br, soft, moist			0.0-3.2 Augered Refusal at 3.2'
	2			3.2'		set 8" PVC casing to 3.2'
	4		Wea Sandstone frags + clay (?), no spl's (Dr.) [No water return, water flowing out at toe of Road bank in Boggs Creek, ~10-12' lower than boring ground surface.]	NO Rec		Made several runs w/NX core bl from 3.2 to 9.9' w/o recovery. Losing all return just [illegible] 3.2'
	6					
	8					
	10		(16.4)	9.9' Run 1		Started coring w/HQ wireline at 9.9'
	12		Clayshale, vdGr-Blk, th bd, carbonaceous, soft. 13.2	5.6/6.4		
	14		Thinly laminated lGr vf sandstone and dGr Shale, ~ hor bd, hard,	-0.8'		
	16			16.3' Run 2		
			vdGr-Blk shale, carb			Losing all water
			0.1' coal seam			
	18		vdGr-Blk shale, carb			
			Lam ss/sh (as above)	5.3/6.6 -1.3		
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-7C-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): WES-6-7C-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Lam ss/sh (Cont.)			
	22			22.9'		22.6' full depth
				Run 3		
	24					
	26					
			27.0'			
	28		Shale, vdGr, th bd, platey, hd, occ th cdy bds, occ siderite lens	10.3 / 10.0		
				10.3		
	30					
	32		32.4			
			Coal/lignite, Blk, soft flakey (38.0)	32.9'		Reamed hole + set 6" PVC Casing to 34.8'
				Run 4		
	34		Shale Blk in Top zone changing to dGr w/depth, th bd, fissile highly carbonaceous soft-firm.	1.7 / 1.9, Co.2, 34.8		
				Run 5		Blocked 2/5/90
	36					
				7.6 / 8.1		Got back 100% water return after setting casing.
	38			-0.5		
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-7-87

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-7-87	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Sh (cont.) (41.5)			
	42		Shale, d Gr, th bd, w/occ sdy zones, hard, num pyrite nodules + occ carbonaceous inclus, occ s'sides.	42.5 Run 6		
	44					
	46					
	48			9.5/10.0		
				-0.5		
	50					
	52		(52.9)	52.9		
	54		Sandstone, f-m Gr, th bd, irreg-wavy bd, num pyrite nodules, occ carb inclus + flakes (shaley pts)	Run 7		
	56			10.0/10.0		95-100% water return
	58		conglomeritic + abundant pyrite.			PENN
			unconformity (58.9') (Beech Creek Fm)			MISS
	60		Ls (cont - next sheet)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-7

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEET

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-7C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Limestone, lGr-Br, m-c crystaline, foss, v hd, v den, occ stylolites			
	62	10		62.9 Run 8		
	64					
	66	85 90	Ls (as above) but m-d Gr, f cryst, occ shly pts			
	68		(Near vert. Jt is tight + at least partially healed in situ)	10.0 / 10.0		No water loss in Ls (95-100% return
	70					
	72	0		72.9 Run 9		
	74	0				
	76					
	78	0	Ls Changes to lgr. Br, coarser grained, + somewhat conglomeritic in appearance w/num rounded to angular	9.9 / 10.0		
	80	0				

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-[illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-7C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		incluss of d Gn (Elwren) sh. Coarser + more conglomeritic in bot ft.			
			(Base Zanesville Creek fm) (81.6)			
	82		(Top Elwren fm) Shale d Gn w/ lGr alter sdy pts + th lens, rippled bd,	82.9		82.8 — Pull depth
	84		Sdy lens increase w/ depth.	4.7 / 4.6		95-100% water return
	86		(zone appears good as an aquaclude)	+0.1		
				87.5		
	88		Bot. Depth - 87.5'			
	90					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-7C-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-7C-89			Date well screen was set: 2/6/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			48.0			
			Bentonite Pellets			
			52.0			6" casing to 34.8'
			Filter Pack			
			61.6			
			Well Screen			
			81.6			
			~~Frac~~			
			87.6 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BC-89

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION NWSC Crane In	SHEET OF

1. PROJECT: Hydrogeologic Studies, Demo site
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): WES-6-BC-89
5. NAME OF DRILLER: Don Taylor
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT: H Q wireline Co
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: UNDISTURBED:
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 2/9/90 COMPLETED 2/20/90
17. ELEVATION TOP OF HOLE: TOC = 709.15
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Geologist Richard W. Hunt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Silty clay, sdy, hd, dry - sli moist			0.0 - 8.5 Augered
	2					
	4					
			5.8			
	6		Sandstone, lt tan-rusty br m-c grain, cross-bd, micaceous, highly oxid - friable, occ lim crusting.			
	8					set 10" PVC casing to 8.5'
						8.5 to 11.8' - R.R. bit
	10					
				11.8		
	12			Run 1		started coring w/ HQ wireline at 11.8'
	14					
	16			10.0 / 10.2		Recovery (feet) / Run (")
				-0.2		Core loss/gain
	18					
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-BC-8

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20		Sandstone (cont)			
						21.8 — pull depth
	22			22.0		
				Run 2		
	24					
	26			10.3 / 10.1		
	28			+0.2'		
	30					
	32			32.1		
				Run 3		
	34					
	36			8.8 / 10.2		
	38			-14		
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-[illegible]-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40		Sandstone (cont.)			
	42			42.3 Run 4		
	44		Lim crusting; ss - lt an Gr, w/dGr sh pts.; Lim crusting			
	46			8.0/10.3		
	48			-2.3'		
	50		(~50.0) ? Core loss ?			
	52		(~52.3) Coal, Blk, blocky, hd. (Pyrite inclus) (53.1)	52.6 Run 5		2/10/90
	54		Sandstone, lGr, mass, w/ abundant Blk thin swirls of Carbonaceous inclus.			
	56		th bd w/shly pts & carb inclus. (52.9)	9.5/10.3		
	58		Sandy shale, highly burrowed, vdGr-Blk, th bd, occ siderite nodules.	-0.8'		
	60					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. W ES-6-BC-8

DRILLING LOG	DIVISION	INSTALLATION	SHEET 9 OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		Sdy sh (Cont.)			
	62		(63.0)	62.9		
			Shale, Blk, th bd - mass, carbonaceous, occ siderite lens, hd.	Run 6		
	64					
	66					
				9.8 / 10.0		
	68					
			69.7	-0.2		Reamed hole and attempted to set 8" dia PVC casing to 72.0', however casing got hung at ~37.0'. A 6" dia PVC casing was inserted + set to 72.0', thru the hung 8" casing + grouted to surface. 2/13/90
	70		Shaley sandstone - sandy shale, vdGr, burrowed, th bd, high carb, has num rounded - flattened lgr ss inclus (concentration in top ft)			
	72		(72.9)	72.9		
			Shale, dGr, th bd, occ carb inclus, blocky, hd	Run 7		
	74					
	76					
			(77.2)	9.5 / 9.9		
			Coal, Blk, blocky, hd, pyrite inclus. (78.2)	-0.4		
	78		Shale vdGr, mass - th bd, hd, occ thin Coal pts + inclus.			
	80		(80.0)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-BC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED / COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80		Sandstone, lGr, vf, shly, carb inclus. — soft el sh			
			(82.0)			
	82		Sandstone, lGr, rippled, vf, clean rounded qtz sd	82.8' Run 8		
	84					
	86			8.7 / 8.7		
			occ shly pts in lower 2'.			
	88		88.7			
			SS, (similar to above) but num carb shale + coal pts (thin closely spaced bd)			
	90			91.5		
	92		Shale Blk, th bd, blocky - platey, hd, homo, slick.	Run 9		
	94			4.5 / 4.5		Reamed hole & set 4" dia PVC Casing thr. 6" (previously set) casing to 96.0'.
	96			96.0' Run 10		12/16/90
	98			6.4 / 6.8		
			(99.2)			
	100		Sandstone, f-m Gr. (cont)	-0.4		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BC-B

DRILLING LOG	DIVISION	INSTALLATION	SHEET 6 OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-B9
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100		th bd, w/occ alter dGr shly lens + thin beds, rippled, vF, hd.			
	102					102.4 Full depth
				102.8 Run 11		
	104					
	106					
				10.2 / 9.8		
	108					
				~~10.4~~		
	110					
	112		Num Blk coal pts + inclus, occ Br SS inclus			
				112.6 Run 12		
	114					
	116		more shly lens in bot 6' than SS lens.			
				9.4 / 9.4		
	118		(118.1) Shale, Blk, th bd, occ Siderite lens, (Siderite Conglo in top 0.5'), hd. blocky-platy, slick			
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-BC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120		Shale (cont)			
	122			122.0 Run 13		
	124		sandy			
	126			9.9 / 10.4		
	128			-0.5		
	130					
	132			132.4 Run 14		
	134					
	136		olive Gr, sdy at bot	9.7 / 10.1		
	138			~~-0.4~~ -0.1		
	140					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BC-B

DRILLING LOG	DIVISION	INSTALLATION	SHEET B OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-B9	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140		Sh (cont.)			
	142			142.5 Run 15		142.2 Pull depth
			siderite	2.4/2.4		
	144		SS yl gn Gr - gr Gn, f-m, mass, w/ irreg flattened shale inclus.	144.9 Run 16		144.6 Pull depth 2/17/90
	146		olive gn Gr sh, s'sides			
			(145.2)			
	148		Shale, Blk, th bd, platy, occ siderite nodules, w/ plant imprints along bd.	7.8/7.9		
	150			~0.1 ~0.3		
	152		(Sh grades to dGr below ~151' and also has s'sides and occ minor lGr sdy pts)	152.4 152.8 Run 17		- Pull depth
	154					
	156			10.4/10.0		
	158			~0.4		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-6-[illegible]-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-[illegible]-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160		Shale cont.			
	162			162.8 Run 18		
	164					
	166					
	168			9.9/10.0		
				-0.1		
	170					
			171.1			
	172		sh (as above) but w/num rippled lgr vf ss pts & thin lens	172.8 Run 19		
	174					
	176		(176.5')			
	178		Sandstone, fm gr, vf, th bd-mass, silty pts, occ carb inclus & swirls.	9.3/9.3		
	180					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BR-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 10 OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BR-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	180		SS (cont.)			
	182		(182.1)	182.1		
			Shale, Blk, th bd, platy, carb, w/ occ thin coal lens + pts.	Run 20		
	184		(184.8)			
			Sandstone, f-m Gr, th bd, vF, occ to mum Blk sh rippled pts, occ possible burrows.			
	186			10.2 / 10.2		
	188					
	190					
	192		(192.3)	192.3		
			Shale, Blk-dGr, th bd, mass, abundant carb inclns, occ th coal lens, occ siderite nodules.	Run 21		2/19/90
	194					
	196			9.7 / 9.7		
			(197.8)			
	198		Sandstone/siltstone lGr, shaley, th bd, w/ dGr shly + carb pts, plant imprints			
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-8-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET / OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-8-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	200		Sandstone/siltstone (cont.)			
	202			202.0 Run 22		
	204			6.2/6.2		
	206					
	208		(208.2)	208.2		
			shale, dGr-Blk, thbd, platey, carb	Run 23 2.7/2.7		
	210		Lignite			
			sdy in bot	210.9 Run 24		
			(211.5)			
	212		Clayey Sandstone, l-d Gr-Gn, mass, hd, f-c grain, occ carb flakes, ss+sh inclus,			
	214			10.3/10.3		
	216					
	218		(Angular lgr Br LS frags + fossils as inclus in bot 2'.)			PENN
			(Mansfield fm) (219.1)			unconformity
			(Indian Springs mem) shale, d Gn, thbd-mass,			MISS
	220					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BC-

DRILLING LOG	DIVISION	INSTALLATION	SHEET 12 OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-69	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED:
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED: — COMPLETED:
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	220		(Sh cont.), hd			
				221.2		
				Run 25		
	222			3.3/3.3		
	224			224.5		
				Run 26		
			(Base Indian spring) 226.5 (Top Big Clifty ss)			
	226		Alternating lGr vf ss + dGn sh lens, ls, nodules in top 2'			
	228			8.6/8.6		
	230					
			231.5			
	232		Sandstone, lgnGr, th bd-mass, rippled, vf, homo, sli friable,	233.1		
				Run 27		
	234					
	236			10.0/10.1		
	238			-0.1		
	240					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-[illegible]

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-[illegible]	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	240		SS (cont.)			
	242					
				243.2		243.1 pull depth
				Run 28		
	244					
	246					
				10.1 / 10.0		
	248					
				+0.1		
	250					
	252					
				253.2		
				Run 29		
	254					
	256					
				9.9 / 10.0		
	258					
				-0.1		
	260					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-6-BC-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET 14 OF 15 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BC-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	260		SS (cont.)			
	262					
				263.2 Run 30		
	264		(Base Big Cliffy SS) (264.2) (Top Beech Creek Ls)			
			Limestone, lgr Br, m-c crystalline, fossiliferous, occ stylolites, dom. hd.			
	266		sh lens			
				9.9/10.0		
	268			-0.1		
	270		270.2			
			Ls (as above) but dl Gr, f-m cryst, occ wavy shly pts			
	272					
				273.2 Run 31		273.1 pull depth
	274					
	276			7.1/7.0		
	278			+0.1		
			(Base Beech Creek Ls) (279.8)			
	280					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT | HOLE NO.

Hole No. WES-6-BB-89

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-BB-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	280		(Top Eleven fm) (2742)	280.2		
			Shale, d Gn, mass, becomes th bd w/depth w/alt th ss lns.	Run 2		
	282			3.0 / 3.0		
				283.2		
	284		Bot Depth 283.2'			
	286					
	288					
	290					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) WES-6-RC-89
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-RC-89			Date well screen was set: 2/20/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen. –
			220.0			
			Bentonite Pellets			
			225.0			
			Filter Pack			4" PVC Casing to 96.0'
			239.8			
			Well Screen			
			279.8			
			~~Trap~~			
			283.2 Boring Depth			

PROJECT | HOLE NO.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) WES-6-BCPZ-89	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Well No: WES-6-BCPZ-89			Date well screen was set: 2/22/90
			+2.5			
			0.0' Ground surface			
			Grout mixture			Water level just Prior to setting screen –
			73.0			
			Bentonite Pellets			Surface casing to (10.0')
			76.0			
			Filter Pack			
			81.5			
			Well Screen			
			91.5			
			~~Trap~~			
			91.5 Boring Depth			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

APPENDIX A.4

OLD JEEP TRAIL

Boring logs and monitoring well construction sheets for the Old Jeep Trail will be included in a future version of this report.

Appendix C
Equipment Manuals

Naval Surface Warfare Center
Crane Division
Crane, Indiana

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order ~~0030~~ 39/48

January 1999

APPENDIX C

EQUIPMENT MANUALS

TABLE OF CONTENTS

SECTION	TAB NUMBER
Bladder Pump Controller	1
Bladder Pump and Freeze Protection	2
Water Quality Meter Sonde and Display	3
Water Level Meter	4
Peristaltic Pump	5
Digital Titrator	6
Colorimeter	7

TABLE OF CONTENTS

SECTION	TAB NUMBER
Bladder Pump Controller	1
Bladder Pump and Freeze Protection	2
Water Quality Meter Sonde and Display	3
Water Level Meter	4

BLADDER PUMP CONTROLLER

MICROPURGE®

From The Leader in Low Flow Sampling ▼QED

ELECTRONIC PROGRAMMABLE CONTROLLER

MODEL 400

▼QED *Environmental Systems, Inc.*

The GroundWater Specialists

P.O. Box 3726. Ann Arbor, Michigan 48106

313-995-2547 · 800-624-2026 Fax: 313-995-1170

E-Mail: info@qedenv.com Website: http://www.micropurge.com

P/N 95116 REV.#2 4/4/97

PRODUCT DESCRIPTION

PAGE NO.

Description of product and features ____ 1

HARDWARE DESCRIPTION AND SETUP

Identification and inventory of parts and components ____ 2
Battery testing ____ 3

BASIC OPERATING INSTRUCTIONS

Air source requirements ____ 4
System hookup ____ 5
Well sampling and purging ____ 6-7

OPERATING GUIDELINES

Discharge/refill timers ____ 8
Pump drive air throttle and pump drive pressure gauge ____ 8
Battery characteristics ____ 8

MAINTENANCE

General care and storage ____ 9
Cold weather storage ____ 9
LCD display ____ 9
Battery removal and replacement ____ 9

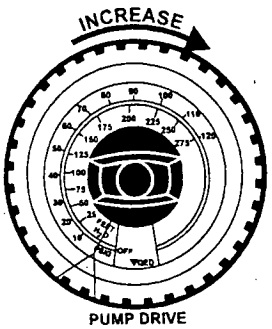
REVIEW BASIC OPERATION

Quick reference to basic functions ____ 10

ADVANCED OPERATION

Alphanumeric keypad overview ____ 11
Add/edit site I.D. or well function ____ 12
Creating a new site I.D. ____ 13
Creating a new well I.D. ____ 13
Select site or well function ____ 14
Modify site I.D. function ____ 14
Modify well I.D. function ____ 15
Deleting an existing sitel I.D. ____ 15
Deleting an exsisting well I.D. ____ 16
Menu display function ____ 16

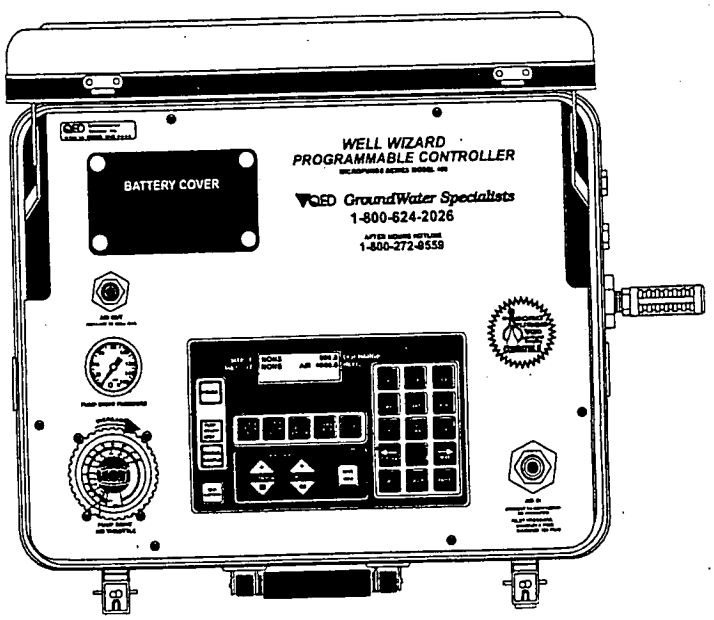
The Well Wizard Series 400 Programmable Controller provides the oscillating air supply and exhaust cycle control, also referred to as discharge and refill modes, to operate pneumatic bladder and air displacement style pumps typically used in ground water monitoring and remediation. The Series 400 not only performs all of the same functions as other controllers on the market, but is capable of accurate and repeatable time settings to 1/10th of a second for precise pump optimization. It has a unique manual sample mode that allows the user to pause the controller in the refill mode while preparing to take a sample then shift to discharge mode to start the pump and take the sample. Furthermore the Series 400 Programmable Controller has the ability to record, store and retrieve discharge and refill times for up to ten (10) different sites and each site can support up to fifty (50) wells. The onboard computer will allow the user to enter an alphanumeric name for each site and well. If the user chooses not to enter alphanumeric names the computer will automatically select default names for each site and well. The user may elect to use the controller in its most basic mode, like other controllers on the market or may use the advanced features. Finally the unique design of the Series 400 circuit board allows for software upgrade as new releases become available.



PUMP DRIVE
AIR THROTTLE

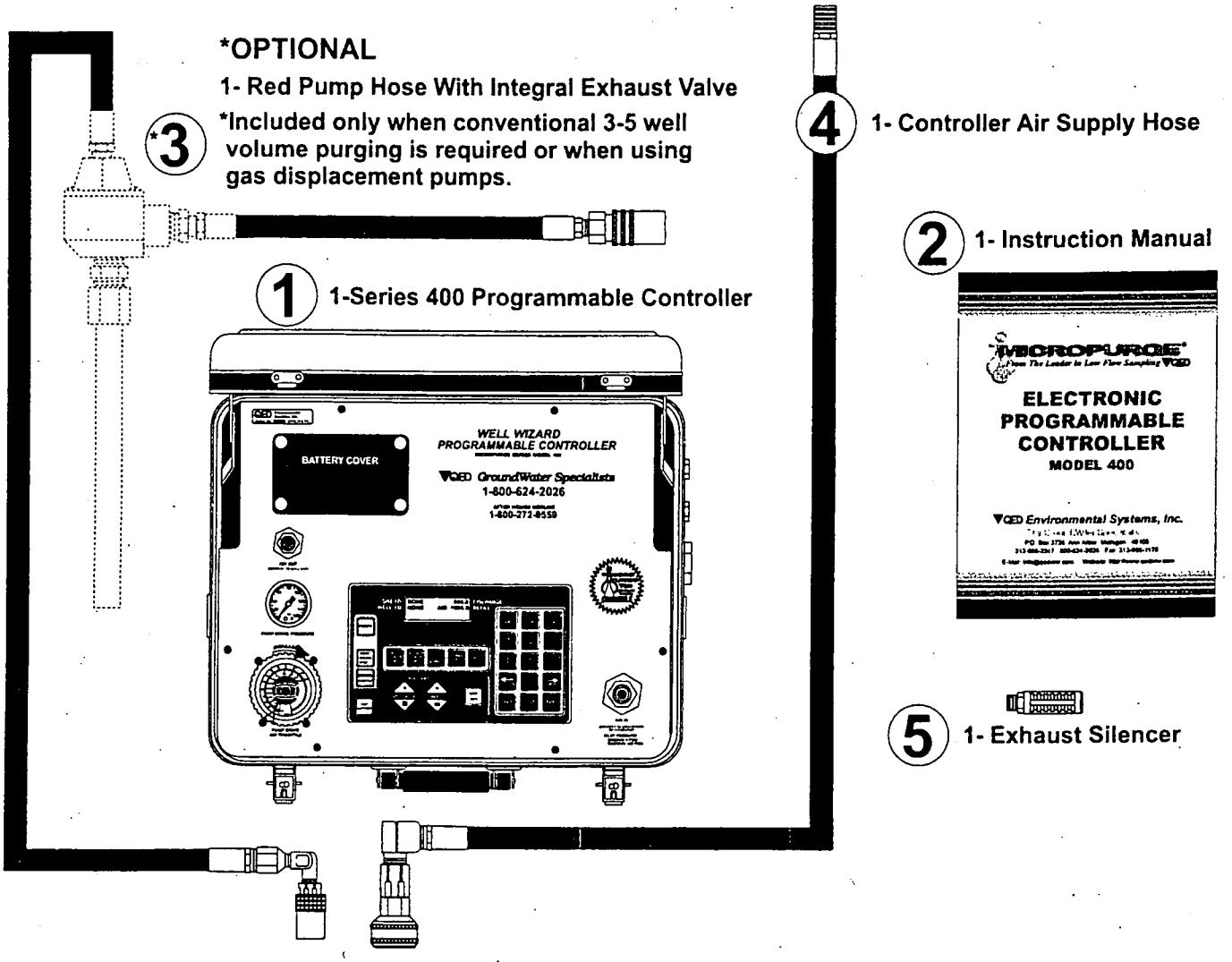
The Series 400 utilizes a new style Pump Drive Air Throttle that allows the user to directly select the air supply pressure to the pump with a single turn of the adjustment knob. Graduations are listed in either PSIG or in Feet Of Water Pressure. With this device there is no more need to adjust, cycle and then observe the resultant pressure setting.

Finally, the Series 400 includes some of the most reliable pneumatic valves in the industry with a field proven history of success. All of these valves have been used in other Q.E.D. products and were selected for use in the Series 400 Controller because they have the ability to operate in a rugged environment with demonstrated performance.



UNPACKING

Every effort is made to insure that your new Series 400 controller is delivered in a manner that enables an easy start up as well as reliable operation. Please check to ensure that your box includes the 5 following items:



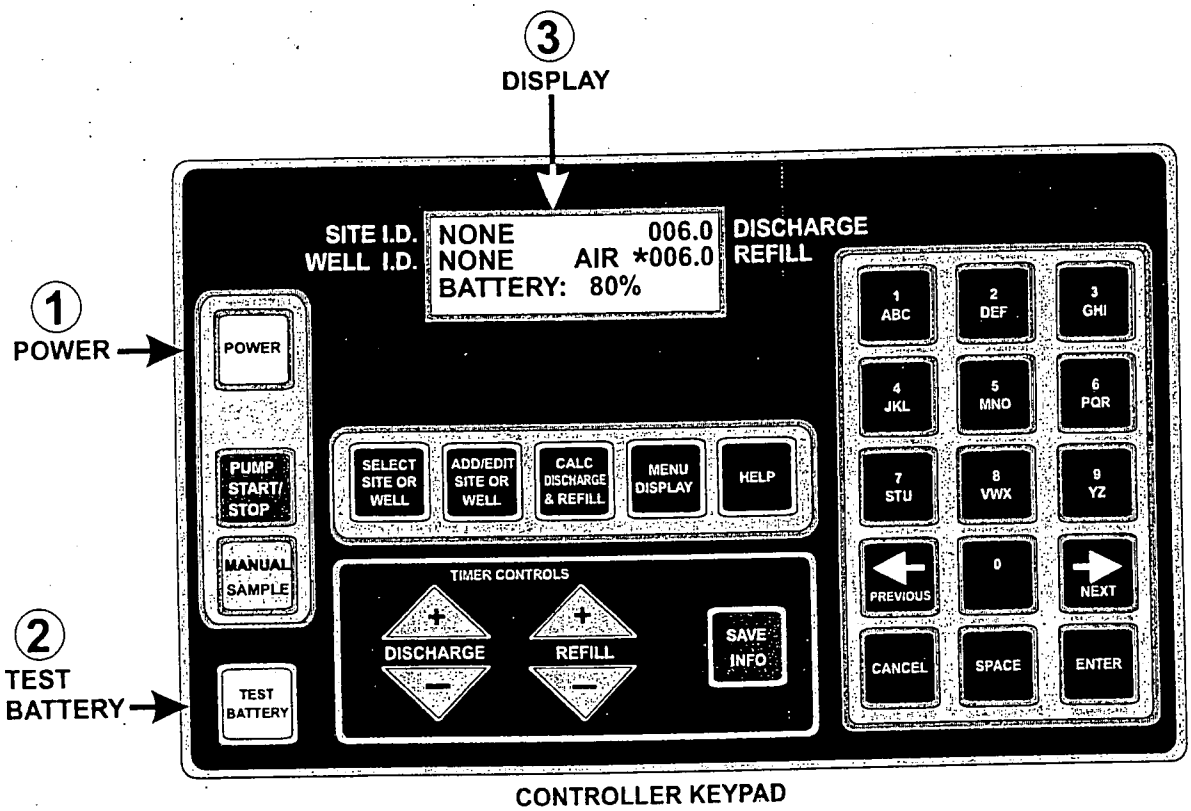
If you are missing any of these pieces please contact QED Groundwater Specialists immediately for replacement.

QED *Environmental Systems, Inc.*
The GroundWater Specialists
P.O. Box 3726. Ann Arbor, Michigan 48106
313-995-2547 800-624-2026 Fax: 313-995-1170
E-Mail: info@qedenv.com Website: http://www.micropurge.com

The Series 400 Controller is shipped with a fresh set of eight (8)-AA batteries already installed. It is best to check battery life after unpacking your unit prior to using for a sampling session.

BATTERY TEST

Press and momentarily hold the red **"POWER"** button on the upper left hand side of the keypad. This will power up the circuit board. Next press the gray **"TEST BATTERY"** button on the lower left side of the keypad. This will display an estimate of the percent of battery life remaining. This estimate will vary with the type, age and brand of batteries. It is best to carry a spare set. It is not unusual for new batteries to fall rapidly to 70-75% and then begin a more gradual decay. Alkaline batteries are recommended. Battery life is estimated at 50,000 continuous cycles. This will vary with the type and age of the batteries. Push the red **"POWER"** button again to turn the unit off to conserve battery life.



CONTROLLER KEYPAD

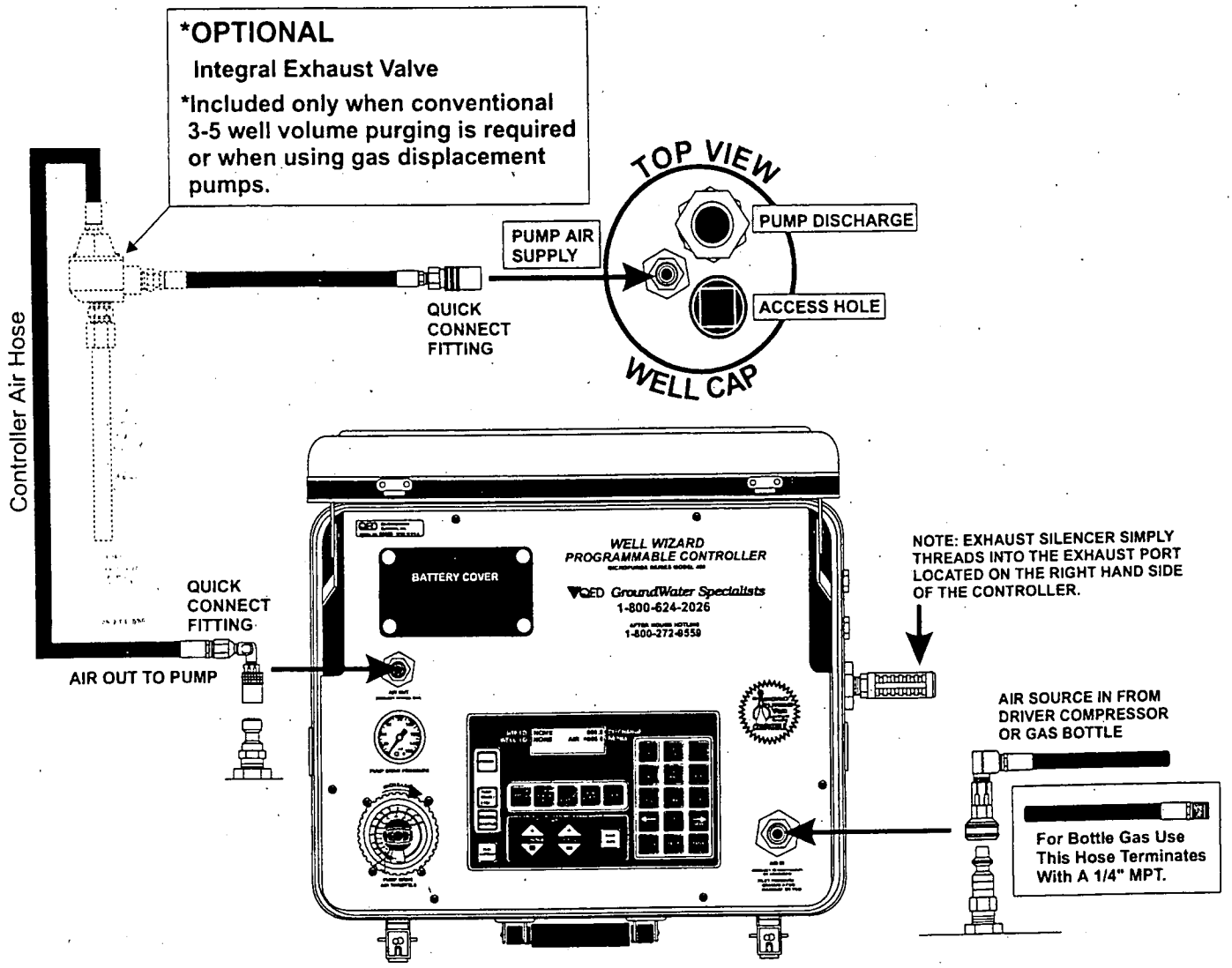
NOTE: Should your batteries need replacing see insructions on page # 9

When connected to an appropriate compressed gas source, the Series 400 Controller alternately pressurizes then vents the air supply line to the pump. The unit is powered by eight (8) double "A" ("AA") size batteries. The duration of the pressurization and venting cycles can be adjusted to maximize the pumping rate to purge a well or reduce to a minimal pumping rate to facilitate sampling.

It is recommended that the compressed gas source be of high quality, such as breathing quality air or air compressed with an oil-less compressor. It is also important to note that precautions should be taken to minimize the chance of freezing in cold climates when water condensate is present in the air source. This will minimize the chance of component failure due to expansion of ice.

WARNING: PRESSURE APPLIED TO THE CONTROLLER MUST NOT EXCEED 120 PSIG. HIGHER PRESSURES MAY CREATE HAZARDOUS CONDITIONS AND WILL VOID SYSTEM WARRANTIES. SPECIAL CARE MUST BE TAKEN WHEN COMPRESSED AIR BOTTLES ARE USED AS AN AIR SOURCE. CHECK WITH THE MANUFACTURER OR SUPPLIER OF THE COMPRESSED AIR BOTTLES TO INSURE THAT A REGULATOR IS INSTALLED ON THE BOTTLE TO REDUCE ITS PRESSURE TO 120 PSIG OR LESS PRIOR TO ATTACHING IT TO THE CONTROLLER.

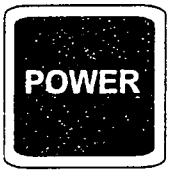
SYSTEM HOOKUP



1. Attach the compressed gas source hose to the long quick connect nipple labeled **"AIR IN"** on the face of the controller, located in the lower right hand corner of the controller panel, using the female portion of the coupling supplied. The other end of this hose has a male ¼ inch pipe thread fitting which should be installed in the air cylinder regulator or oil-less compressor.

2. Attach the controller air hose. The controller air hose has an exhaust valve connected in line. On the exhaust valve, a short length of hose is connected to the **"OUT"** port, and a longer length of hose is connected to the **"IN"** port. Attach the fitting on the short length of hose to the short brass quick connect nipple on the well cap (or hose reel). Attach the fitting on the longer length of hose to the short brass quick connect nipple labeled **"AIR OUT"** located on the upper left hand side of the control panel.

WELL SAMPLING AND PURGING

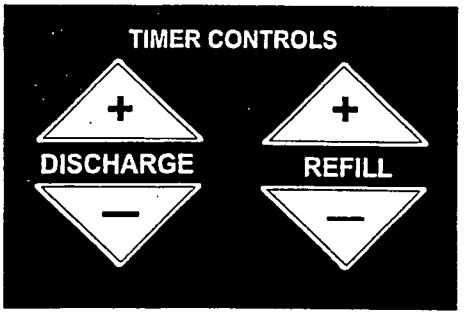


1. To begin operation, turn on the controller by pressing the red **"POWER"** button on the upper left hand side of the keypad. A battery check may be performed at any time by pressing the gray **"TEST BATTERY"** button. This will display an estimate of percentage of battery life remaining. If **"Bat"** appears on the display to the left of the discharge time, the battery pack is low. **"Air"** will appear on the display if no air is attached to the controller. Turn on the supply of air connected to the controller. **"Air"** on the display should disappear.

2. Up to this point controller preparation is similar to other Q.E.D. products such as the Model 3013 and 350 controllers. The operation may proceed using the basic controller features outlined here. Advanced controller features will be discussed later in this manual.

3. To start the controller press the green **"PUMP START/STOP"** button. The controller will start in the refill mode. The unit is programmed with start up discharge and refill times set at 6.0 seconds. The operator may select a different set of start up values by first setting the discharge and refill times at the desired setting and then pressing the red **"SAVE INFO"** button while the controller display shows **"NONE"** to the right of **"SITE ID"** and **"WELL ID"**. At this point the controller should be oscillating between the refill and discharge modes at the displayed start up values. The symbol "*" on the display indicates that the unit is paused on the side of the timer cycle by which it appears. The symbol ">" on the display indicates that the unit is oscillating and currently in the timer cycle by which it appears.

4. If the controller has not begun cycling after pressing the green **"PUMP START/STOP"** button within the displayed times, briefly press the yellow **"MANUAL SAMPLE"** button located on the left hand side of the keypad. This procedure will move the solenoid valve into a known state.



5. At this point the operator may change the time settings by pressing the blue "+" or "-" triangles surrounding the discharge or refill timer controls. Each time one of the timer adjustment buttons is pressed the time setting increases or decreases by 0.1 seconds. If the button is pressed and held, the time setting will advance first by 0.1 seconds increments, then accelerate to 1.0 second increments, and finally 5.0 second increments. If the key is released and pressed again the acceleration cycle will repeat.

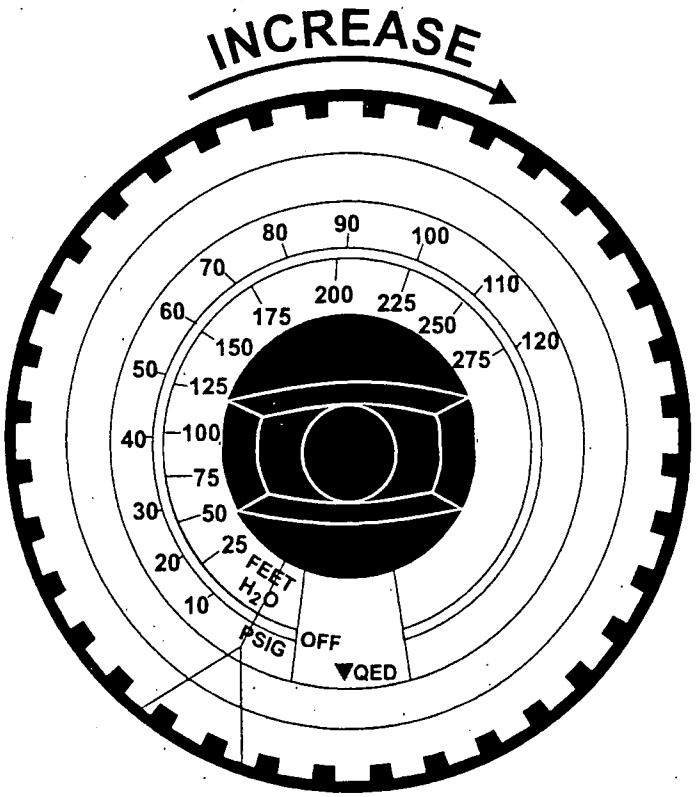
6. For typical well depths of 50-75 feet and submergence of 20-30 feet the following three step procedure may be used to determine optimum discharge and refill timer settings to maximize pumping efficiency:

A. Adjust the refill and discharge cycles to 10-15 seconds each. Measure the water volume discharged in a single discharge cycle.

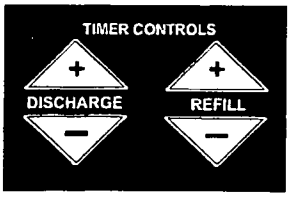
B. Shorten the discharge cycle period until the end of the discharge cycle just coincides with the end of the water flow from the sample pump outlet.

C. Shorten the refill cycle period until the water volume per discharge cycle decreases 10 -25% from the original maximum volume measured in step A, then lengthen the refill cycle time just enough to obtain the maximum pump volume once again.

7. The operator may use the yellow **"MANUAL SAMPLE"** button to assist in sample collection. To reduce flow rate during sample collection decrease the pump supply pressure by turning the knob labeled **"PUMP DRIVE AIR THROTTLE"** in a counter-clockwise direction. This device is located in the lower left hand corner of the controller. The **"PUMP AIR DRIVE THROTTLE"** has graduations in PSIG and Feet Of Water Pressure. If the pump depth is known set the **"PUMP AIR DRIVE THROTTLE"** at a slightly higher equivalent pressure. When **"PUMP AIR DRIVE THROTTLE"** is decreased the operator may press the yellow **"MANUAL SAMPLE"** button to shift the controller to the refill mode and pause. The yellow **"MANUAL SAMPLE"** can then be pressed again to shift the controller to the discharge mode and pause. The pump will flow until the volume contained in the pump's bladder is depleted. This may vary between 150 to 450 ml depending on the model of the pump that is used.



PUMP DRIVE AIR THROTTLE



1. Deeper wells require both the refill and discharge cycles to be lengthened by pressing the "+" arrows on the blue triangle buttons on the timer controls.

2. During the discharge cycle the compressed gas source is applied to the sample pump to discharge water. During the refill cycle the pump is vented to atmosphere at the controller which allows the pump to refill.

3. When the water discharge flow rate is decreased with the **"PUMP DRIVE AIR THROTTLE"** to facilitate sampling, it is often necessary to increase the discharge cycle time to deliver a full pump volume.

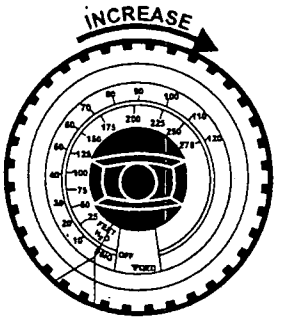
4. The volume of water pumped per cycle should be approximately 150-450 ml depending on the model of pump used. If the volume is significantly below the anticipated level, recheck cycle lengths according to the three step procedure outlined in step #6 on page #7.

PUMP DRIVE THROTTLE GUIDELINES

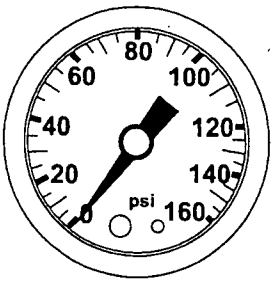
1. Turning the throttle control knob clockwise increases pressure applied to the pump and increases the pump's flow rate.

2. Turning the throttle control knob counterclockwise decreases pressure supplied to the pump and decreases the pump's flow rate.

3. The **"PUMP DRIVE PRESSURE"** gauge on the controller shows the pressure being applied to the sample pump. During the refill cycle the gauge will fall to zero as the pressure is vented out through the controller



PUMP DRIVE AIR THROTTLE



PUMP DRIVE PRESSURE

BATTERY CHARACTERISTICS

The Model 400 Series Programmable Controller is powered by eight (8) double "A" ("AA") size batteries. Battery life will largely depend on controller duty and the temperature the controller is used in. Batteries will last longer at room temperature than they will at lower temperatures and intermittent controller usage will result in longer battery life than continuous usage. 50,000 cycles from a set of batteries is typical. This would correspond to approximately seven (7) days of continuous 24 hour/day use with 6 second refill and discharge cycles. Since controller duty is normally not continuous, a longer battery life should be expected.

GENERAL CARE AND STORAGE

The recommended operating temperature range for the controller is 32° F to 100° F. It is recommended that the unit be protected from direct rain. When storing the unit the temperature should be kept between 40-100 degrees Fahrenheit. A dry storage area is preferable. If the controller is to be stored for an extended period, the batteries should be removed (as described below).

COLD WEATHER STORAGE

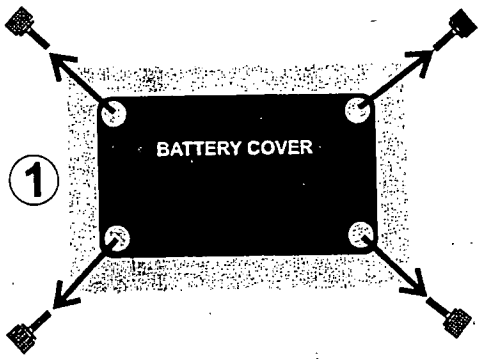
Use of the controller in subfreezing temperatures is possible but some complications may arise. If the controller is allowed to sit in a subfreezing environment without cycling, condensed water generated by the air compressor may cause the valves and other components to freeze. The controller will need to be warmed to above freezing before it will begin cycling.

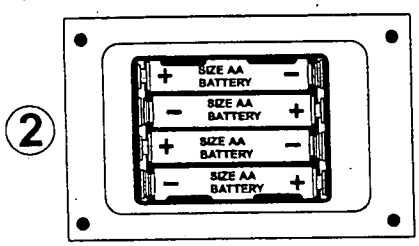
LCD DISPLAY

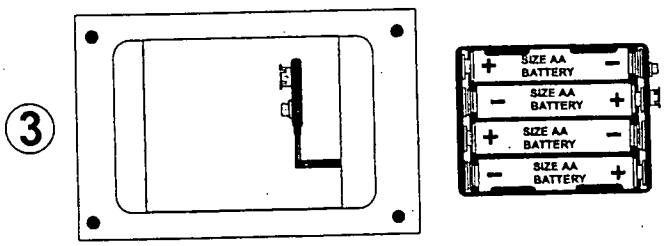
The display is protected by a scratch resistant polycarbonate lens. The lens should be protected from sharp objects or abrasives that could scratch it. Care should be taken when cleaning it.

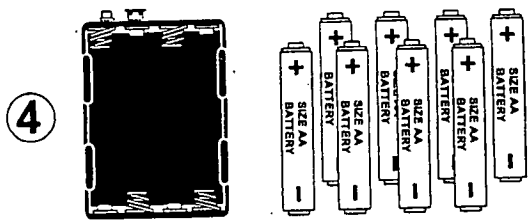
BATTERY REMOVAL/REPLACEMENT

Remove the four (4) thumb screws which hold the battery case panel located on the upper left hand side of the controller. Lift off the black battery cover and lift out the battery pack. Disconnect the battery snap. Remove the old batteries from the battery holder and replace with new ones. The orientation of the batteries is shown on the inside of the battery holder.









The operator should become familiar with the basic operation of the controller before using the advanced features. The basic operation emulates features of other QED controllers. The basic features include the following:

POWER (RED)

Turns the controller on and off. The unit is on when text is shown on the display.

PUMP START/STOP (GREEN)

Press this button to start the pump oscillation cycle. Pressing the button again stops the controller from cycling. If the unit is stopped an "*" will be displayed to the left of the refill time shown on the display. When the unit is cycling, an arrow ">" is displayed to the left of the timer setting on the display. The location of the arrow ">" indicates the part of the oscillation between the refill and discharge modes. If the button is pressed again the pattern will repeat.

MANUAL SAMPLE (YELLOW)

Pressing this button causes the unit will pause in the refill mode. A second press of the button shifts the controller to the discharge mode. If the button is pressed again the pattern will repeat.

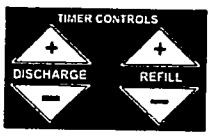
TEST BATTERY (GRAY)

This will display an estimate of the percent of battery life remaining. This estimate will vary with the type, age and brand of batteries. It is best to carry a spare set. It is not unusual for new batteries to fall rapidly to 70-75% and then begin a more gradual decay. Alkaline batteries are recommended. Life of batteries is estimated at 50,000 continuous cycles. This will vary with the type, age and brand of batteries. Push the red **"POWER"** button again to turn the unit off to conserve battery life.

SAVE INFO. (RED)

The operator may select a different set of start up values by first setting the discharge and refill times at the desired setting and then pressing the red **"SAVE INFO"** button while the controller display shows **"NONE"** to the right of the **"SITE ID"** and to the right of the **"WELL ID"**. The term **"NONE"** on the display simply indicates the default startup mode.

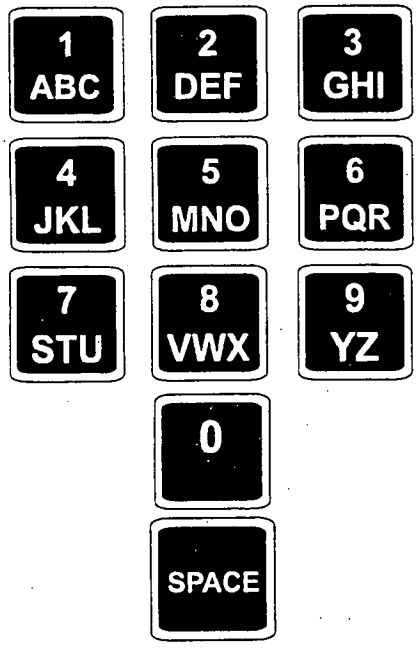
TIMER CONTROLS (BLUE TRIANGLES)



The timer controls consist of four triangular shaped keys. Discharge timer controls are on the left and refill timer controls are on the right. The keys are labeled with either a "+" or a "-". The "+" increases the time setting and the "-" decreases the time setting. The timer settings may be adjusted at any time during controller use.

Advanced operation allows the operator to store the controller discharge and refill timer settings for up to ten (10) sites each with fifty (50) wells. The operator may select a specific name for each site and well or accept the default name provided by the software. The site and well names may be edited in the future as needed. It is suggested that the operator become familiar with all operations in this section prior to use of actual well data. It is also advised that a written copy of entered data be kept as a back up in case data is lost. The following keys are used in advanced controller operation:

ALPHANUMERIC KEYPAD OVERVIEW



Names with up to eight (8) alpha and or numeric characters can be assigned to a site ID or a well ID. This is accomplished by using the eleven (11) alphanumeric keys located on the top portion of the keypad. Numeric characters may be entered by simply pressing the desired key. Alpha characters are entered by pressing the alphanumeric key containing the desired character and holding it until the desired character appears, then release the key. If the alphanumeric key is held down, the display will continue to cycle through the available choices. When the key is released a character is entered. If the incorrect character is entered, press the **"PREVIOUS"** to back space and repeat entry of the correct character. Use the **"NEXT"** key to advance to another character location to the right of the correction. A space may be placed in the name by pressing the **"SPACE"** key. When the ID appears correct, press **"ENTER"** to accept the name.

The **"PREVIOUS"** key allows the operator to scroll backwards through the menus.

The **"NEXT"** key allows the operator to scroll forward through the menus.

The **"CANCEL"** key will stop a programming operation.

The **"ENTER"** key is required to accept the proposed program change.

ADD/EDIT SITE OR WELL (BLACK)

This function allows the operator to:

Modify a site or well name
Create a new site or new well
Delete a site or a well

If the operator selects this function the first option displayed is to modify the site. The **"NEXT"** key may be pressed to advance to the next screen, modify well. If the operator continues to press the **"NEXT"** button the screen will advance to new site, new well, delete site and delete well. One additional press of the **"NEXT"** key returns the screen to modify site. If the operator passes the desired screen, the **"PREVIOUS"** key may also be used to return to the previous screen. The output on the display will appear as follows:

```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
Mod Site    (Next/Prev)
```

The site name may be modified from here.

```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
Mod Well    (Next/Prev)
```

The well name may be modified from here.

```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
New Site    (Next/Prev)
```

A new site may be created from here.

```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
New Well    (Next/Prev)
```

A new well may be created within a selected site from here.

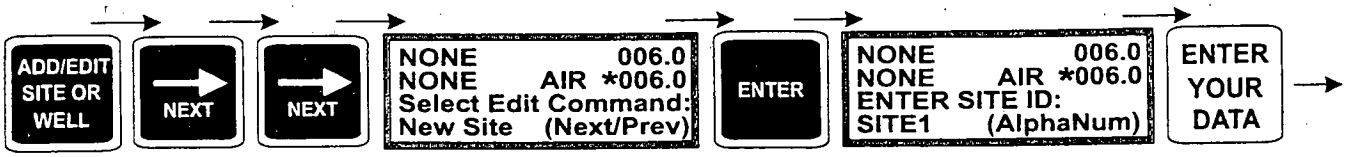
```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
Del Site    (Next/Prev)
```

A site and wells within it may be deleted from here.

```
NONE              006.0
NONE        AIR  *006.0
Select Edit Command:
Del Well    (Next/Prev)
```

A well within a selected site may be deleted from here.

New Site (Next/Prev)

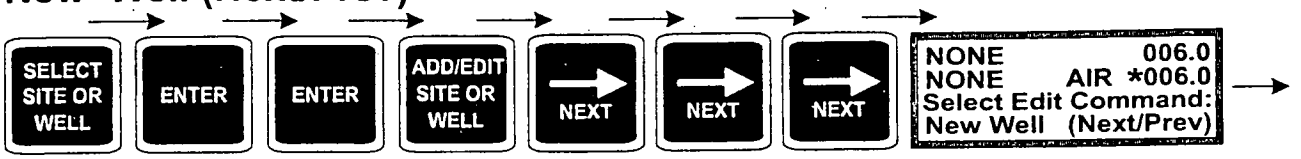


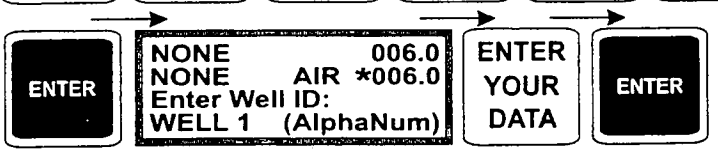
This function allows the operator to create a new site. To use this function the operator must press the **"ADD/EDIT SITE OR WELL"** key. Press the **"NEXT"** key twice until the display shows **"New Site (Next/Prev)"** then press the **"ENTER"** key. The display will now show **"Enter Site ID"**. The name for the site ID may be up to eight (8) alphanumeric characters. Numeric characters show **"Modify the Site ID:"**. The name for the site ID may be up to eight (8) alphanumeric characters. Numeric characters may be entered by simply pressing the desired key. Alpha characters are entered by pressing the alphanumeric key containing the desired character and holding it until the desired character appears, then release the key. If the alphanumeric key is held down, the display will continue to cycle through the available choices. When the key is released a character is entered. If the incorrect character is entered, press the **"PREVIOUS"** to back space and repeat entry of the correct character. Use the **"NEXT"** key to advance to another character location to the right of the correction. A space may be placed in the name by pressing the **"SPACE"** key. When the site ID appears correct, press **"ENTER"** to accept the name.

NOTE: After ten (10) sites have been selected, the display will show **"No memory for Site:"**. This will indicate that the maximum number of sites has already been entered.

An alternative to the alphanumeric name entry is provided in the software. This will offer the operator a default site which may be selected by pressing the **"ENTER"** key when the default site appears on the display. The default site names are **"SITE 1, SITE 2, SITE 3"** and so on.

New Well (Next/Prev)





This function allows the operator to create a new well. **NOTE: A SITE MUST FIRST BE SELECTED OR CREATED BEFORE THE USER CAN CREATE A NEW WELL.**

To use this function first press the **"SELECT SITE OR WELL"** key. Next select an existing site, or create a new site for the well that is to be created to be assigned to. Next press the **"ENTER"** key twice (the **"ENTER"** key must be pressed twice in order to allow you into the next mode). Press the **"ADD/EDIT SITE OR WELL"** key then press the **"NEXT"** key three times until **"New Well (Next/Prev)"** shows on the display then press the **"ENTER"** key. The display will now show the message **"Enter Well ID:"**. The name for the new well ID may be up to eight (8) alphanumeric characters. Numeric characters may be entered by simply pressing the desired key. Alpha characters are entered by pressing the alphanumeric key containing the desired character and holding it until the desired character appears, then releasing the key. If the alphanumeric key is held down, the display will continue to cycle through the available choices. When the key is released a character is entered. If the incorrect character is entered, press the **"PREVIOUS"** to back space and repeat entry of the correct character. Use the **"NEXT"** key to advance to another character location to the right of the correction. A space may be placed in the name by pressing the **"SPACE"** key. When the site ID appears correct, press **"ENTER"** to accept the name.

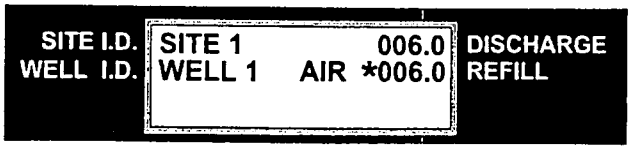
NOTE: After fifty (50) wells have been entered within a selected site, the display will show the message **"No memory for Well"**. This indicates that the maximum number of wells for the selected site has been entered.

An alternative to the alphanumeric well name entry is provided in the software. This will offer the operator a default well name which may be selected by pressing the **"ENTER"** key when the desired default name shows on the display. The default well names are **"WELL 0, WELL 1, WELL 2"** and so on.

SELECT SITE OR WELL (BLACK)

This function allows the operator to recall refill and discharge timer settings for a site and well previously entered and saved. The display will prompt the operator to first select the desired site. The operator may scroll through a list of up to ten (10) sites by pressing the **"PREVIOUS"** or **"NEXT"** key located on the alphanumeric portion of the keypad. When the desired site is displayed the operator may select it for use by pressing the **"ENTER"** key.

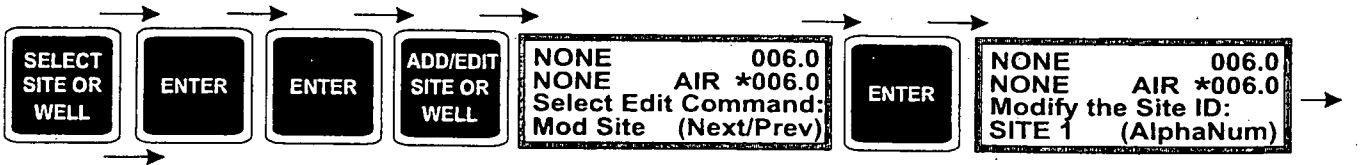
Next the display will prompt the operator to first select the desired well. The operator may scroll through a list of up to fifty wells specific to the selected site by pressing the **"PREVIOUS"** or **"NEXT"** located on the alphanumeric portion of the keypad. When the desired well is displayed the operator may select it for use by pressing the **"ENTER"** key.



The display will show the site ID, well ID and the previously save discharge and refill time for the selected site and well. At this point the operator may begin controller operation by pressing the green **"PUMP START/STOP"** button. The operator may change the timer settings at any time. If the new settings are to be recalled at a future time the operator must press the **"SAVE INFO."** button otherwise only the original setting will be saved.

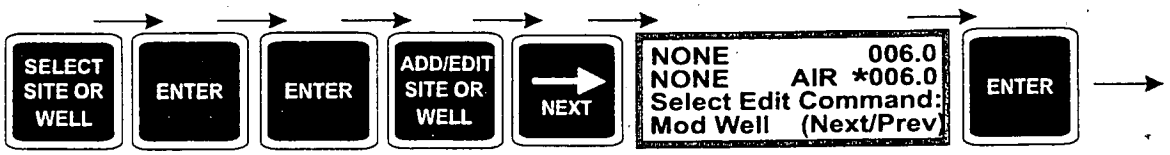
At the conclusion of the sampling event the operator may choose to shut the controller off or select another well within the listing for the selected site or select a different site and well.

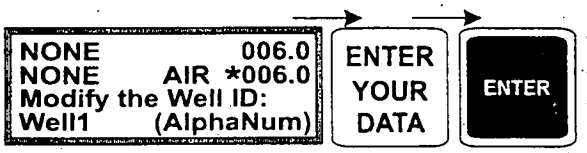
Mod Site (Next/Prev)



This function allows the operator to edit the site ID. First select a site using **"SELECT SITE OR WELL"**. If the site displayed is the one to be changed press the **"ENTER"** key. The display will show **"Modify the Site ID:"**. The name for the site ID may be up to eight (8) alphanumeric characters. Numeric characters may be entered by simply pressing the desired key. Alpha characters are entered by pressing the alphanumeric key containing the desired character and holding it until the desired character appears, then release the key. If the alphanumeric key is held down, the display will continue to cycle through the available choices. When the key is released a character is entered. If the incorrect character is entered, press the **"PREVIOUS"** key to back space and repeat entry of the correct character. Use the **"NEXT"** key to advance to another character location to the right of the correction. A space may be placed in the name by pressing the **"SPACE"** key. When the site ID appears correct, press **"ENTER"** to accept the name.

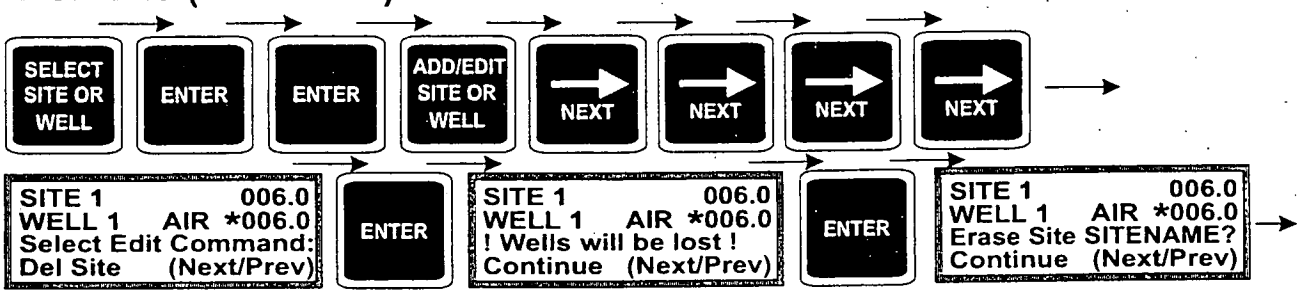
Mod Well (Next/Prev)





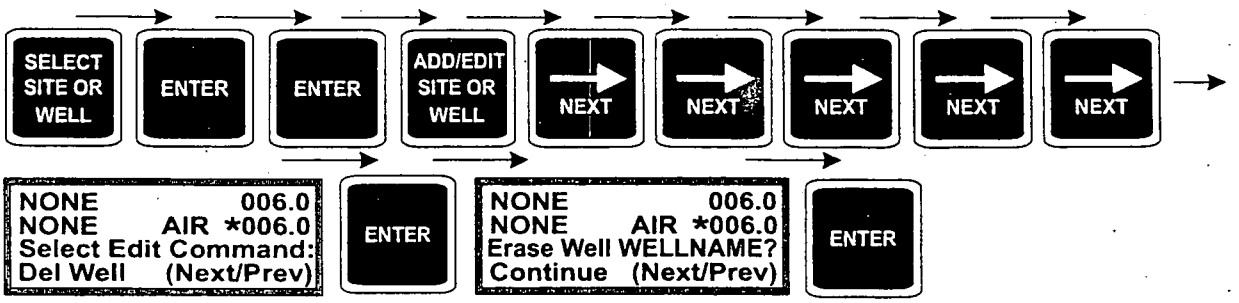
This function allows the operator to edit the well ID. First press the **"SELECT SITE OR WELL"** key. Locate the site where the well that you want edited is located. Once the site is located press the **"ENTER"** key. Next locate the specific well to be edited and press the **"ENTER"** key again. Next press the **"ADD/EDIT SITE OR WELL"** key. Next press the **"NEXT"** key once until the display shows **"Mod Well (Next/Prev)"** then press the **"ENTER"** key. **"Modify the Well ID:"** will appear on the display. The name for the well ID may be up to eight (8) alphanumeric characters. Numeric characters may be entered by simply pressing the desired key. Alpha characters are entered by pressing the alphanumeric key containing the desired character and holding it until the desired character appears, then release the key. If the alphanumeric key is held down, the display will continue to cycle through the available choices. When the key is released a character is entered. If the incorrect character is entered, press the **"PREVIOUS"** to back space and repeat entry of the correct character. Use the **"NEXT"** key to advance to another character location to the right of the correction. A space may be placed in the name by pressing the **"SPACE"** key. When the well ID appears correct, press **"ENTER"** to accept the name.

Del Site (Next/Prev)



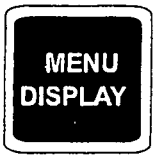
This allows the operator to delete a site and all the wells assigned to that site. To use this function the operator must press the **"SELECT SITE OR WELL"** key then locate the site that is to be deleted and then press the **"ENTER"** key twice (pressing the **"ENTER"** key twice allows you to go to the next mode). Press the **"ADD/EDIT SITE OR WELL"** key then press the "NEXT" key four (4) times until the message **"Del Site (Next/Prev)"** shows on the display. Press the **"ENTER"** key. The message on the display will now read **"!Wells will be lost! Continue (Next/Prev)"**.At this point the operator has the option to stop the deletion by pressing the **"CANCEL"** key or to continue with the deletion by pressing the **"ENTER"** key. If **"ENTER"** is pressed the display will now show **"Erase Site SITENAME? Continue (Next/Prev)"**. This prompt is designed to confirm that the operator truly wants to delete this site. The operator has the option again to push the **"CANCEL"** key to stop the deletion. Press the **"ENTER"** key to delete the site and all the wells assigned to it. **NOTE: ALL PREVIOUSLY ENTERED DATA WILL BE LOST**. After deletion of the site, the controller will automatically select and display the next site in sequence. For example if **"SITE 2"** is deleted, **"SITE 3"** will be displayed by default. The controller default start mode, indicated by "NONE" displayed next to **"SITE ID"** and **"WELL ID"** can not be deleted. If deletion of the default is attempted, the display will show **"Can't Del DEFAULT:"**. Press **"CANCEL"** to continue.

Del Well (Next/Prev)



This allows the operator to delete a well selected within a site. To use this function the operator must press the **"SELECT SITE OR WELL"** key then locate the site that contains the well that is to be deleted and then press the **"ENTER"** key. The operator then locates the well within the selected site that is to be deleted and then presses the **"ENTER"** key. The operator then presses the **"ADD/EDIT SITE OR WELL"** key. The operator must press the **"NEXT"** key five (5) times until the display message shows **"Del Well (Next/Prev)"**. The **"ENTER"** key is now pressed. The display will now read **"Erase Well WELLNAME? Continue (Next/Prev)"**. At this point the operator has the option to stop the deletion by pressing the **"CANCEL"** key or to continue with the deletion by pressing the **"ENTER"** key. After deletion of the well, the controller will automatically select and display the next well in sequence. For example if **"WELL 1"** is deleted, **"WELL 4"** will then be displayed by default.

MENU DISPLAY

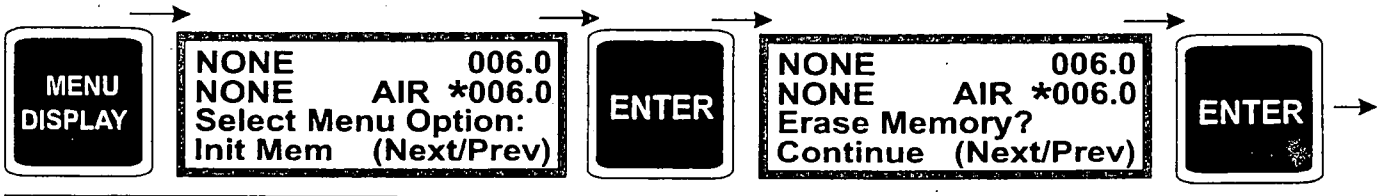


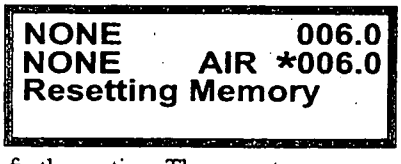
The **"MENU DISPLAY"** function will display a list of available options the operator may use. Currently only one option is available. This option is **"Init Mem"**. The purpose of the **"Init Mem"** is to allow the storage memory to be reinitialized from the keypad without returning the unit to the factory for service. The operator may want to use this option in one of two cases:

1. The operator desires to erase all stored memory in both **"SITES"** and **"WELLS"**. **"Init Mem"** will erase all memory in a single operation. The operator may also use **"ADD/EDIT SITE OR WELL"** to perform this operation but it will require multiple steps.

   NOTE: "DATA WILL BE LOST!" It is highly recommended that the operator keep a written backup copy of data stored in the controller in the event that it must be entered again after data loss.

2. In the unlikely event that stored data becomes corrupt it may be necessary to reinitialize the memory. Again it is highly recommended that the operator keep a written backup copy of data stored in the controller in the event that it must be entered again after data loss.



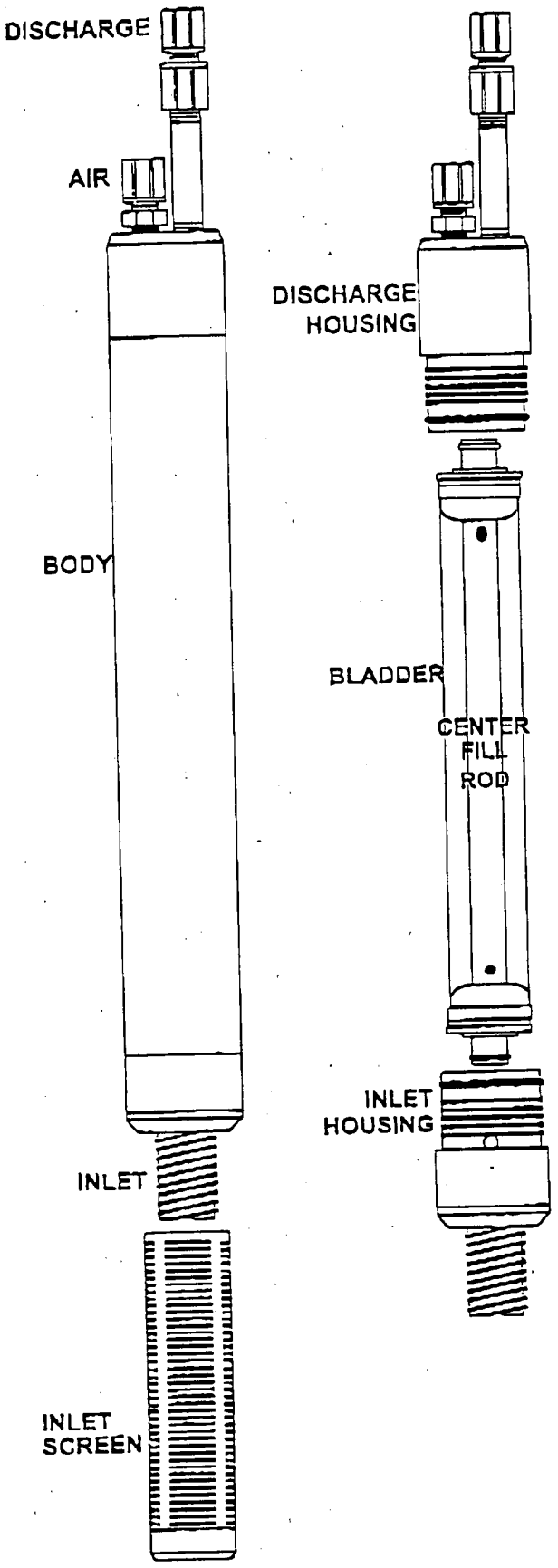


In order to reinitialize the memory the operator will first press the **"MENU DISPLAY"** button. The display will show **"Init Mem"**. The operator may press **"CANCEL"** to stop any further action. If the operator presses the **"ENTER"** button the screen will display **"Erase Memory?"**. Again pressing the **"CANCEL"** button will stop any further action. The operator may proceed with the reinitialization of the memory by pressing the **"ENTER"** button. **NOTE: DATA WILL BE LOST!** The display will show **"Resetting Memory..."** during the reinitialization process. When this message disappears the reinitialization is complete.

BLADDER PUMP & FREEZE PROTECTION

TECHNICAL DATA / SPECIFICATION SHEET

WELL WIZARD® PUMP
MODEL P1150



PUMP TYPE:

POSITIVE DISPLACEMENT BLADDER PUMP

MATERIALS:

BODY - PVC
BLADDER - TEFLON ®
INLET & DISCHARGE HOUSINGS - PVC
O-RINGS - VITON

DIMENSIONS:

DIAMETER - 1.66"
LENGTH - 19.5"
LENGTH WITH SCREEN - 22.75"
WEIGHT - 1.6 LBS.
SCREEN SLOT SIZE - .010

FITTINGS:

POLYPROPYLENE COMPRESSION-TYPE
AIR - 1/4" O.D., 3/16" I.D.
DISCHARGE - 1/4" O.D., 3/16" I.D.

PUMP VOLUME:

LITERS	MILLILITERS	GALLONS	OUNCES
.130	130	.03	4.3

MAXIMUM LIFT:

300 FEET

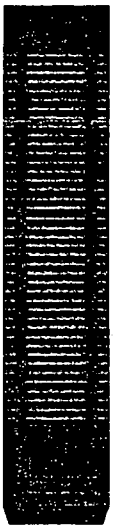
ACCESSORIES:

INLET SCREEN 4.5" PVC P/N 37727
BLADDER KIT P/N 37763
CLAMP HAND TOOL P/N 35052
BLADDER CARTRIDGE P/N 37764

PVC AND TEFLON SCREEN ATTACHMENT

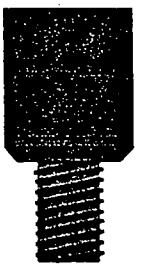
P1101 / P1101M / T1100 / T1100M - 6" Screen

Thread PVC screen (clockwise) onto the threaded inlet of the bladder pump until snug.



Check to insure that the screen's end cap is snug before inserting pump into well

P1150 - 4.5" Screen

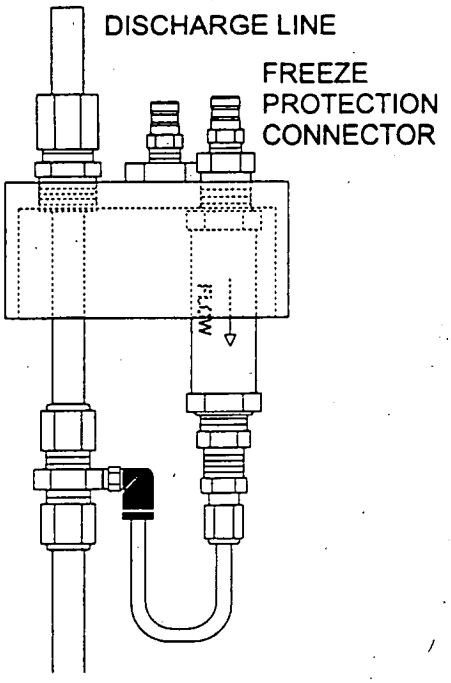


Thread PVC screen (clockwise) onto the threaded inlet of the bladder pump until snug.

Check to insure that the screen's end cap is snug before inserting pump into well

HOW TO USE THE FREEZE PROTECTION KIT

2120A/2120AM/2120AS STANDARD 2" WELL CAPS



To remove water from the discharge line

STEP 1. Disconnect air supply hose from the controller to the pump.

STEP 2. Turn controller discharge timer on the controller to a long discharge time. Turn controller refill timer on the controller to a short refill time.

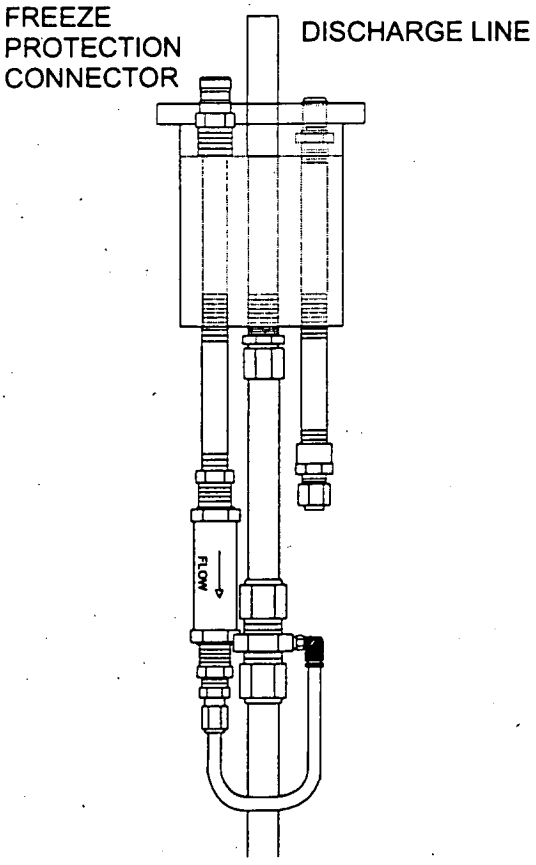
STEP 3. Turn the pressure regulator on the controller down to read 0 P.S.I.

STEP 4. Connect air supply hose from the controller to the blow down connector.

STEP 5. Slowly increase the the air pressure back up using the pressure regulator on the controller until water in the discharge tube moves at a rate desired.

STEP 6. When all the water has been removed, disconnect the controller air supply hose from the blow down connector.

2120AL/2120ALM/2120ALS LOW CLEARANCE 2" WELL CAPS



To remove water from the discharge line

STEP 1. Disconnect air supply hose from the controller to the pump.

STEP 2. Turn controller discharge timer on the controller to a long discharge time. Turn controller refill timer on the controller to a short refill time.

STEP 3. Turn the pressure regulator on the controller down to read 0 P.S.I.

STEP 4. Connect air supply hose from the controller to the blow down connector.

STEP 5. Slowly increase the the air pressure back up using the pressure regulator on the controller until water in the discharge tube moves at a rate desired.

STEP 6. When all the water has been removed, disconnect the controller air supply hose from the blow down connector.

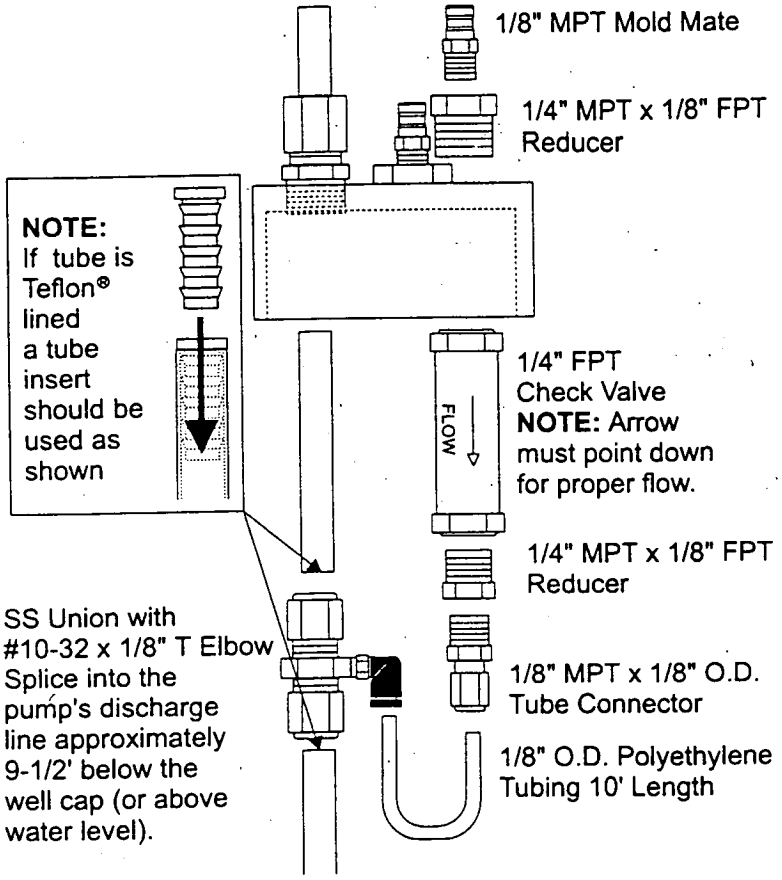
For instructions on "How To Install The Freeze Protection Kit" see back of this sheet

P/N 95142 12-6-96

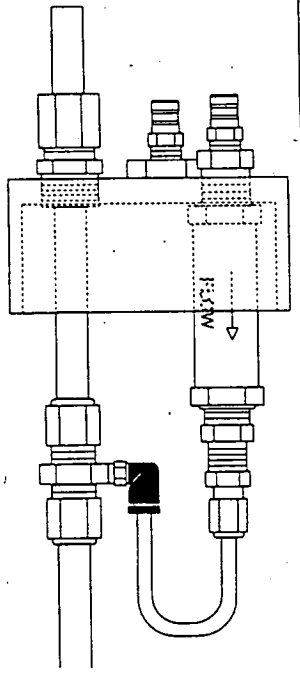
FREEZE PROTECTION KIT INSTALLATION

37753

2120A/2120AM/2120AS STANDARD 2" WELL CAPS



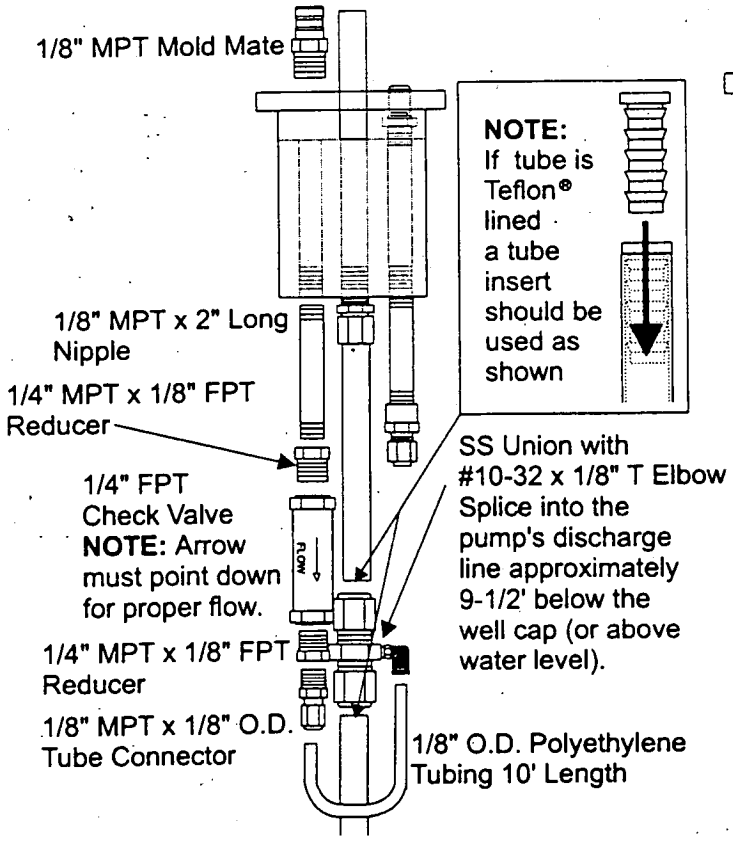
FREEZE PROTECTION CAP ASSEMBLY

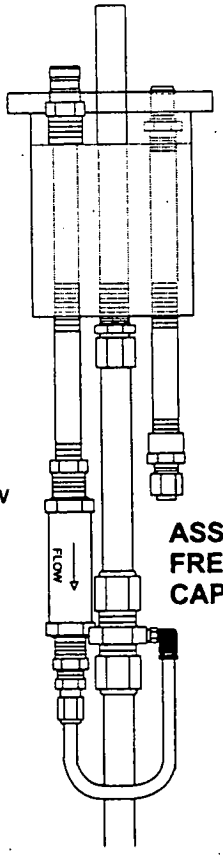


PARTS NOT USED FOR THIS ASSEMBLY

- 1/8" MPT x 2" Long Nipple
- 1/2" MPT x 1/8" FPT Bushing
- 1/4" MPT x 1/8" MPT Reducer

2120AL/2120ALM/2120ALS LOW CLEARANCE 2" WELL CAPS





ASSEMBLED FREEZE PROTECTION CAP ASSEMBLY

PARTS NOT USED FOR THIS ASSEMBLY:

- 1/2" MPT x 1/8" FPT Bushing
- 1/4" MPT x 1/8" MPT Reducer

For instructions on "How To Use The Freeze Protection Kit" see back of this sheet

P/N 95142 12-6-96

WATER QUALITY METER SONDE AND DISPLAY

APPENDIX J

USING SONDES WITH A 610

Getting Readings from the Sonde

Making Connections to the 610

Powering Up the 610

610 Menu Overview

Choosing Which Readings to Display

Displaying Readings

Basic Calibration

Site List

Using the Site List with the Marked File

Using the Site List for Capture, Log, and Add Files

Sampling Applications

Stash Memory

Capture and Add

Mark

Logging Applications

Logging with the 610

Setting Up the 6000 for Unattended Logging

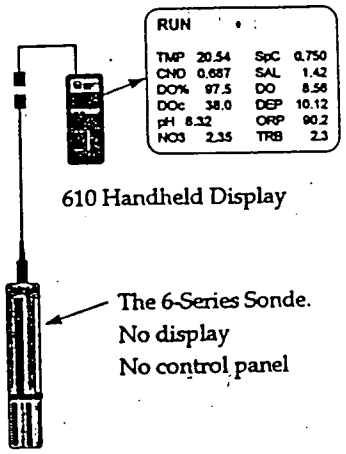
Setting Up the 6920 for Unattended Logging

Uploading Logged Files from a 6000

Uploading Logged Files from a 6920

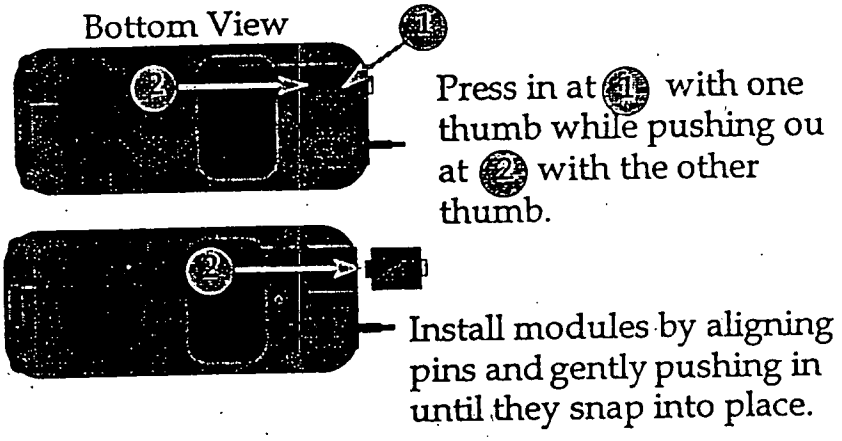
Transferring Files from the 610 to a PC

Getting Readings from the Sonde



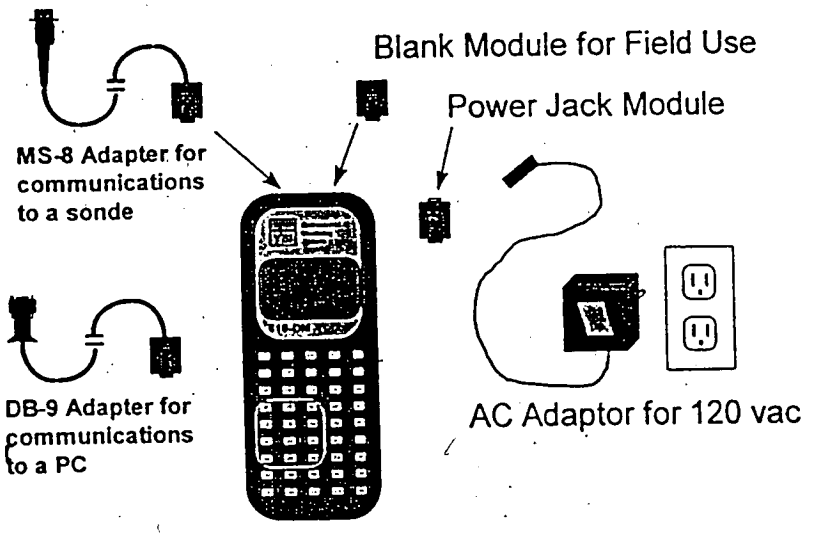
Making Connections to the 610

There are two slide plugs on the back of the 610. They are not interchangeable. One side is for power and the other for communications to a sonde or computer. In the lab, you will often use the AC adapter plug to power and charge your 610. Use these while you are learning to use the 610. Because this plug is not intended to be watertight, when going to the field we recommend replacing this plug with the blanking plug. Available separately is also a slide plug adapter for connecting your 610 to an external battery.



Two slide plug cable adapters are available for the communications side. One is for communication with a PC and terminates in a 9 pin miniature sub-D connector. When

communicating with a PC, be sure to use a null modem cable. The other adapter is for use with a sonde and terminates in an 8 pin, military style connector. Plug this adapter in and plug it into the sonde cable.



Powering Up the 610

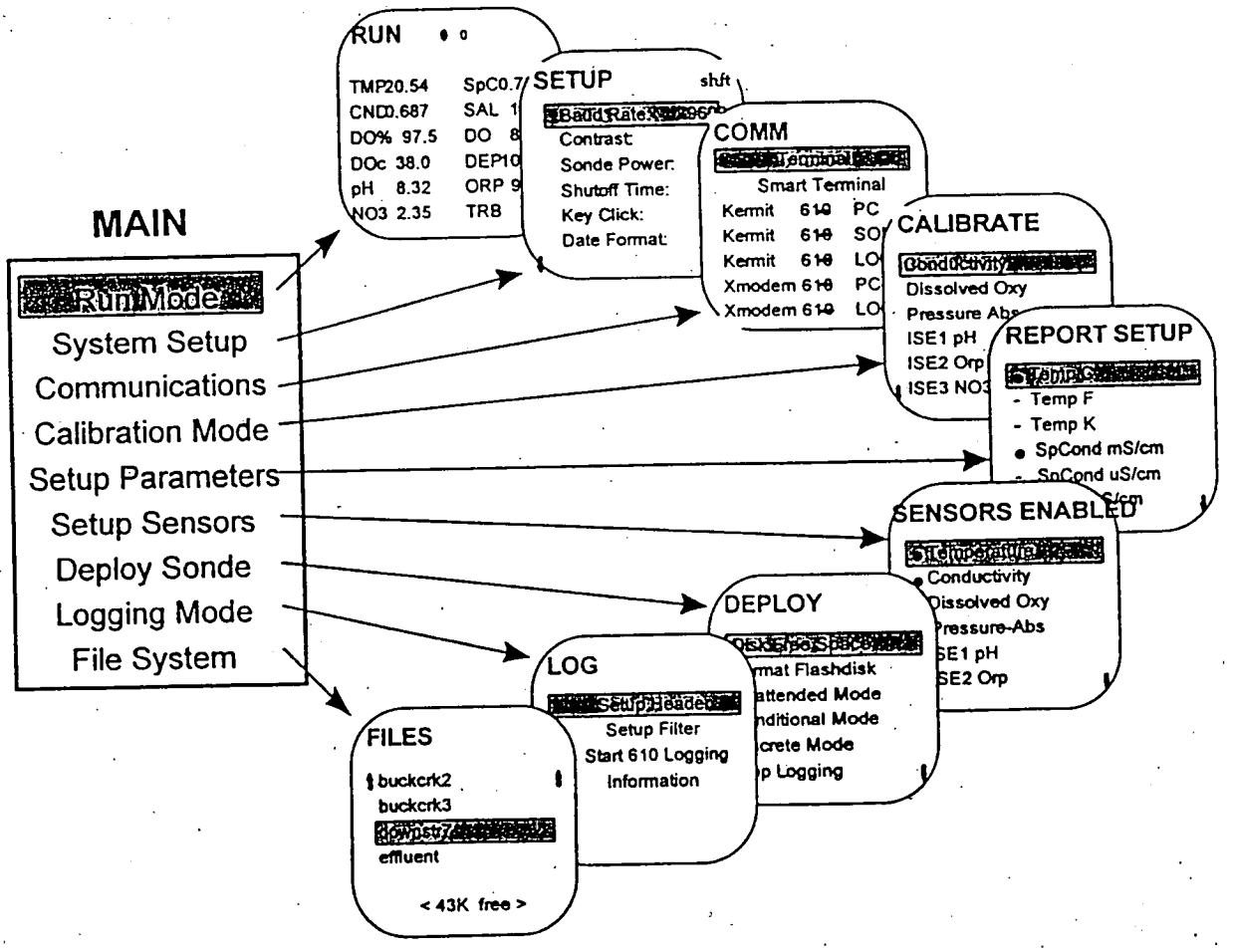
Normally, the 610 powers up whenever the AC adapter is plugged in, but when the 610 is shipped, the batteries may need a few minutes of charging before the unit can be powered on. To turn the 610 off when the AC adapter is plugged in, press the Power button, wait for the power up display to appear and then press the Power button again. Do not allow the 610 to charge more than 48 hours continuously.

With a sonde plugged in, the 610 powers up in Run Mode, that is, displaying readings.

Information can be entered when you see a blinking cursor within the item being highlighted. If you wish to change the highlighted information, type in the new information, then press Enter. Inputs can always be entered in upper or lower case. When an item only has a few specific possibilities (like "above" and "below") you need only type the first letter or two before pressing Enter.

Durations and Intervals, which appear on logging and deployment menus, are entered in a special way. Values may be entered in units of seconds (s), minutes (m), hours (h) or days (d). You must type a number followed by a letter (press Shift after typing the numeric portion). Thus 15 seconds is entered as "15s", and 36 hours is entered as "36h".

610-DM Menu



The upper right corner of the screen indicates the keyboard shift status by showing "shft", "caps", or "ctrl". The 610 automatically sets/clears the shift status when it expects numeric/text input. Inputs can always be entered in upper or lower case.

Some menus are too large to fit on the screen. In such cases, arrow symbols appear in the upper or lower corners. To access items not shown, just use the Arrow keys as usual. The screen will scroll as necessary.

The message, "No Sonde in Use" may appear occasionally while the 610 is trying to establish communication to a 6000 sonde. If the message does not go away after 15 seconds, then check cables, power and baud rate selection on both the 610 and the sonde.

Choosing Which Readings to Display

In the YSI product line, "sensor" refers to a physical piece of sensing hardware, and "parameter" refers to a calculation which can be derived from one or more sensors. Thus temperature is a physical sensor, but salinity is a calculated parameter derived from a temperature sensor and conductivity sensor. More subtly, temperature in Celsius is a parameter derived from a physical temperature sensor.

The Sensors and Parameters menus of the 610 allow you to display or change the active sensors and parameters in the sonde. Except when you first purchase a sonde, you will rarely find yourself in the Sensors menu, and you will only occasionally use the Parameters menu. Both menus are entered through the Main menu. They have a similar format to each other. To select or deselect an item, just highlight it and press Enter.

The Sensors menu tells a sonde what hardware it is equipped with. The 610 and sonde will believe whatever you tell them here - if you activate a sensor that isn't really connected, you'll see false readings for that sensor.

Displaying Readings

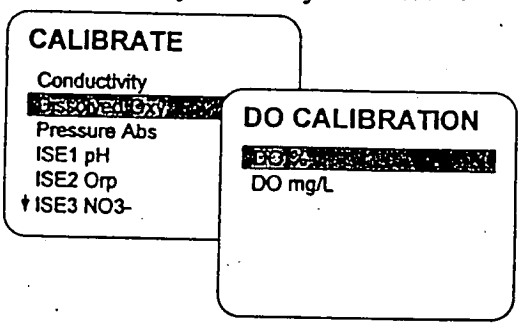
Run mode is accessed by selecting Run from the Main menu, or by powering up the 610 with a sonde connected. In Run mode the 610 constantly requests live data from the sonde and displays it on the screen.
When 6 parameters or fewer are selected, data is displayed double-size. If more than 12 parameters are selected, then you may scroll to see all parameters.

Pressing H in Run mode displays the Help screen. The Help screen reminds you of the special keys which are active in Run mode. Such keys can be pressed in Run mode, or when the Help screen is showing. The keys are as follows:

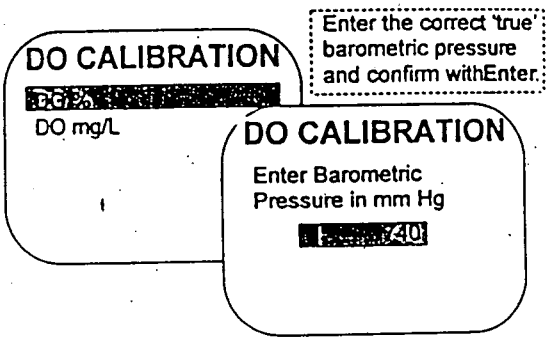
C	Turn Capture mode on/off (610-DM only)
A	Add a reading to a file (610-DM only)
S	Store a reading
M	Capture or Add readings to the marked file
R	Recall a reading
W	Local Weather
N	Notepad editor
L	Show Last 11 Stores/Weathers/Notes
T	Clean turbidity probe attached to sonde
H	Show Help screen

Basic Calibration

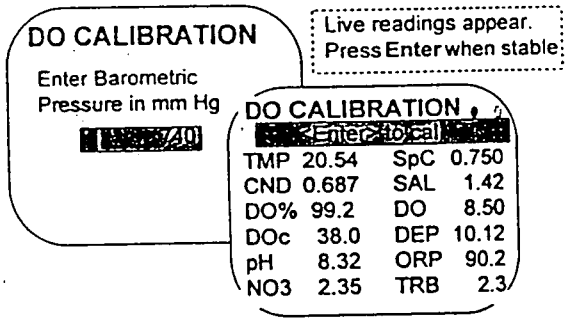
Most real-world physical sensors need to be calibrated occasionally. When you calibrate a sensor, you are telling the sonde that you know the exact value for what it is measuring. For example you may know the exact pH of a solution the probe is immersed in. Keep in mind that although you may use the 610, it is the sonde that is being calibrated and the results of that calibration are stored in the sonde.



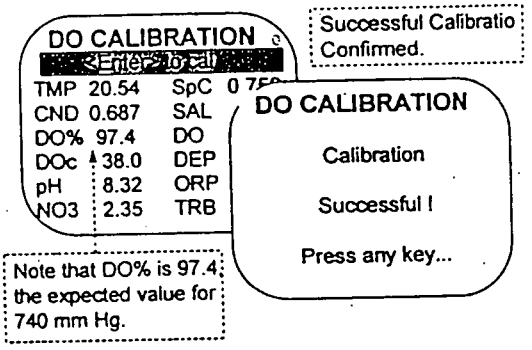
All calibrations are very similar. An example of DO calibration is shown here. When you enter the Calibration menu (from the Main menu), you are presented a list of sensors which can be calibrated. Some sensors, like pH or nitrate, can be calibrated using 1, 2, or 3 points. These options are either shown separately on the list, or offered right after you select a sensor. Select the sensor and number of points you wish and press Enter.



The 610 asks for the exact value to calibrate to and commands the sonde to calibrate. The 610 will step you through multi-point calibrations if applicable.



YSI Sondes calibrate slightly different from each other. The 6000 automatically waits for stabilization of the reading, and notifies you when calibration is finished. Other sondes will do the same thing if auto-sleep is enabled. In all other situations the sonde shows you data until you are satisfied it is stable.



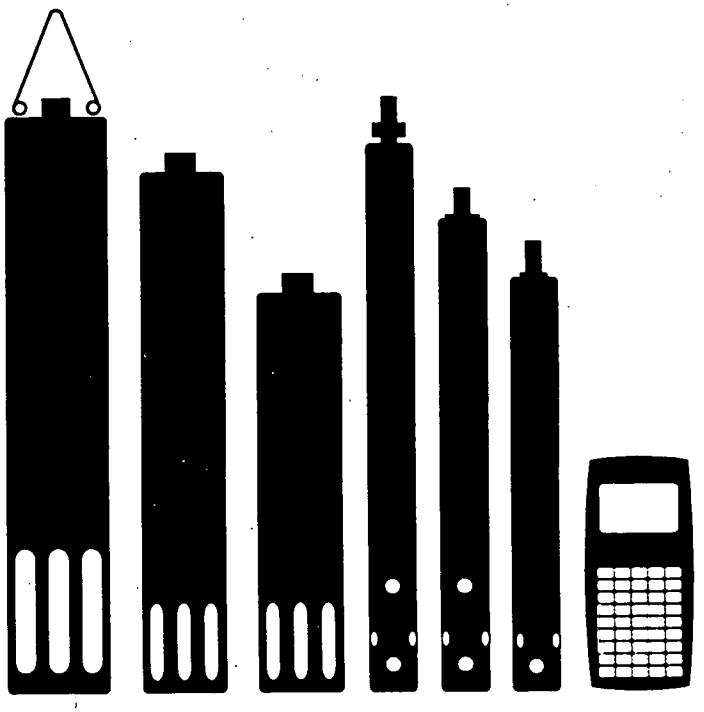
Errors can occur during calibration. The number you enter may be out of range, the sensor may be installed incorrectly, the sensor may be drifting. If an error occurs, the sonde rejects the calibration and an error message is displayed on the 610. Some types of errors can be overridden; you will be offered this option if applicable.

When calibrating turbidity, it is important to eliminate bubbles which can drastically alter the results. The 6026 Turbidity Probe has a wiper that is very helpful in removing bubbles during calibration and reading. If your sonde is a 6000, the 610 automatically activates the wiper prior to each turbidity calibration. If your sonde is a 6820 or a 6920, you can activate the wiper manually by pressing T, at any time while you wait for stabilization.

Before a calibration is completed, you may press Esc to abort it.

YSI *incorporated*

6-SERIES



Environmental Monitoring Systems

Operations Manual

SAFETY NOTES

TECHNICAL SUPPORT AND WARRANTY INFORMATION

Contact information for technical support and warranty information on YSI's Environmental Monitoring Systems products, can be found in **Section 8, Warranty and Service Information** of this manual.

COMPLIANCE

If you are using your YSI 6920, 6600 or 600XLM sonde in a European Community (CE) country, you must install two clamp-on ferrite bead assemblies to the sonde end of your cable. This will allow you to comply with the Residential, Commercial and Light Industrial Class B Limits for the 600XLM and 6920, and Class A Limits for the 6600 for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. *These ferrite assemblies are not required in many areas of the world and therefore are not supplied as part of cables kits. Thus, the parts must to be ordered separately by European Community users.* Please see **Appendix C, Accessories** for ordering information, and **Appendix H, EMC Performance/Ferrite Bead Installation** for installation instructions and electromagnetic compatibility performance issues.

SPECIFICATIONS

For general specifications for all of YSI Environmental Monitoring Systems products included in this manual, please see **Appendix I, Specifications**.

GENERAL SAFETY CONSIDERATIONS

For Health and Safety issues concerning the use of the calibration solutions with the sondes, please see **Appendix A, Health and Safety**.

NOTICE

Information contained in this manual is subject to change without notice. Effort has been made to make the information contained in this manual complete, accurate and current. YSI shall not be held responsible for errors, or omissions in this operation's manual.

WARNING:

When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact, if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

Note: Strikethrough sections are not used on this job and have been removed from the Operations Manual.

CONTENTS

SECTION 1 INTRODUCTION **1**
- 1.1 About YSI 1
- 1.2 How to Use This Manual 2
- 1.3 Unpacking and Inspection 2

SECTION 2 SONDES **3**
- 2.1 Getting Started 3
- 2.2 Connecting Your Sonde 4
- 2.3 Preparing the Sonde for Use 7
  - 2.3.1 Installing the Dissolved Oxygen Membrane 7
  - 2.3.2 Installing the Probes 9
  - 2.3.3 Power 13
  - 2.3.4 Connecting a Field Cable 16
- ~~2.4 EcoWatch for Windows – Getting Started 18~~
  - ~~2.4.1 Installing EcoWatch Software 18~~
  - ~~2.4.2 Running EcoWatch Software 18~~
  - ~~2.4.3 EcoWatch Software Setup 18~~
- ~~2.5 Sonde Software Setup 19~~
- 2.6 Getting Ready to Calibrate 29
  - 2.6.1 Calibration Procedures 31
- 2.7 Taking Readings 38
- ~~2.8 Using EcoWatch to Capture, Upload and Analyze Data 45~~
- 2.9 Sonde Menu 58
  - 2.9.1 Run 58
  - 2.9.2 Calibrate 66
  - 2.9.3 File 72
  - 2.9.4 Status 74
  - 2.9.5 System 75
  - 2.9.6 Report 77
  - 2.9.7 Sensor 80
  - 2.9.8 Advanced 81
- 2.10 Care, Maintenance and Storage 89
  - 2.10.1 Sonde Care and Maintenance 89
  - 2.10.2 Probe Care and Maintenance 90
  - 2.10.3 Sonde Storage 94
  - 2.10.4 Probe Storage 96

~~**SECTION 3 DISPLAYS AND LOGGERS** 101~~
- ~~3.1 Getting Started 101~~
  - ~~3.1.1 Batteries and Charging 101~~
  - ~~3.1.2 Connecting to a Sonde 101~~
  - ~~3.1.3 Powering Up 103~~
- ~~3.2 Using the Keyboard 104~~
- ~~3.3 Choosing Which Readings to Display 104~~
  - ~~3.3.1 Setting Up and Using the Site List 105~~
- ~~3.4 Logging 108~~

3.4.1 Setting Up a Sonde for Unattended Logging 110
3.5 Files 112
3.5.1 Uploading Logged Files 112
3.5.2 Transferring Files to a Computer 113
3.6 Sampling 113
3.6.1 Stash Memory 114
3.6.2 Capture and Add Memory 115
3.6.3 Mark 116
3.7 The 610 Menu 119
3.7.1 Run 120
3.7.2 Setup 610 122
3.7.3 Communications 122
3.7.4 Calibration Mode 124
3.7.5 Setup Parameters and Setup Sensors 125
3.7.6 Deploy Sonde 125
3.7.7 Logging Mode 125
3.7.8 File System 126
3.8 Technical Information 128
3.8.1 Software Updates 128
3.8.2 Loading New Software 128

SECTION 4 ECOWATCH FOR WINDOWS 131
4.1 Introduction 131
4.1.1 Compatible Equipment 131
4.1.2 Glossary 132
4.1.3 Tutorial 134
4.1.4 Using the Toolbar 135
4.1.5 Typical Application 136
4.2 Data Acquisition and Analysis 138
4.2.1 Connect a Sonde or a Model 610 Display/Logger 138
4.2.2 Upload a File From a 600XLM, 6920, 6600 or 6000 139
4.2.3 Upload a file from a 610D or DM Display/Logger 139
4.2.4 Using the Graph 140
4.2.5 Graph Data in Real Time 141
4.3 EcoWatch Menu 141
4.3.1 File 141
4.3.2 Edit 150
4.3.3 View 151
4.3.4 Comm(unication) 154
4.3.5 Real-Time 160
4.3.6 Graph 161
4.3.7 Setup 162
4.3.8 Appl(ications) 170
4.3.9 Window 171
4.3.10 Help 171

SECTION 5 PRINCIPLES OF OPERATION **173**
5.1 Conductivity 174
5.2 Salinity 174
5.3 Oxidation Reduction Potential (ORP) 174
5.4 pH 176
5.5 Depth and Level 177
5.6 Temperature 178
5.7 Dissolved Oxygen 179
5.8 Nitrate 182
5.9 Ammonium and Ammonia 184
5.10 Chloride 187
5.11 Turbidity 188
5.12 Flow 191

SECTION 6 TROUBLESHOOTING **193**
6.1 Calibration Errors 194
6.2 Sonde Communication Problems 195
6.3 Sensor Performance Problems 196

~~**SECTION 7 COMMUNICATION** **199**~~
~~7.1 Overview 199~~
~~7.2 Hardware Interface 199~~
~~7.3 RS-232 Interface 200~~
~~7.4 SDI-12 Interface 200~~

SECTION 8 WARRANTY AND SERVICE INFORMATION **205**

APPENDIX A HEALTH AND SAFETY 209
APPENDIX B REQUIRED NOTICE 217
APPENDIX C ACCESSORIES AND CALIBRATION STANDARDS 219
APPENDIX D SOLUBILITY AND PRESSURE/ALTITUDE TABLES 223
APPENDIX E TURBIDITY MEASUREMENTS 227
APPENDIX F FLOW 233
APPENDIX G USING VENTED LEVEL 239
APPENDIX H EMC PERFORMANCE/FERRITE BEAD INSTALLATION 243
APPENDIX I SPECIFICATIONS 245
APPENDIX J INDEX 251

SECTION 1 INTRODUCTION

1.1 ABOUT YSI INCORPORATED

From a three-man partnership in the basement of the Antioch College science building in 1948, YSI has grown into a commercial enterprise designing and manufacturing precision measurement sensors and control instruments for users around the world. Although our range of products is broad, we focus on four major markets: water testing and monitoring, health care, bioprocessing, and OEM temperature measurement.

In the 1950s, Hardy Trolander and David Case made the first practical electronic thermometer using a thermistor. This equipment was developed to supply Dr. Leland Clark with a highly sensitive and precise temperature sensor for the original heart-lung machine. The collaboration with Dr. Clark has been critical to the success of the company. In the 1960s, YSI refined a Clark invention, the membrane covered polarographic electrode, and commercialized oxygen sensors and meters which revolutionized the way dissolved oxygen was measured in wastewater treatment plants and environmental water. Today, geologists, biologists, environmental enforcement personnel, officials of water utilities and fish farmers recognize us as the leader in dissolved oxygen measurement.

In the 1970s, YSI again worked with Clark to commercialize one of his many inventions, the enzyme membrane. This development resulted in the first practical use of a biosensor, in the form of a membrane based on immobilized glucose oxidase, to measure blood sugar accurately and rapidly. In the next few years, this technology was extended to other enzymes, including lactate oxidase for applications in biotechnology, health care, and sports medicine.

In the early 1990s, YSI launched a line of multi-parameter water monitoring systems to address the emerging need to measure non-point source pollution. Today we have thousands of these instrument in the field that operate with the push of a button, store data in memory and communicate with computers. These instruments (described in this manual) are ideal for profiling and monitoring water conditions in industrial and wastewater effluents, lakes, rivers, wetlands, estuaries, coastal waters, and monitoring wells. If the instrument has 'on board' battery power, it can be left unattended for weeks at a time with measurement parameters sampled at your setup interval and data securely saved in the unit's internal memory. The fast response of our sensors make the systems ideal for vertical profiling and the small size of some our sondes allows them to fit down 2 inch diameter monitoring wells. All of our multi-parameter systems feature the YSI-patented Rapid Pulse Dissolved Oxygen Sensor which exhibits low stirring dependence and, therefore, provides accurate results without an expensive, bulky and power-intensive stirrer.

We have established a worldwide network of selling partners in 54 countries that includes laboratory supply dealers, manufacturers' representatives, and our own sales force. Our subsidiary, YSI Limited, distributes our products in the United Kingdom, and our sales office in Hong Kong supports our distribution partners in the Asia Pacific. We have established joint ventures with several other companies that have strengths that complement ours.

Through an employee stock ownership plan (ESOP), every employee is one of the owners. In 1994, the ESOP Association named YSI the ESOP Company of the Year. We are proud of our products and we are committed to meeting or exceeding our customers' expectations.

1.2 HOW TO USE THIS MANUAL

The manual is organized to let you quickly understand and operate the YSI 6-Series environmental monitoring systems. However, it cannot be stressed too strongly that informed and safe operation is more than just knowing which buttons to push. An understanding of the principles of operation, calibration techniques, and system setup is necessary to obtain accurate and meaningful results.

Because of the many features, configurations and applications of these versatile products, some sections of this manual may not apply to the specific system you have purchased.

If you have any questions about this product or its application, please contact our customer service department or authorized dealer for assistance. See **Section 8, Warranty and Service Information** for contact information.

1.3 UNPACKING AND INSPECTION

Inspect the outside of the shipping box for damage. If any damage is detected, contact your shipping carrier immediately. Remove the equipment from the shipping box. Some parts or supplies are loose in the shipping box so check the packing material carefully. Check off all of the items on the packing list and inspect all of the assemblies and components for damage. If any parts are damaged or missing, contact your YSI representative immediately. If you purchased the equipment directly from YSI, or if you do not know from which YSI representative your equipment was purchased, refer to **Section 8, Warranty and Service Information** for contact information.

SECTION 2 SONDES

2.1 GETTING STARTED

The 6 Series Environmental Monitoring Systems are multi parameter, water quality measurement, and data collection systems. They are intended for use in research, assessment, and regulatory compliance applications. Section 2 concentrates on sondes and how to operate them during different applications. A sonde is a torpedo-shaped water quality monitoring device that is placed in the water to gather water quality data. Sondes may have multiple probes. Each probe may have one or more sensors that read water quality data.

The following list contains parameters that your sonde may measure. See **Appendix I, Specifications** for the specific parameters of each sonde.

- Dissolved Oxygen
- Conductivity
- Specific Conductance
- Salinity
- Total Dissolved Solids
- Resistivity
- Temperature
- pH
- ORP
- Depth
- Level
- Flow
- Turbidity
- Nitrate-N
- Ammonia-N
- Ammonium-N
- Chloride

This section is designed to quickly familiarize you with the hardware and software components of the sondes and their accessories. You will then proceed to probe installations, cable connections, software installation and finally basic communication with your Sonde. Diagrams, menu flow charts and basic written instructions will guide you through basic hardware and software setup.

2.2 CONNECTING YOUR SONDE

There are a number of ways in which you may connect the sondes to various computers, data collection devices and VT-100 terminal emulators. To utilize the configuration that will work best for your application, make sure that you have all of the components that are necessary. The following list and diagrams (figures 1-4) are a few possible configurations.

- ❑ Sonde to Lab Computer (recommended for initial setup)
- ❑ Sonde to Data Collection Platform
- ❑ Sonde to Portable Computer
- ❑ Sonde to YSI 610 Display/Logger

Figure 1

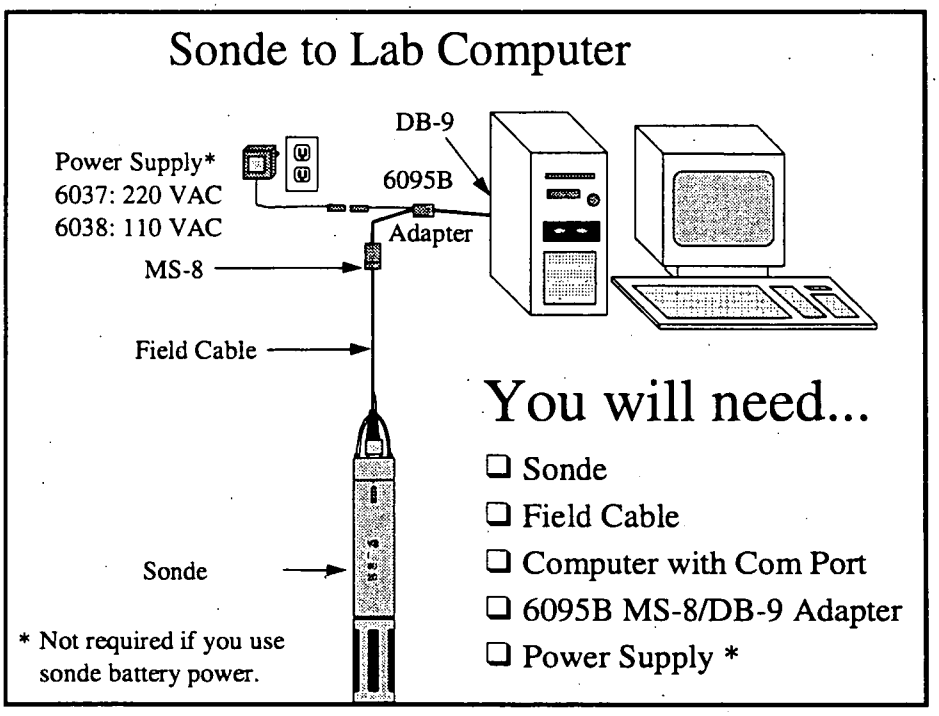


Figure 2

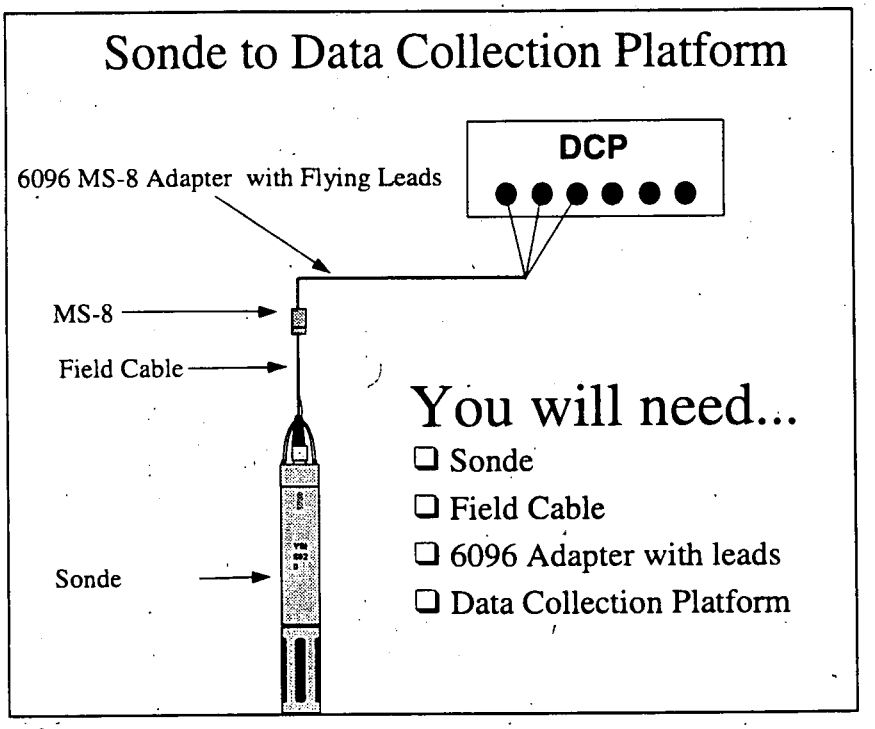


Figure 3

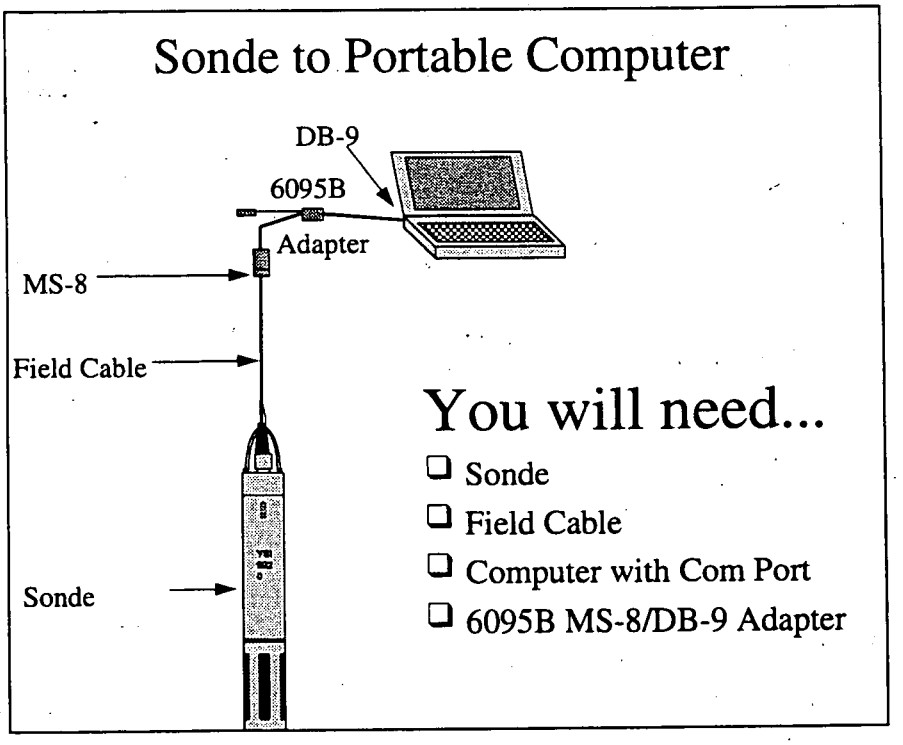
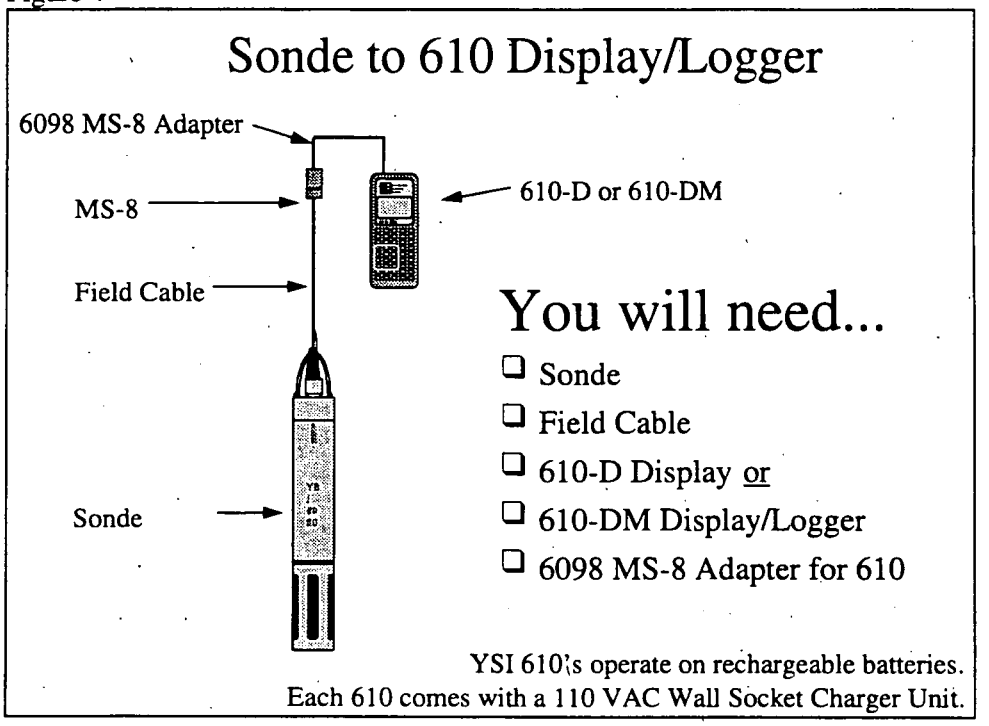


Figure 4


Sonde to 610 Display/Logger
6098 MS-8 Adapter
MS-8
Field Cable
Sonde
610-D or 610-DM
You will need...
Sonde
Field Cable
610-D Display or
610-DM Display/Logger
6098 MS-8 Adapter for 610
YSI 610's operate on rechargeable batteries.
Each 610 comes with a 110 VAC Wall Socket Charger Unit.

2.3 PREPARING THE SONDE FOR USE

To prepare the sonde for calibration and operation, you need to install probes (sensors) into the connectors on the sonde bulkhead. In addition to probe installation, you need to install a new membrane on the 6562 DO Probe. It is recommended that you install the DO membrane before installing the probe onto the bulkhead. For membrane changes in the future, you may be able to perform this operation without removing the DO probe. This will largely depend on whether the other installed probes interfere with your ability to install a membrane. The next step is providing power for the sondes, through batteries or AC and then connecting a field cable. The four steps necessary for getting your sonde ready for use are listed below.

Step 1 Installing the Dissolved Oxygen Membrane – Section 2.3.1
Step 2 Installing the Probes – Section 2.3.2
Step 3 Power – Section 2.3.3
Step 4 Connecting a Field Cable – Section 2.3.4

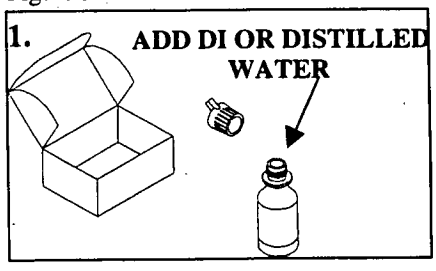
The exception is the 600R sonde, which comes with all probes installed. You still need to install the membrane onto the 600R, and it must be done while the probe is attached to the bulkhead. Follow the instructions in ***Section 2.3.1, Installing the Dissolved Oxygen Membrane.*** *Do not try to remove the 600R's DO probe at any time. The DO probe on the 600R sonde is factory-installed.*

2.3.1 STEP 1 - INSTALLING THE DISSOLVED OXYGEN MEMBRANE

The DO probe is shipped with a protective dry membrane on the sensor tip, held in place by an O-ring. Remove the O-ring and membrane. Handle the probe with care. It is very important not to scratch or contaminate the sensor tip. See **Section 2.10.2, Probe Care and Maintenance**, for information on how often the membrane should be replaced.

Unpack the 6562 DO Probe Kit and follow the instructions below.

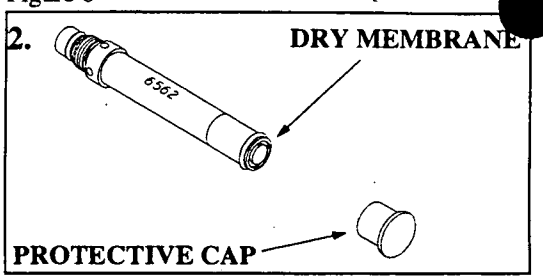
Figure 5



1. Open the membrane kit and prepare the electrolyte solution. Dissolve the KCl in the dropper bottle by filling it to the neck with deionized or distilled water and shaking until the solids are fully dissolved. After the KCL is dissolved, wait a few minutes until the solution is free of bubbles.

2. Remove the protective cap and the dry membrane from the 6562 Dissolved Oxygen probe.

Figure 6



3. Hold the probe in a vertical position and apply a few drops of KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.

4. Secure a membrane between your left thumb and the probe body. Always handle the membrane with care, touching it only at the ends.

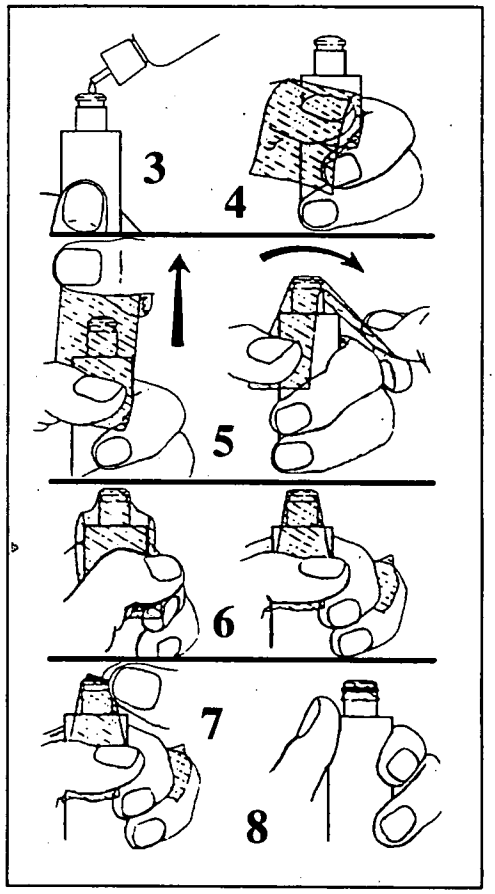
5. With the thumb and forefinger of your right hand, grasp the free end of the membrane. With one continuous motion, gently stretch it up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.

6. Secure the end of the membrane under the forefinger of your left hand.

7. Roll the O-ring over the end of the probe, being careful not to touch the membrane surface with your fingers. There should be no wrinkles or trapped air bubbles. Small wrinkles may be removed by lightly tugging on the edges of the membrane. If bubbles are present, remove the membrane and repeat steps 3-8.

8. Trim off any excess membrane with a sharp knife or scissors. Rinse off any excess KCl solution, but be careful not to get any water in the connector.

Figure 7

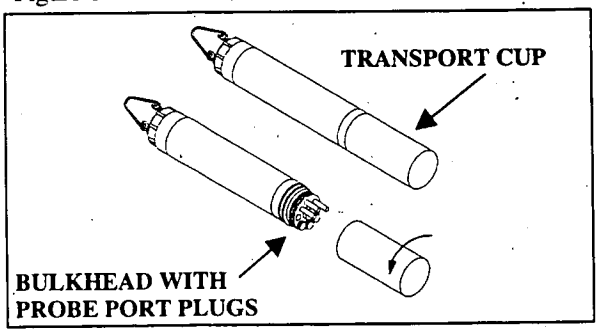


TIP: You may find it more convenient to mount the probe vertically in a vise with rubber jaws while applying the electrolyte and membrane to the sensor tip.

2.3.2 STEP 2 - INSTALLING THE PROBES

Remove the calibration cup from your sonde by hand as shown in figure 8, to expose the bulkhead.

Figure 8



REMOVING THE PORT PLUGS

Using the probe installation tools that are supplied in the YSI #6570 Maintenance Kit, remove the port plugs. Save all the port plugs for possible future use.

There are a variety of probe options for the sondes. Figures 9, 10 and 11 illustrate various tools that are used for port plug removal. Some of these tools may also be used to install the various probes.

In place of the small tool provided port plug removal, you may use a 7/64" hex key.

Figure 9

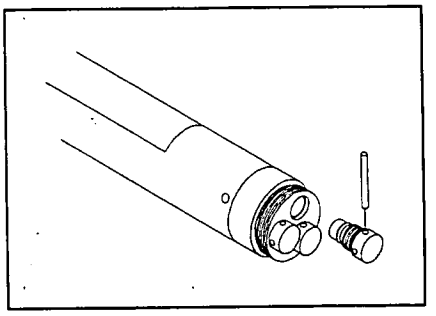


Figure 10

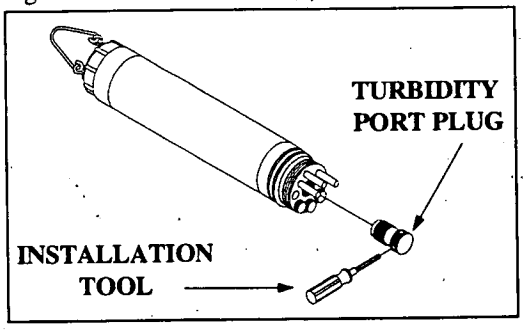
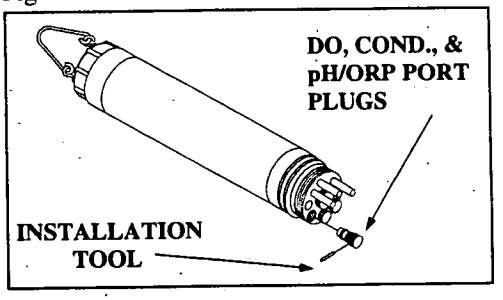
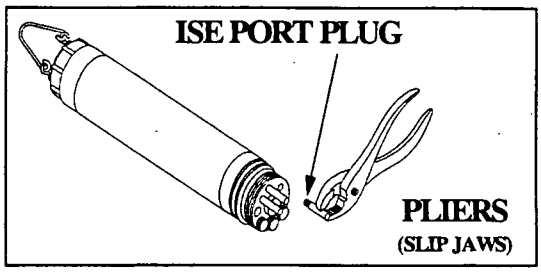


Figure 11



NOTE: You may need pliers to remove the ISE port plugs, but do not use pliers to tighten the ISE probes. Hand-tighten only.

Figure 12

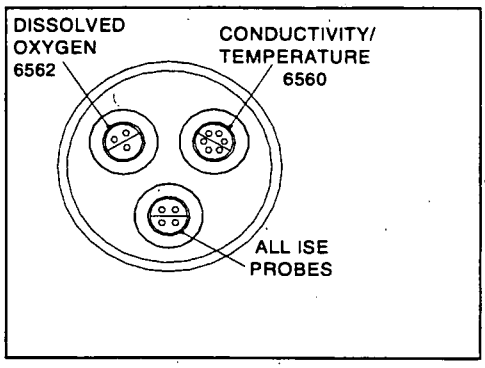


Now refer to figures 13, 14, 15 and 16 to find the probe locations in your sonde.

600XL & 600XLM SONDE BULKHEAD

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 pH probe = 4 pin connector
- 6565 Combo pH/ORP probe = 4 pin connector

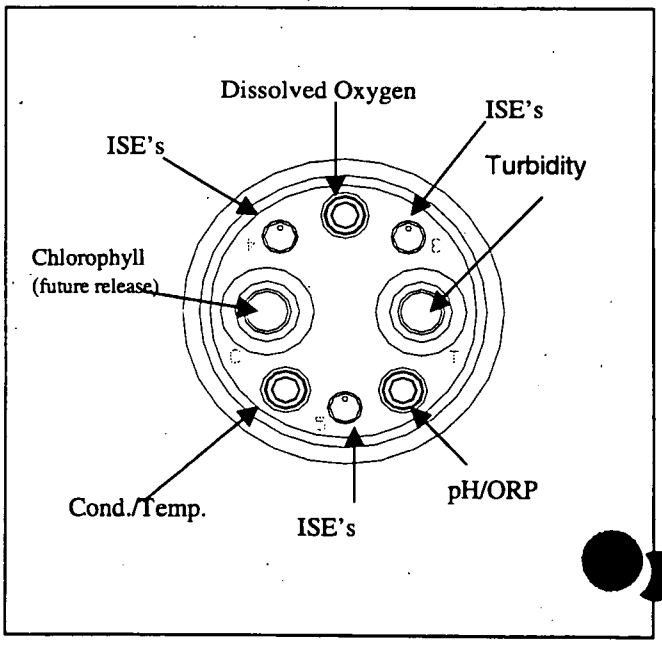
Figure 13



6600 SONDE BULKHEAD

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 pH probe = 4 pin connector
- 6565 Combination pH/ORP probe = 4 pin connector
- 6882 Chloride Probe = leaf spring connector
- 6883 Ammonium Probe = leaf spring connector
- 6884 Nitrate Probe = leaf spring connector
- 6036 Turbidity Probe, Non-wiping = 8 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector

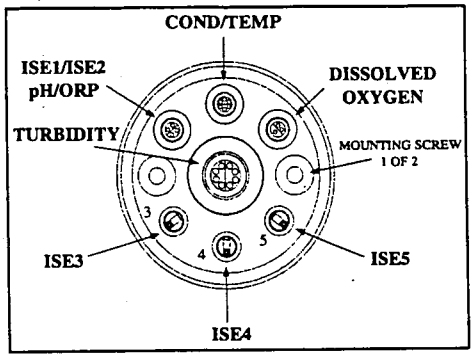
Figure 14



6820 & 6920 SONDE BULKHEAD

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 pH probe = 4 pin connector
- 6565 Combination pH/ORP probe = 4 pin connector
- 6882 Chloride Probe = leaf spring connector
- 6883 Ammonium Probe = leaf spring connector
- 6884 Nitrate Probe = leaf spring connector
- 6036 Turbidity Probe, Non-wiping = 8 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector

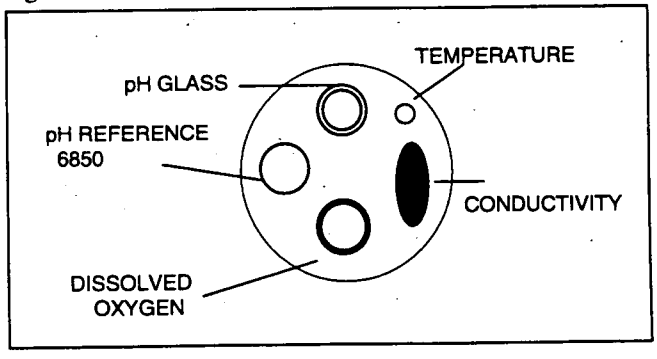
Figure 15



600R BULKHEAD

If are working with a 600R sonde, your instrument will arrive with the probes installed.

Figure 16

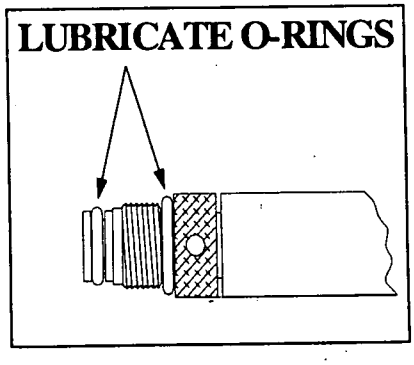


LUBRICATE O-RINGS

Apply a thin coat of O-ring lubricant, supplied in the YSI 6570 Maintenance Kit, to the O-rings on the connector side of each probes that is to be installed.

***CAUTION:* Make sure that there are NO contaminants between the O-ring and the probe. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Figure 17



NOTE: Before installing any probe into the sonde bulkhead, be sure that the probe port is free of moisture. If there is moisture present, you may use a can of compressed air to blow out the remaining moisture.

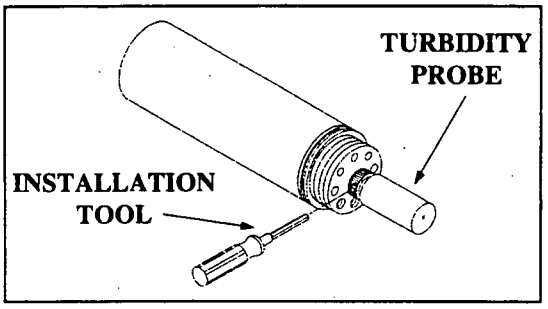
INSTALLING THE TURBIDITY PROBE

We recommend that you install the turbidity probe first due to its center position in the sonde bulkhead. If you are not installing a turbidity probe, do not remove the port plug, and go on to the next probe installation.

Both "wiping" (6026) and "non-wiping" (6036) turbidity probes are installed using the same method. Install the probe into the center port, seating the pins of the two connectors before you begin to tighten. Tighten the probe nut to the bulkhead using the 9/64" hex key installation tool. Do not over-tighten.

CAUTION: Be careful not to cross-thread the probe nut.

Figure 18



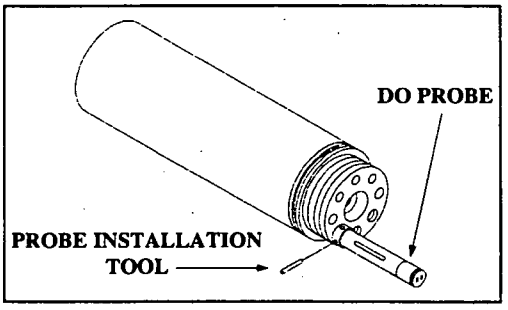
INSTALLING THE DISSOLVED OXYGEN PROBE, CONDUCTIVITY/TEMP AND pH/ORP PROBES

Insert the probe into the correct port and gently rotate the probe until the two connectors align.

The probes have slip nuts that require a small probe installation tool to tighten the probe. With the connectors aligned, screw down the probe nut using the probe installation tool. Do not over-tighten.

CAUTION: Do not to cross thread the probe nut.

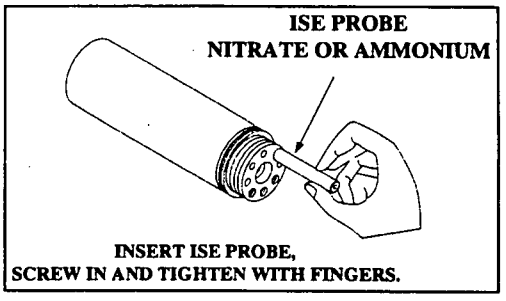
Figure 19



INSTALLING THE ISE PROBES

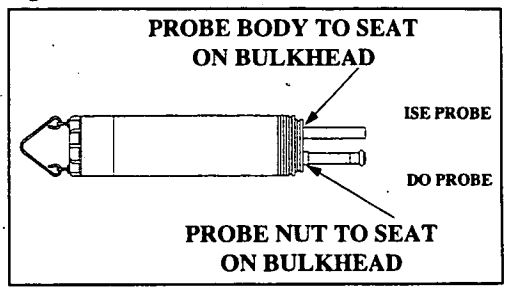
The Ammonium, Nitrate and Chloride ISE probes do not have slip nuts and should be installed without tools. Use only your fingers to tighten.

Figure 20



IMPORTANT: Make sure that the probe nut or probe body of the ISE probes are seated directly on the Sonde Bulkhead. This will ensure that connector seals will not allow leakage.

Figure 21



INSTALLING THE PROBE GUARD

Included with each sonde is a probe guard. The probe guard protects the probes during calibration and measurement procedures. Once the probes are installed, install this guard by aligning it with the threads on the bulkhead and turn the guard clockwise until secure.

CAUTION: Be careful not to damage the DO membrane during installation of the probe guard.

Figure 22 shows the 6820, 6600 and 6920 probe guards. The 600R, 600XL and 600XLM probe guards resemble Figure 23.

Figure 22

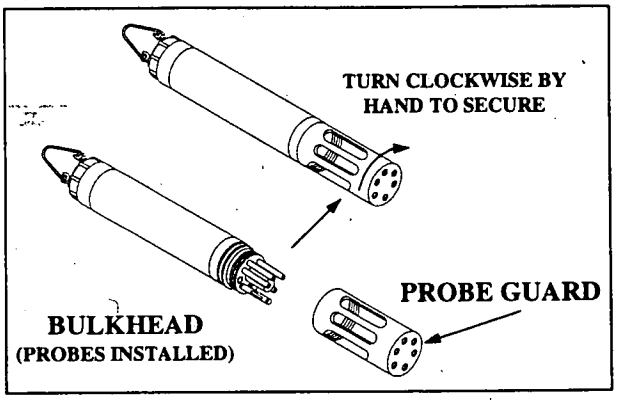
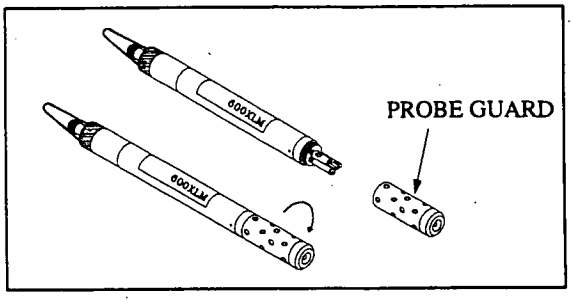


Figure 23



2.3.3 STEP 3 - POWER

Some type of external power supply is required to power the 600R, 600XL and 6820 Sondes. The 6920, 6600 and 600XLM have internal batteries or can run on external power.

If you have purchased a 610 or 610DM display/logger, attaching your sonde to the display/logger will allow your sonde to be powered from the batteries or external power of the display/logger. See **Section 3, Displays/Loggers,** for power options.

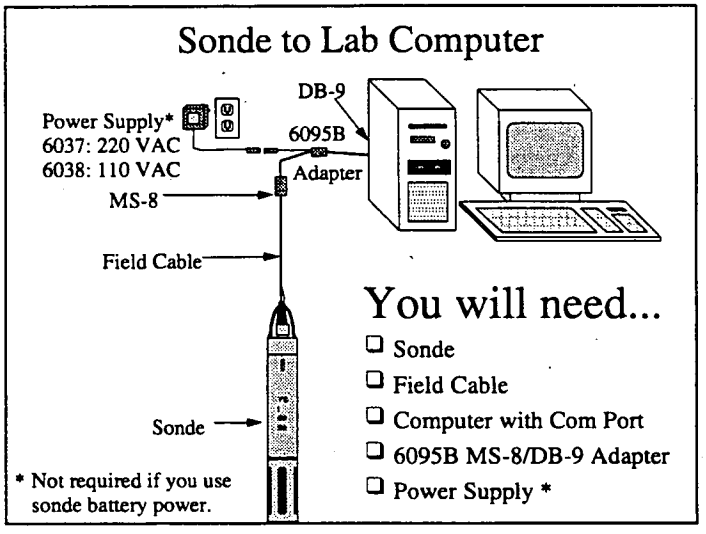
POWER FOR LAB CALIBRATION

For lab calibration and setup with the 6920, 6600 and 600XLM sonde interfaced to a computer, the YSI 6038 (110 VAC) or 6037 (220 VAC) Power Supply is optional but convenient and saves battery life. While attached to a PC, it is necessary for the 600R, 600XL and 6820 sondes to be used with the YSI 6038 or 6037 during lab calibration and setup. Most adapters include a short pigtail for power that plugs into the power supply. After attaching the four pin connector from the power supply to the pigtail, simply plug the power supply into the appropriate AC outlet.

See **Section 2.2, Connecting Your Sonde**, for specific information on cables, adapters and power supplies required for connecting your sonde to various devices.

The system configuration best suited for initial setup is shown in figure 24.

Figure 24



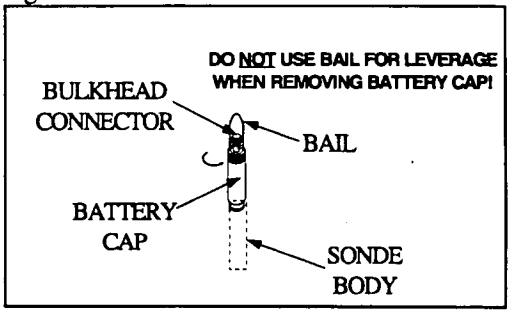
INSTALLING BATTERIES

The 600XLM, 6600 and the 6920 are the only sondes that use alkaline batteries for power. If you do not have one of these sonde model types, you may skip this section.

INSTALLING BATTERIES INTO THE YSI 600 XLM

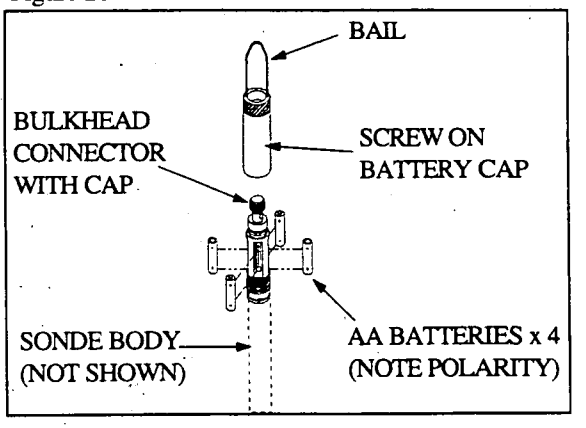
Your first set of batteries are supplied with the instrument. To install 4 AA-size alkaline batteries into the sonde, refer to the following directions and figure 25.

Figure 25



Grasp the cylindrical battery cover and unscrew by hand. Then slide the battery lid up and over the bulkhead connector. Insert batteries, paying special attention to polarity. Labeling on the battery compartment posts describes the orientation. It is usually easiest to insert the negative end of battery first and then "pop" the positive terminal into place.

Figure 26



Check the O-ring and sealing surfaces for any contaminants which could interfere with the O-ring seal of the battery chamber.

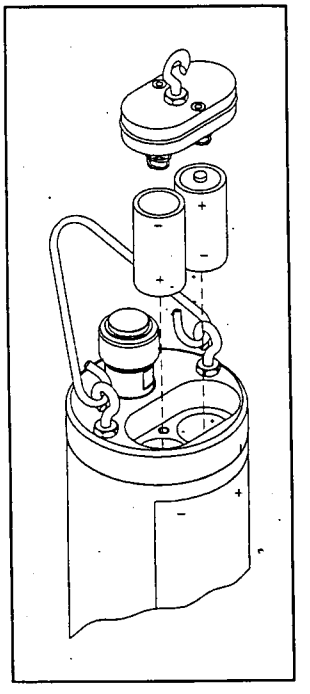
CAUTION: **Make sure that there are NO contaminants between the O-ring and the sonde. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Apply a very thin coat of O-ring lubricant (supplied in the 6570 Maintenance Kit) to battery chamber O-rings.

Return the battery lid and tighten by hand. *DO NOT OVER-TIGHTEN.*

INSTALLING BATTERIES INTO THE YSI 6600

Figure 27



Your first set of are supplied with the instrument. Install 8 C-size alkaline batteries according to the following directions and figure 27.

Using the hex driver, supplied in the 6570 Maintenance Kit, loosen the battery lid screws.

NOTE: The battery lid screws are captive. It is not necessary to remove them from the lid completely.

Remove the battery lid and install the batteries, as shown. Observe the correct polarity before installing the batteries into the battery chamber.

CAUTION: Be sure the bottom O-ring is installed in the groove of the lid. Check the O-ring and sealing surfaces for any contaminates which could interfere with the O-ring seal of the battery chamber. Remove any contaminates present. Also clean the protective O-ring which is located in the middle of the side of the battery lid.

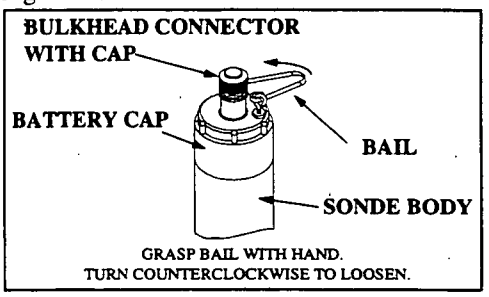
Apply a very thin coat of O-ring lubricant (supplied in the 6570 Maintenance Kit) to both battery chamber O-rings.

Return the battery lid and HAND tighten the screws until snug. *DO NOT OVER TIGHTEN.*

CAUTION: Over-tightening the screws may cause the battery compartment to flood.

INSTALLING BATTERIES INTO THE 6920

Figure 28

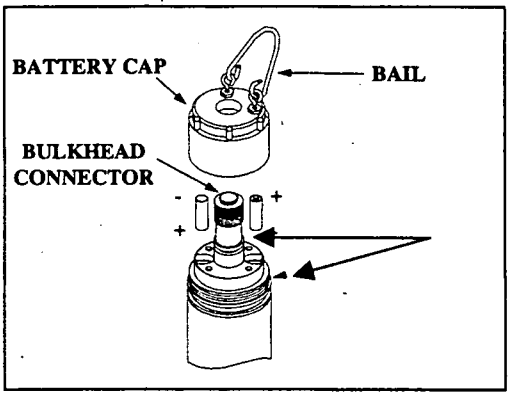


Your first set of batteries are supplied with the instrument. To install the 8 AA-size alkaline batteries into the sonde, refer to the following directions and figures 28 and 29.

Position the bail so that it is perpendicular to the sonde and use it as a lever to unscrew the battery cap by hand. Then slide the battery lid up and over the bulkhead connector.

Insert batteries, paying special attention to polarity. Labeling on the sonde body describes the orientation.

Figure 29



Check the O-ring and sealing surfaces for any contaminants which could interfere with the O-ring seal of the battery chamber.

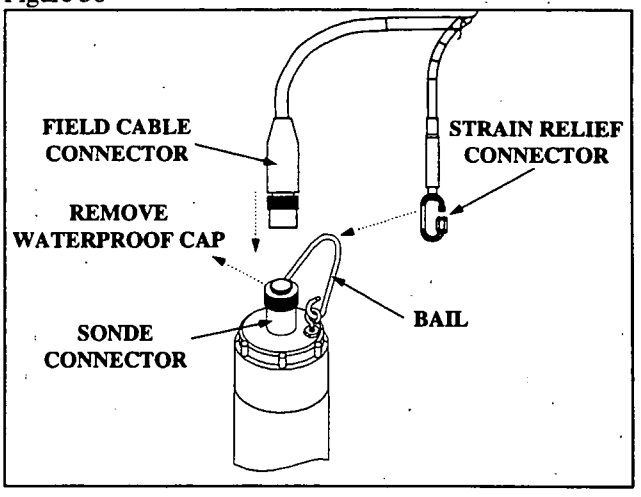
CAUTION: **Make sure that there are NO contaminants between the O-ring and the probe. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Apply a very thin coat of O-ring lubricant (supplied in the 6570 Maintenance Kit) to battery chamber O-rings.

Return the battery lid and tighten by hand. *DO NOT OVER-TIGHTEN.*

2.3.4 STEP 4 - CONNECTING A FIELD CABLE

Figure 30



The 6600, 6920 and 600XLM have a sonde-mounted cable connector for attachment of the field cable.

Some versions of the YSI 600R, 600XLM and 6820 have permanently attached "integral" cables. If your sonde has a cable that is non-detachable, parts of the next paragraph will not be relevant.

To attach a field cable to the sonde connector, remove the waterproof cap (provided with sondes with logging capability or vented level) from the sonde connector and set it aside for later
reassembly during deployment or storage. Then connect your field cable to the sonde connector.

A built-in "key" will ensure proper pin alignment. Rotate the cable gently until the "key" engages and then tighten the connectors together by rotating clockwise. Attach the strain relief connector to the sonde bail. Rotate the strain relief connector nut to close the connector's opening.

Caution: The connectors should be tightened by hand only! No tools should be used.

For all of the sondes, the other end of the cable is a military-style 8-pin connector (MS-8). Through use of a YSI #6095B MS-8 to DB-9 adapter, the sonde may be connected to a computer for setup, calibration, real-time measurement, and uploading files.

This MS-8 connector also plugs directly into the 610-D or 610-DM display/loggers. The displays and loggers are microcomputers and can be used in a similar manner to that of EcoWatch on a PC.

As an alternative to the field cable, you may use a YSI #6067B calibration cable for laboratory interaction with the sonde. In this case, simply plug the proper end of the cable into the sonde connector and attach the DB-9 connector of the cable to the Com port of your computer. This cable is for laboratory use only -- it is not waterproof and should not be submersed!

Sondes that are equipped with level sensors use vented cables. See **Appendix G, Using Vented Level**, for detailed information.

CAUTION FOR 6920, 6600 and 600XLM SONDES USED IN EUROPEAN COMMUNITY (CE) COUNTRIES: To comply with the Residential, Commercial, and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment, the user must install two (2) clamp-on ferrite bead assemblies to the sonde end of the cable. All of the other sondes are CE compliant without the use of ferrite beads. See **Appendix H, EMC Performance/Ferrite Bead Installation**.

2.6 GETTING READY TO CALIBRATE

HEALTH AND SAFETY

WARNING: Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review health and safety information in Appendix A of this manual. Some calibration standard solutions may require special handling.

CONTAINERS NEEDED TO CALIBRATE A SONDE

The calibration cup that comes with your sonde serves as a calibration chamber for all calibrations and minimizes the volume of calibrant reagents required. However, if you are using the 6026 "wiping" turbidity probe, you should visually verify proper movement of the wiper mechanism before beginning the calibration procedures.

Instead of the calibration cup, you may use laboratory glassware to perform calibrations. If you do not use a calibration cup that is designed for the sonde, you are cautioned to do the following:

- ✓ Perform all calibrations with the Probe Guard installed. This protects the probes from possible physical damage.
- ✓ Use a ring stand and clamp to secure the sonde body to prevent the sonde from falling over. Much laboratory glassware has convex bottoms.
- ✓ Insure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other probes (e.g., temperature probe). The top vent hole of the conductivity sensor must also be immersed during calibrations.

TIPS FOR GOOD CALIBRATIONS

1. If you use the Calibration Cup for dissolved oxygen (DO) calibration, make certain to loosen the seal to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.

2. The key to successful calibration is to insure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.

3. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the sonde. You may wish to save old calibration standards for this purpose.

4. Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.

5. Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. Shake the excess

rinse water off of the sonde, especially when the probe guard is installed. Dry off the outside of the sonde and probe guard. Making sure that the sonde is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.

6. If you are using laboratory glassware for calibration, you do not need to remove the probe guard to rinse and dry the probes between calibration solutions. The inaccuracy resulting from simply rinsing the probe compartment and drying the outside of the sonde is minimal.

7. If you are using laboratory glassware for the 600R, 600XL and 600XLM, remove the stainless steel weight from the bottom of the sonde by turning the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors without displacing a lot of fluid. This also reduces the amount of liquid that is carried between calibrations.

8. Make certain that port plugs are installed in all ports where probes are not installed. It is extremely important to keep these electrical connectors dry.

RECOMMENDED VOLUMES FOR USE WITH THE CALIBRATION CUP

Follow these instructions to use the calibration cup for calibration procedures with all of the instruments except the 600R. For the 600R, the over-the-guard bottle that comes with your sonde, must be used.

- ✓ Ensure that a gasket is installed in the gasket groove of the calibration cup bottom cap, and that the bottom cap is securely tightened. **Note:** Do not over-tighten as this could cause damage to the threaded portions of the bottom cap and tube.
- ✓ Remove the probe guard, if it is installed.
- ✓ Remove the o-ring, if installed, from the sonde.
- ✓ Inspect the installed gasket on the sonde for obvious defects and if necessary, replace it with the extra gasket, supplied.
- ✓ Screw cup assembly into place on the threaded end of sonde and securely tighten. **Note:** Do not over tighten as this could cause damage to the threaded portions of the bottom cap and tube.
- ✓ Sonde calibration can be accomplished with the sonde upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the sonde in the inverted position.
- ✓ To calibrate, follow the procedures in the next section, Calibration Procedures. The approximate volumes of the reagents are specified below for both the upright and upside down orientations.

✓ When using the Calibration Cup for dissolved oxygen calibration, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly, depending on orientation, and that approximately 1/8" of water is present in the cup.

Table 1

6820 and 6920 Sondes	**Upright**	**Upside Down**
Conductivity	200ml	200ml
pH/ORP	100ml	250ml
ISE	125ml	275ml
Turbidity	25ml	N/A

Table 2

600XL and 600XLM Sondes	**Upright**	**Upside Down**
Conductivity	50ml	50ml
pH/ORP	25ml	50ml

Table 3

6600 Sonde	**Upright**	**Upside Down**
Conductivity	425ml	225ml
pH/ORP	300ml	275ml
ISE	300ml	275ml
Turbidity	130ml	N/A

2.6.1 CALIBRATION PROCEDURES

The following calibration procedures are for the most commonly used sensors. For detailed information on all calibration procedures, refer to **Section 2.9.2, Calibrate**.

NOTE: Please be aware that some performance issues concerning the 600XLM, 6600 or 6920 sondes may occur during calibration in the presence of electromagnetic fields. Please see **Appendix H, EMC Performance** for more information.

To ensure more accurate results, you can rinse the calibration cup with water, and then rinse with a small amount of the calibration solution for the sensor that you are going to calibrate. Discard the rinse solution and add fresh calibrator solution. Use tables 1, 2 and 3 to find the correct amount of calibrator solution.

1. Carefully immerse the probes into the solution and rotate the calibration cup to engage several threads. It is recommended to support the sonde by using a ring stand and clamp to prevent the sonde from falling over.

2. With a field cable connecting the sonde to a PC, secure the sonde upright by using a ring stand and clamp. Access EcoWatch for Windows and proceed to the Main menu (for information on how to run EcoWatch for Windows software, see **Section 2.4.2, Running EcoWatch Software**). From the sonde Main menu, select number **2-Calibrate**.

```
----------------Calibrate--------------
1-Conductivity        5-ISE2 ORP
2-Dissolved Oxy       6-ISE3 NH4+
3-Pressure-Abs        7-ISE4 NO3-
4-ISE1 pH             8-Turbidity

Select option (0 for previous menu):
```

4. To select any of the parameters from the Calibrate menu, input the number that is next to the parameter and press **Enter**. Once you have chosen a parameter, some of the parameters will have a number that appears in parentheses. These are the default values and will be used during calibration if you press **Enter** without inputting another value. If no default value appears, you must type a numerical value and press **Enter**.

5. After you input the calibration value, or accept the default, press **Enter**. A real-time display will appear on the screen. Carefully observe the stabilization of the readings of the parameter that is being calibrated. When the readings have been stable for approximately 30 seconds, press **Enter** to accept the calibration. The calibrated value is bolded on the example screen on the following page.

6. Press **Enter** to return to the Calibrate menu, and proceed to the next calibration.

NOTE: If an ERROR message appears, begin the calibration procedure again. Be certain that the value you enter for the calibration standard is correct. Also see **Section 6, Troubleshooting** for more information on error messages. If you continue to observe error messages during calibration, contact YSI Customer Service. See **Section 8, Warranty and Service Information**.

```
=================================================================
 Temp  SpCond    Sal  DOsat     DO   Depth     pH NH4+ N NO3- N Turbid
    C  mS/cm     ppt     %   mg/L    feet            mg/L   mg/L    NTU
-----------------------------------------------------------------
To calibrate, press <Enter> when the readings are stable.
23.52  7.496   4.13  98.4   8.36   0.310  7.15  11.03  0.000    0.9
```

You will find specific start-up calibration procedures for all sensors that commonly require calibration in the following sections. If a sensor listed is not installed in your sonde, skip that section and proceed to the next sensor until the calibration protocol is complete. Before you use the sonde in the laboratory or field, read and study the more-detailed information on calibration in **Section 2.9.2, Calibrate**.

Temperature does not require calibration, and is therefore not included in the Calibrate menu. ORP calibration is required only infrequently and is only discussed in **Section 2.9.2, Calibrate.**

CONDUCTIVITY

This procedure calibrates conductivity, specific conductance, salinity, and total dissolved solids.

Place approximately the correct amount (by using tables 1, 2 and 3) of conductivity standard into a clean, dry or pre-rinsed calibration cup.

For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the water you are preparing to sample. However, we do not recommend using standards less than 1 mS/cm. For example:

- ✓ For fresh water use a 1 mS/cm conductivity standard.
- ✓ For brackish water use a 10 mS/cm conductivity standard.
- ✓ For seawater use a 50 mS/cm conductivity standard.

Caution: Before proceeding insure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP probes, particularly if you are employing standards of low conductivity.

Carefully immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The probe must be completely immersed past its vent hole. Using the recommended volumes from the table in the previous subsection should insure that the vent hole is covered.

Allow at least one minute for temperature equilibration before proceeding.

From the Calibrate menu, select number **1-Conductivity** to access the Conductivity calibration procedure and then number **1-SpCond** to access the specific conductance calibration procedure. Enter the calibration value of the standard you are using (mS/cm at 25°C) and press **Enter**. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under Specific Conductance or Conductivity and when they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

DISSOLVED OXYGEN

Place approximately 3 mm (1/8 inch) of water in the bottom of the calibration cup. Place the probe end of the sonde into the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Two calibration protocols are provided below for dissolved oxygen, one for sampling applications and one for long-term monitoring applications.

Sampling Applications

If your instrument will be used in sampling applications where the dissolved oxygen is pulsing continuously, deactivate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**.

From the Calibrate menu, select number **2-Dissolved Oxy**, then number **1-DO %** to access the DO percent calibration procedure. Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in mm of Hg. (Inches of Hg x 25.4 = mm Hg).
Caution: Barometer readings that appear in meteorological reports are generally corrected to sea level and are not useful for your calibration procedure unless they are uncorrected.

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under DO %. When they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

Monitoring Applications

If your instrument will be used in monitoring applications where data is being captured at a longer interval (e.g. 15 – 60 minutes) to internal sonde memory, a data collection platform or a computer, you need to activate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**. Then follow the instructions detailed above for the Sampling Application calibration. With Autosleep active, the calibration will occur automatically with a display similar to that shown below.

```
-----------------------------------------------------------------------
 Temp  SpCond    Sal  DOsat     DO    Depth     pH  NH4+ N  NO3- N  Turbid
   C   mS/cm    ppt     %    mg/L    feet            mg/L    mg/L     NTU
-----------------------------------------------------------------------
Stabilizing: 38
```

After the warm-up time is complete, the readings just before and just after calibration are displayed. When you press **Enter**, the screen returns to the DO Calibration menu.

DEPTH AND LEVEL

For the depth and level calibration, you can leave the sonde set up the same way as for dissolved oxygen, in water-saturated air.

From the Calibrate menu, select number **3-Pressure-Abs** (or number **3-Pressure-Gage** if you have a vented level sensor) to access the depth calibration procedure. Input 0.00 or some known sensor offset in feet. Press **Enter** and monitor the stabilization of the depth readings with time. When no significant change occurs for approximately 30 seconds, press **Enter** to confirm the calibration. This zeros the sensor with regard to current barometric pressure. Then press **Enter** again to return to the Calibrate menu.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH 2-POINT

Using the correct amount of pH 7 buffer standard (from tables 1, 2 and 3) into a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

From the Calibrate menu, select number **4-ISE1 pH** to access the pH calibration choices and then press number **2- 2-Point**. Press **Enter** and input the value of the buffer (7 in this case) at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. The display will indicate that the calibration is accepted.

After the pH 7 calibration is complete, press **Enter** again, as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde before proceeding to the next step.

Using the correct amount (from tables 1, 2 and 3) of an additional pH buffer standard into a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the value of the second buffer at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. After the second calibration point is complete, press **Enter** again, as instructed on the screen, to return to the Calibrate menu.

Rinse the sonde in water and dry. Thoroughly rinse and dry the calibration containers for future use.

The next calibration instructions are only for the 6820, 6600 and 6920 sondes. If you do not have either of these sondes, you may skip to 2.7, Taking Readings.

AMMONIUM (NH_4^+) , CHLORIDE CL^- AND NITRATE (NO_3^-) 3-POINT

WARNING: AMMONIUM AND NITRATE SENSORS CAN ONLY BE USED AT DEPTHS OF LESS THAN 50 FEET (15 METERS). USE OF THE SENSORS AT GREATER DEPTHS IS LIKELY TO PERMANENTLY DAMAGE THE SENSOR MEMBRANE.

The calibration procedures for ammonium, nitrate or chloride are similar to pH except for the reagents in the calibration solutions. Suggested values for calibrants are 1 and 100 mg/L of either ammonium-nitrogen (NH_4-N) or nitrate-nitrogen (NO_3-N). Suggested values for calibrants are 10 and 1000 mg/L of Chloride (Cl^-).

NOTE: The following procedure requires one portion of the high concentration calibrant and two portions of the low concentration calibrant. The high concentration solution and one of the low concentration solutions should be at ambient temperature. The other low concentration solution should be chilled to less than 10°C prior to beginning the procedure.

Place the proper amount of 100 mg/L standard (1000mg/l for chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Select number **6-Ammonium, 7-Nitrate** or number **8- Chloride** to access the appropriate calibration choices. Then select number **3-3-Point**. Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$ or Cl^-. When they show no significant change for approximately 30 seconds, press **Enter**.

After the first calibration point is complete, proceed as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde prior to the next step.

Place the proper amount of 1 mg/L standard for Ammonium or Nitrate (10 mg/l for Chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$ or Cl^- and when they have show no significant change for approximately 30 seconds, press **Enter**.

After the second value calibration is complete, press **Enter** to continue. Place the proper amount of chilled 1 mg/L standard (10 mg/L for the chloride) into a clean, dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 5 minutes for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$ or Cl^- and when they show no significant change for approximately 30 seconds, press **Enter**.

After the third value calibration is complete, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

CALIBRATION TIP: HOW TO AVOID DRIFT DURING CALIBRATION OF THE NH4+, NO3- AND Cl- PROBES AFTER pH CALIBRATION. Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in these ISE probes (ammonium, nitrate and chloride probes). Therefore, when calibrating the pH probe, we recommend that you use one of the following methods to minimize errors in the subsequent readings:

- Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard (1000 mg/L chloride) and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with the calibration.

- When calibrating pH, remove the probe guard and immerse only the pH and temperature probes in the buffers. You can then calibrate nitrate, ammonium or chloride immediately. This will be virtually impossible if a turbidity probe is installed.

TURBIDITY 2-POINT

Select **8-Turbidity** from the Calibrate Menu and then **2-2-Point**.

NOTE: One standard must be 0 NTU, and this standard must be calibrated first.

To begin the calibration, the correct amount (from tables 1, 2 and 3) of 0 NTU standard (clear deionized, distilled, or tap water) into the clear calibration cup (provided) or in a 600 mL glass beaker. With the probe guard installed, immerse the sonde in the water. Input the value 0.00 NTU at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. If you have a mechanically-cleaned turbidity probe installed, activate the wiper 1-2 times by pressing number **3-Clean Optics** as shown on the screen to remove any bubbles. If your probe is not mechanically cleaned, rotate the sonde back and forth in the water to facilitate removal of bubbles. After stabilization is complete, press **Enter** to "confirm" the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second turbidity standard (100 NTU is suggested) using the same container as for the 0 NTU standard. Input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the "3" key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the turbidity sensor, see **Appendix E, Turbidity Measurements**.

2.7 TAKING READINGS

600R, 600XL AND 6820 SONDES

After you have (1) enabled the sensors, (2) set the report to show the parameters you want to see and (3) calibrated the sensors, you are now ready to take readings.

Select **1-Run** from the sonde Main menu. The following menu will be displayed:

```
----------------Run setup---------------
1-Start sampling     2-Sample interval=4

Select option (0 for previous menu): 1
```

Select number **2-Sample** interval. The following prompt will be displayed.

```
Enter sample interval:
```

Input a number that represents the number of seconds between samples at this prompt. For this example, input **4** seconds, which is also the minimum sample interval for most applications.

Select number **1-Start sampling** from the Run setup menu.

```
=================================================================
 Temp SpCond    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
    C  mS/cm    ppt     %   mg/L    feet          mg/L   mg/L    NTU
-----------------------------------------------------------------
23.49  0.000   0.00  98.5   8.37   0.307  7.16   2.24   1.52    4.9
23.49  0.000   0.00  98.6   8.37   0.306  7.16   2.26   1.53    4.9
23.49  0.000   0.00  98.6   8.37   0.307  7.17   2.26   1.52    4.9
```

Measurements will begin to appear on the screen at the sampling interval you have defined (in this case, 4 seconds). This data will not be stored to a file unless you instruct EcoWatch to capture this data. See **Section 2.8, Using EcoWatch to Capture Data**.

600XLM, 6600 AND 6920 SONDES

After you have (1) enabled the sensors, (2) set the report to show the parameters you want to see, you are now ready to take readings and (3) calibrated the sensors.

There are two basic approaches to sampling with the 600XLM, 6600 or 6920, discrete sampling and unattended sampling. Using discrete sampling, you connect the sonde via a communication cable to a computer or terminal. Your sampling frequency is likely to be rapid (seconds) in order to obtain a representative sampling as you move from site to site. You will likely log readings to several different files.

Using unattended sampling, your sampling frequency is likely to be longer (minutes). You will typically deploy the sonde for days or weeks at a time and will log to a single file. You may disconnect the communication cable and use internal battery power to operate the sonde. Alternatively, you may connect the 600XLM, 6600 or 6920 sonde via SDI-12 communication to a data collection platform (DCP).

NOTE: Please be aware that some performance issues concerning the 600XLM, 6600 or 6920 with Ferrite Beads (CE applications) may occur during deployment. Please see **Appendix H, EMC Performance** for more information.

From the Main menu of the sonde, there are two submenus under Run Mode, Discrete Sampling and Unattended Sampling. The following sections help you understand basic setup options in these two modes of operation.

Select number **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run menu as shown below.

```
---------------Run setup--------------
1-Discrete sample   2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Select number **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
-----------Discrete sample------------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

Select number **2 - Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample

interval is 4 seconds and works best for most discrete sampling applications. The shortest possible sample interval for obtaining new DO readings is 4 seconds. If a smaller interval is selected, then the DO readings remain constant for the number of samples necessary to fill 4 seconds.

Select number **3 -File** to enter a filename with a maximum of 8 characters. This is the file that you will log readings.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press 1-LOG last sample or 2-LOG ON/OFF from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

Select number **4-Site** to assign a site name with a maximum of 31 characters This allows you to enter the name of the site where you are sampling.

When you select number **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and number 5 changes back to **Open File**.

Now select number **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, (e.g. 4 seconds in the example above), sequential lines of data will appear on the screen.

```
-----------------------------------------------------------------
 Temp    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
   C     ppt   %    mg/L    feet          mg/L   mg/L    NTU
-----------------------------------------------------------------
23.54   0.00  96.5   8.20   1.001  5.20  0.853  0.522    0.3
*** LOG is ON,  hit 2 to turn it OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.001  5.20  0.856  0.520    0.3
23.53   0.00  96.5   8.20   1.000  5.20  0.854  0.521    0.3
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
*** 1-LOG last sample   2-LOG ON/OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
Sample logged.
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics.

By entering **1–LOG last sample**, a single line of data can be logged to flash disk (sonde) memory and the following message will be displayed: **Sample logged.**

By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

By entering **3-Clean optics**, if your unit has a turbidity probe (with wiper) installed and enabled, the wiper will clean the optical surface. The **3-Clean optics** portion of the prompt will only appear if a turbidity probe was installed and enabled.

Select **Esc** or press **0** to exit discrete sampling.

UNATTENDED SAMPLING

Select number **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

> **Example:**
> You are going to deploy the sonde for 2 weeks, collecting a set of readings every 15 minutes. You start at 6:00 PM on July 17, 1996 and end the sampling at 6:00 PM on July 31, 1996. The site is Clear Lake, near the spillway, and you want to log all of the readings to a single file CLRLAKE3.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=
6-Site=
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your 600XLM, 6600 or 6920 sonde for unattended deployment as described below:

To verify and/or correct the time and date enter number **4-Status** or number **5-System menu** from the Main menu. You may enter the correct date and time from either of these submenus.

- Select number **1-Interval** and enter the desired time between samples (e.g. 15 minutes in the screen above). Use the 24-hour clock format to enter interval.

- Select number **2-Start Date** and number **3-Start Time** to set the time that data will begin to log to sonde memory. If you do not make any change to these entries, then the

study will automatically begin at the next integral time interval, once you have pressed **C-Start logging**.

> **Example:** If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory. If you should desire to start the instrument at the site at 6:00 PM as noted in the above example, change the Start Time to 18:00:00.

- Select number **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software.

- Skip **B-View params to log** in this initial test study. This feature will be explained in detail in **Section 2.9, Sonde Menu**.

After making the above entries, the sonde software will automatically calculate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration as items 8, 9, and A. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the entries. For example, you can free up memory in the sonde by uploading all existing data from the sonde memory to your PC and then deleting them out of the sonde (see 3-File from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

Review the screen below, which now displays the entries made above and reflects your logging conditions.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 4.10 minutes
B-View params to log
C-Start logging
```

Once you press **C-Start logging**, a screen will appear to request confirmation.

```
------------Start logging------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select **1-Yes** and the screen will change.

```
----------------Logging----------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 11.7
9-Bat life 25.5 days
A-Free mem 41.3 days
B-Stop logging

Select option (0 for previous menu):
```

The display now shows the next date and time for logging, and the stop date and time for the logging study. Most importantly, note that the bottom command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

The Unattended study will terminate when the duration you specified has expired. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**. Select **1-yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.9 SONDE MENU

The functions of the sondes are accessible through the sonde menu. The sonde menu structure makes it simple and convenient to select functions. This section provides a description of the menus and their capabilities.

When moving between menus within the sonde software structure, use the **0** or **Esc** to back up to the previous menu. To exit menus and return to the sonde command line (the # sign), press **0 or Esc** until the question **"Exit menu (Y/N)?"** appears. Type **Y** and press **Enter**. To return to the Main sonde menu, type **menu** and press **Enter.**

IMPORTANT MESSAGE!
WHAT IF THERE IS NO RESPONSE TO A KEYSTROKE?

To save power, the sondes will power down automatically if no interaction from the keyboard occurs for approximately 60 seconds when an Autosleep function (RS232 or SDI12) is activated in the **Advanced Setup** menu. When the software is in this "sleep" mode, the first subsequent keystroke simply "wakes it up" and has no visible effect on the display. The next keystroke after the unit is "awakened" will be input to the software in the intended manner. Thus, if you press a key after the sonde has been inactive for some time and nothing seems to happen, press the key again.

To gain experience with the sonde menus, select the sonde icon in EcoWatch for Windows and press **Enter**. See figures 31and 32 for the Sonde Menu Flow Charts.

In the following subsections you will learn about the functions of the various menu items and when to use them. The discussion of the menu and submenu functions is organized in numerical order, beginning with **Section 2.9.1 RUN**.

2.9.1 RUN

600R, 600XL AND 6820 SONDES

- Select number **1-Run** from the Main menu to begin taking readings or to set/verify the Sample interval required for a study. There are two options on the Run menu as shown in the following display.

```
---------------Run setup---------------
1-Start sampling    2-Sample interval=4

Select option (0 for previous menu):
```

- Select number **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. The shortest possible sample interval for obtaining new DO readings is 4 seconds. If a smaller interval is selected, then the DO readings remain constant for the number of samples necessary to fill 4 seconds.

> For special applications, the sondes are capable of faster sampling. The only limitation is a reduction of the number of sensors selected. To determine the maximum sampling frequency for your sensor setup, divide 36 by the number of enabled sensors in addition to the DO sensor.
>
> Example: If you enable any three sensors plus DO, divide 36 by 3 to obtain 12 samples/second (12 Hz) or 0.083 seconds between samples as the maximum sampling frequency. Remember that for sample intervals less than 4 seconds, DO readings are updated only every 4 seconds. Thus, at 12 Hz, the display will show 48 identical DO readings before a change occurs.

After you have typed in the sampling interval that is best for your study, press **Enter**.

- Select **1-Start sampling** from the Run menu. If the sonde software has been set up according to the instructions in **Section 2.5, Sonde Software Setup**, sequential lines of data for the selected parameters will be displayed immediately.

An example of the sampled data is shown below. At a 4-second interval, this represents about 16 seconds of sampling. Note that the data has no date/time entry, because the 600R, 600XL and 6820 have no internal clock. To stop sampling, press **Esc**.

Temp C	Sal ppt	DOsat %	DO mg/L	Depth feet	pH	NH4+ N mg/L	NO3- N mg/L	Turbid NTU
23.54	0.00	96.5	8.20	1.001	5.20	0.853	0.522	0.3
23.53	0.00	96.5	8.20	1.001	5.20	0.856	0.520	0.3
23.53	0.00	96.5	8.20	1.000	5.20	0.854	0.521	0.3
23.53	0.00	96.5	8.20	1.000	5.19	0.852	0.522	0.3

600XLM, 6600 AND 6920 SONDES

- Select number **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run.

```
---------------Run setup---------------
1-Discrete sample
2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Discrete sampling is usually used in short term, spot sampling applications when the user is present at the site and the unit is attached to a data logger or laptop PC. It could be used in the vertical profiling of a lake or river where the user lowers the sonde incrementally into the water, and data acquired for a few minutes at each depth. In this section, you will learn how to use the sonde menu structure to open and close files, set the interval between samples, start the sampling operation, and log data to the internal memory of the sonde.

- Select number **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
------------Discrete sample-----------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

- Select number **1 – Start sampling** option to start discrete sampling. After the initial sampling time interval has passed (4 seconds in the screen above), sequential lines of data will appear on the screen.

```
=================================================================================
    Date      Time   Temp SpCond    Sal   DO     Depth     pH    Turbid   Battery
mm/dd/yy hh:mm:ss     C  mS/cm     ppt  mg/L    feet            NTU     volts
---------------------------------------------------------------------------------
*** 1-LOG last sample   2-LOG ON/OFF,  3-Clean optics***
05/05/97 10:04:40 21.57  0.009   0.00  7.73  -0.293  7.55    0.3      10.2
05/05/97 10:04:44 21.57  0.009   0.00  8.41  -0.300  7.55    0.3      10.3
*** LOG is ON,  hit 2 to turn it OFF,  3-Clean optics***
05/05/97 10:04:48 21.58  0.009   0.00  8.41  -0.302  7.55    0.3      10.3
05/05/97 10:04:52 21.58  0.009   0.00  8.40  -0.302  7.55    0.3      10.3
05/05/97 10:04:56 21.58  0.009   0.00  8.41  -0.303  7.55    0.3      10.2
05/05/97 10:05:00 21.58  0.009   0.00  8.42  -0.303  7.55    0.3      10.3
*** 1-LOG last sample   2-LOG ON/OFF ,  3-Clean optics***
05/05/97 10:05:04 21.58  0.009   0.00  8.44  -0.304  7.55    0.3      10.3
Sample logged.
05/05/97 10:05:08 21.58  0.009   0.00  8.45  -0.305  7.55    0.3      10.3
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics

- By entering **1–LOG last sample**, A single line of data can be logged to flash disk (sonde) memory and the following message will be displayed: **Sample logged.**

- By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

- By entering **3-Clean optics**, if your unit has a turbidity probe (with wiper) installed and enabled, the wiper will clean the optical surface. The **3-Clean optics** portion of the prompt will only appear if a turbidity probe was installed and enabled.

Select **Esc** or press **0** and return to the Discrete Sampling menu.

- From the Discrete Sampling menu, select number **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. The shortest possible sample interval for obtaining new DO readings is 4 seconds. If a smaller interval is selected, then the DO readings remain constant for the number of samples necessary to fill 4 seconds.

For special applications, the 6600 or 6920 sonde is capable of faster sampling. The only limitation is a reduction of the number of sensors selected. To determine the maximum sampling frequency for your sensor setup, divide 36 by the number of enabled sensors in addition to the DO sensor.

Example:
If you enable any three sensors plus DO, divide 36 by 3 to obtain 12 samples/second (12 Hz) or 0.083 seconds between samples as the maximum sampling frequency. Remember that for sample intervals less than 4 seconds, DO readings are updated only every 4 seconds. Thus, at 12 Hz, the display will show 48 identical DO readings before a change occurs.

- Select number **3 -File** to enter a filename with a maximum of 8 characters. You will log readings to the filename that you enter.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press **1-LOG last sample** or **2-LOG ON/OFF** from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

- Select number **4-Site** to assign a site name with a maximum of 31 characters This allows you to enter the name of the site where you are sampling.

- When you select number **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and number 5 changes back to **Open File**. When you start logging it changes automatically.

Now select number **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, sequential lines of data will appear on the screen.

In the screen above, both the logging of a set and a single line of data are shown. When logging is not active, you may press **1-LOG last sample** to capture a single line of data. The message "**Sample logged**" verifies that the previous line was logged to memory.

UNATTENDED SAMPLING

This option is used for long-term deployment of the battery-powered sonde when the user is not present at the site. Prior to this selection, the sonde is usually attached to a computer in a laboratory and set up to automatically log data to sonde memory at a fairly long time interval (15-60 minutes). The unit is then taken to the field site and left for an extended time period (30 – 60 days). When the study is complete, or the batteries are expended, the unit is brought back to the laboratory and the data file is uploaded to a computer. Quality assurance checks are performed prior to redeployment.

NOTE: Please be aware that some performance issues concerning the 600XLM, 6600 or 6920 sondes may occur during calibration in the presence of electromagnetic fields. Please see **Appendix H, EMC Performance** for more information.

Select number **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=14
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 9.1
8-Bat life 21.2 days
9-Free mem 18.9 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your 600XLM, 6600 or 6920 sonde for unattended deployment as described below:

- Verify that the current time and date are correct to ensure that your unattended sampling study begins and ends when you desire. To verify and/or correct the time and date enter **4-Status** or **5-System menu** from the main menu. You may enter the correct date and time from either of these submenus.

- Select number **1-Interval** and enter the desired time between samples. Use the 24-hour clock format to enter interval.

- Select number **2-Start Date** and number **3-Start Time** to set the time that data will begin to log to sonde memory. If you do not make any change to these entries, then the study will automatically begin at the next integral time interval, once you have pressed **C-Start logging**.

  Example: If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory. If you should desire to start the instrument at the site at 6:00 PM, change the Start Time to 18:00:00.

- Select number **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software.

- Select **B-View Parameters to log** to confirm that your sensor and report setups are configured correctly. An example screen is shown below.

```
-------------Params to log-------------
1-Temp C                6-Orp mV
2-Cond mS/cm            7-NH4+ N mg/L
3-DOsat %               8-NO3- N mg/L
4-DOchrg                9-Turbid NTU
5-pH                    A-Battery volts

Select option (0 for previous menu):
```

In some cases, the **View params to log** screen only identifies the raw parameters that are used in the calculation of the items that you have selected in the Report setup.

> **Example:** You have selected DO mg/L in the Report setup, but it does not appear under **View parameters to log** because it is calculated from DO saturation %,Temperature, and Conductivity. Likewise, although specific conductance is selected in the Report setup, it does not appear under **Parameters to log** because it is calculated from Conductivity and Temperature. In all but a few cases, the proper configuration of **Parameters to log** will be automatically set up as long as the sensor is enabled.

There are several items that must be activated in the Report setup so they will be available from the file after upload. These special parameters are: DO Chg, pH mV, $NH4^+$ mV, $NO3^-$ mV, and Cl^- mV. If you want to log DO chg to your data file, be certain that it is active in the Report setup before you begin the unattended study.

After making the above entries, the sonde software will automatically estimate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration as items 8, 9, and A. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the entries. For example, you can free up memory in the sonde by uploading all existing data from the sonde memory to your PC and then deleting them out of the sonde (see **3-File** from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

The predicted battery life is an estimate only. The temperature of the site and the brand of batteries used can affect battery life. It is better to recover the sonde earlier than the predicted battery life, and to use new batteries for each deployment.

Once you press **C-Start logging**, the following screen will appear.

```
-------------Start logging-------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select number **1-Yes** and the screen will change.

```
----------------Logging----------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 9.0
9-Bat life 21.2 days
A-Free mem 18.9 days
B-Stop logging

Select option (0 for previous menu):
```

The display now shows the next date and time for logging and the stop date and time for the logging study. Most importantly, note that the bottom command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

The Unattended study will terminate when the duration you specified has expired. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**.. Select **1-Yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.9.2 CALIBRATE

All of the sonde sensors (except temperature) require periodic calibration to assure high performance. However, the calibration protocols for dissolved oxygen are significantly different depending on whether the sonde is being set up for spot sampling or longer term unattended monitoring studies. This difference is user-selectable and is required primarily because the optimal performance of the Rapid Pulse dissolved oxygen sensor cannot be attained unless the control of this sensor varies from short term to long term applications.

For spot sampling it is best to pulse the sensor continuously during the Run mode to attain the most accurate results and optimize the response time. However, this continuous pulsing is not ideal for longer term logging studies in which the sonde data is captured to sonde memory or to a data collection platform at much less frequent intervals (e.g. 15 minutes). Continuous pulsing not only shortens the time between required probe maintenance, but consumes more power. With proper selection of the "Auto sleep" option (discussed in detail in **Section 2.9, Sonde Menu**), the user can configure the sonde software to either run continuously or "go to sleep" between samples to minimize DO probe wear and conserve power. The effect of this choice on the user interface relative to dissolved oxygen calibration is significant as described below:

- If "Auto sleep" is **deactivated**, the sonde runs continuously no matter what sample interval has been selected. Under these conditions, you retain manual control of the dissolved oxygen calibration routine, viewing the stabilization of the readings in real time and confirming the calibration with keyboard entries.

- If "Auto sleep" is **activated**, the sonde will 'warm up' the sensors for the period of time selected for the DO sensor. Under these conditions, you lose manual control of the DO calibration routine. DO will automatically calibrate after the selected time for warm up of the DO sensor has expired. In this mode of calibration, you do not observe stabilization of the readings in real time, but instead will observe a countdown of the warm up period followed by a message indicating that the DO calibration is complete.

Only the calibration of dissolved oxygen is affected by whether "Auto sleep" is on or off; the user retains manual control of the calibration of all other parameters regardless of the "Auto sleep" setting. Once warm up time has been utilized in DO calibration, the length of that time should not be changed during a study. A new calibration should be performed whenever the value of the warm up time is altered.

From the Main sonde menu select **2-Calibrate**. The Calibrate menu will be displayed. Only the enabled parameters will be available for calibration.

```
---------------Calibrate--------------
1-Conductivity        6-ISE3 NH4+
2-Dissolved Oxy       7-ISE4 NO3-
3-Pressure-Abs        8-ISE5 Cl-
4-ISE1 pH             9-Turbidity
5-ISE2 ORP

Select option (0 for previous menu):
```

CONDUCTIVITY

Select number **1 - Conductivity** to calibrate the conductivity probe and a second menu will offer you the options of calibrating in specific conductance, conductivity, or salinity. Calibrating any one option automatically calibrates the other two. After selecting the option of choice (specific conductance is normally recommended), you will be asked to enter the value of the standard used during calibration. Be certain that the units are correct. After pressing **Enter**, you will be able to follow the stabilization of the readings and confirm the calibration when the readings are stable by pressing **Enter** as instructed on the screen. Then, as instructed, press **Enter** again to return to the Calibrate menu.

DISSOLVED OXYGEN WITH AUTOSLEEP ON

These calibration instructions are for a 6920, 6600 or 600XLM sonde with Autosleep turned on. If you have a different sonde, or have Autosleep turned off proceed to the next section.

Select number **2 - Dissolved oxygen** to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor has stabilized prior to beginning the calibration routine, particularly after a membrane change. Relieve pressure in the cup if necessary.

Remember, the Calibration Cup is designed to be air-tight and must be loosened if it is used as a calibration chamber. See **Section 2.6, Calibration** for more details. Follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and the calibration will automatically occur after the warm-up time which has been selected by the user (default is 40 seconds). Then, as instructed, press **Enter** again to return to the Calibrate menu.

For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will be carried out automatically as for the percent saturation mode above.

NOTE: After a membrane change, we recommend running the probe in the Run mode (Discrete sample - 4 second interval) for 15-30 minutes prior to calibration in order to break in the membrane.

DISSOLVED OXYGEN WITH AUTOSLEEP OFF

Select the **Dissolved Oxygen** option from the Calibrate menu to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor has stabilized prior to beginning the calibration routine, particularly after a membrane change. Relieve pressure in the cup if necessary. Remember, the Calibration Cup is designed to be air-tight and must be loosened if used as a calibration chamber. Then follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and monitor the stabilization of the DO readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press Enter again to return to the **Calibrate** menu.

For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by a Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will begin with similar viewing of stabilization and confirmation of calibration as for the percent saturation mode above.

NOTE: If you have resurfaced your DO sensor, we recommend running the probe continuously for 15-30 minutes or until good stability is realized.

PRESSURE – ABS AND GAGE

Select number **3 - Pressure – Abs (non-vented) or Gage (vented)** to zero the depth sensor. The depth sensor is factory calibrated, but it is always necessary to zero the absolute sensor relative to the local barometric pressure. A minor correction is sometimes necessary to set Gage to exactly 0.000 feet. The zeroing procedure should be carried out with the sonde in air for this initial calibration. Alternatively, you may set zero or an offset while the sonde is submersed for "relative depth" applications. After the depth option is selected, enter 0.00 (or other appropriate number) at the prompt, press **Enter** and monitor the stabilization of the depth readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. As instructed, press **Enter** again to return to the Calibrate menu.

Zeroing the depth sensor by the above protocol (entering 0.00 at the screen prompt) will result in a measurement of the distance between the water surface and the ports of the depth module. In order for the observed depth readings to reflect the distance between the water surface and the actual probe array, measure the length between the upper hole and the bottom of the standard 6-inch sonde guard. Enter the length at the screen prompt instead of 0.00.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH

When selecting number **4 – ISE1-pH**, you will be given the choice of 1-point, 2-point, or 3-point calibrations.

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. Immerse the sonde in a buffer of known pH value and press **Enter.** You will be prompted to type in the pH value of the solution. Press **Enter** again, and the screen will display real-time readings that will allow you to determine when the pH and temperature readings have stabilized. Pressing **Enter** will confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu. This calibration procedure adjusts only the pH offset and leaves the previously determined slope(s) unaltered.

Select the **2-point** option to calibrate the pH probe using only two calibration standards. In this procedure, the pH sensor is calibrated using a pH 7 buffer and *one additional* buffer. A two point calibration procedure (as opposed to a 3-point procedure) can save time if the pH of the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is appropriate. Three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.

To begin the calibration, immerse the sonde in one of the buffers and enter the actual pH value. Press Enter, and the screen will display real-time readings that will allow you to determine when the pH sensor has stabilized. Pressing **Enter** will confirm the calibration. Following the instructions on the screen, place the sonde in the second pH buffer, input the pH value, press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

Select the **3-point** option to calibrate the pH probe using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer to complete the 3-point procedure.

ORP

Select number **5 - ISE2-ORP** to calibrate the ORP sensor. Immerse the sonde in a solution with a known oxidation reduction potential value (we recommend Zobell solution) and press **Enter.** You will be prompted to enter the ORP value of the solution. Press **Enter**, and monitor the stabilization of the ORP and temperature readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

The following calibrations are for the 6820, 6600 or 6920 sondes only. If you do not have one of these sondes, skip to Section 2.9.6, Report.

AMMONIUM

When selecting number **6 – ISE3-NH4+,** you will be given the choice of 1-point, 2-point, or 3-point calibrations for your ammonium (NH_4^+) sensor.

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by doing a one point calibration. Immerse the sonde in any solution of known ammonium concentration and press **Enter.** You will be prompted to type in the NH_4^+ value (in mg/L of NH_4-N) of the solution you are using. Press **Enter** again, and the screen will display real-time readings which will allow you to determine when the NH4+ readings have stabilized. Pressing **Enter** will confirm the calibration.

Select the **2-point** option to calibrate the NH_4^+ probe using only two calibration standards which are both at approximately the temperature of your environmental sample. In this procedure, the NH_4^+ sensor is usually calibrated using solutions which contain 1 and 100 mg/L of NH_4-N . Be certain that the calibration solution and sensor are thermally equilibrated prior to entering NH_4^+ values.

To begin the calibration immerse the sonde in the 1 mg/L standard, press **Enter**, input the NH_4-N value, and again press **Enter.** The screen will display real-time readings which will allow you to determine when the sensor has stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second NH_4^+ standard, press **Enter**, input the correct concentration value, again press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option to calibrate the NH_4^+ probe using three calibration solutions, two at ambient temperature and one at a temperature significantly different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure. Be certain that the calibration solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 100 mg/L standard at ambient temperature, (2) 1 mg/L standard at ambient temperature, and (3) 1 mg/L standard at a different temperature (usually lower) than ambient. For best results, insure a temperature difference of at least 10 C°.

NITRATE

When selecting number **7 – ISE4-NO3**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your nitrate (NO_3^-) sensor. *The procedures for calibration of the nitrate sensor are identical to those above for the ammonium sensor*, except that the calibrant values are in mg/L of NO_3-N instead of NH_4-N.

CHLORIDE

When selecting number **8 – ISE5-CL-**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your chloride (Cl^-) sensor. *The procedures for calibration of the chloride sensor are identical to those above for the ammonium sensor*, except that the calibrant values are in mg/L of Cl instead of NH_4-N. IMPORTANT: We recommend that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate. Thus, the low calibration value should be 10 mg/L and the high calibration value should be 1000 mg/L Cl-. The difference is due to the fact that the effect of contamination of standards from inadvertent leakage of chloride ion from either the DO probe or the reference junction of the pH probe will be less significant at higher concentrations.

TURBIDITY

When selecting number **9 – Turbidity,** you will be given the choice of 1-point, 2-point, or 3-point calibrations for your turbidity sensor.

The **1-point** option is normally used to zero the turbidity probe in 0 NTU standard. Place the sonde in clear water with no suspended solids, and input 0 NTU at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the turbidity readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu. The 1-point option can also be used to adjust the turbidity system offset to any other turbidity value within the 0-1000 NTU range of the sensor while maintaining the slope(s) of previous 2- or 3-point calibration routines. For example, if desired, the sensor could be placed in 20 NTU standard, this value (rather than zero) Entered at the screen prompt, and the calibration confirmed to adjust the offset. The key to remember with regard to the 1-point calibration is that this procedure should <u>only</u> be used to update a previous 2-point or 3-point calibration.

Select the **2-point** option to calibrate the turbidity probe using only two calibration standards. In this case, one of the standards <u>must</u> be clear water (0 NTU) and the other should be in the range of known turbidity for the water to be monitored. For example, if the water to be evaluated is known to be low in turbidity, an appropriate choice of standards might be 0 and 10 NTU. However, for general purpose measurements an appropriate choice of standards is usually 0 and 100 NTU.

To begin the calibration, immerse the sonde in the 0 NTU standard, as instructed, and press **Enter.** It is mandatory that the 0 NTU standard be calibrated first. The screen will display real-time readings which will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second turbidity standard, input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 1000 NTU. As for the 2-point procedure, one of the standards <u>must</u> be 0 NTU. Because of the linearity characteristics of the sensors, we recommend that the other two standards have turbidity values of 10 and 100 NTU. However, the user can select any values which are deemed appropriate. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all turbidity calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration. *Remember that all multi-point turbidity calibrations must be done in order from 0 NTU and up. In the 3-point example, do 0 NTU, then 10 NTU, and finally 100 NTU.*

For further information related to setting up, calibrating and running turbidity measurements, refer to **Appendix E, Turbidity Measurements**.

2.9.3 FILE

This section is only for 600XLM, 6600 and 6920 sondes. If you do not have these sondes, skip to **Section 2.9.6, Report.**

Selections from the File menu allow the user to access data that has been stored in the sonde flash disk memory. Select number **3-File** from the Main menu.

```
-----------------File-----------------
1-Directory        4-View file
2-Upload           5-Quick view file
3-Quick Upload     6-Delete all files

Select option (0 for previous menu): 1
```

- Select number **1-Directory** to view all files currently stored in sonde flash disk memory. The screen below shows 5 files that suggest the sonde was used to spot check two bridge locations, deployed for a week in the lake (sampling every 15 minutes), then used to recheck the bridge locations.

```
 File        Samples  First sample        Last sample         Interval  Site
1-BRIDGE1        20   07/10/96 09:42:52   07/10/96 09:44:12   Discrete  Kenton Rd.
2-BRIDGE2        20   07/10/96 10:15:20   07/10/96 10:16:40   Discrete  Lakeview Dr.
3-UPLAKE-A      672   07/17/96 12:00:00   07/31/96 12:00:00   00:15:00  Lake Site A
4-BRIDGE11       21   07/31/96 12:31:00   07/31/96 12:32:22   Discrete  Kenton Rd.
5-BRIDGE22       21   07/31/96 12:42:31   07/31/96 12:43:54   Discrete  Lakeview Dr.

Select option (0 for previous menu):
```

- Select number **2 - Upload** to view file lists in memory (same as shown above) and then upload the data to a PC or to the YSI 610 Display/Logger. The uploaded data can then be processed with YSI EcoWatch for Windows to allow data manipulation and to easily generate reports, plots, and statistics. Three formats for file transfer are available: PC6000, Comma & Quote Delimited, and ASCII text.

PC6000 format will transfer the data so that it will be compatible with either EcoWatch (supplied with your sonde) or PC6000 (ordered separately) software packages. YSI recommends data transfer in this format since it is significantly more rapid than other transfer options. If this data is required in Comma & Quote Delimited and/or ASCII formats, the user can quickly generate data in these formats using the Export function in EcoWatch for Windows.

Comma & Quote Delimited format is commonly used to import files into spreadsheet software in your PC, where you can perform custom data analysis. A comma is still the delimiter, but the radix is corrected to a period. In most cases you should set the Page Length to 0 before using this type of upload format. See the Windows Help section in EcoWatch for information on setting the page length.

ASCII Text is another alternative to transferring data directly to your computer into spreadsheet or other PC-based software.

Prior to upload, a "Time window" display appears to allow you the option to select portions of the logged data to upload. You may select **1-Proceed** to upload all data logged from the dates and times shown.

```
-------------Time window-------------
1-Proceed
2-Start date=07/17/96
3-Start time=12:00:00
4-Stop  date=07/31/96
5-Stop  time=12:00:00

Select option (0 for previous menu):
```

Select **1-Proceed.** Notice that the symbol ' ' stands for quote. Choose the appropriate file transfer protocol. A status box will appear in the lower right quadrant of the screen. Verification of a successful transfer is indicated when all of the requested data are transferred.

```
--------------File type--------------
1-PC6000
2-Comma & ' ' Delimited
3-ASCII Text

Select option (0 for previous menu):
```

Press **0** or **Esc** to return to the File menu.

- When you select the number **3 – Quick Upload** option the same operation as **2-Upload** is performed, except that only the most recent flash disk file is uploaded and it is uploaded in its entirety. You still must choose the transfer format from the three options provided.

- Select number **4 - View File** to examine the data in any file currently stored in sonde flash disk memory. You will first view the same screen as viewed in the Directory menu. From this menu choose the file of interest, then, using the Time window menu, choose the dates and/or times of interest. If you choose dates or times that are not within the designated start and stop times, no data will be displayed.

You may choose the entire file. Use the **Space Bar** to alternately stop and to resume scrolling. Use the **Esc** key to cancel the view.

- Select the number **5 – Quick View File** option to view the last page of data from the last data file in flash disk memory. This feature is particularly useful in quickly reviewing recently acquired data at field sites so that system performance can be assessed.

- Select the number **6 – Delete all files** to IRREVERSIBLY remove all files from the sonde flash disk memory. It is critical not to use this option until all relevant data from sonde memory has been transferred to your computer via one of the upload options. There is a verification screen that appears, so that pressing the number 6 key does not immediately delete all files at this point.

2.9.4 STATUS

This section is only for 600XLM, 6600 and 6920 sondes.

Select number **4-Status** from the Sonde Main menu to obtain general information about the sonde and its setup.

```
-----------------Status----------------
1-Version:1.00
2-Date=07/22/96
3-Time=09:04:28
4-Bat volts: 9.0
5-Bat life 21.2 days
6-Free bytes:129792
7-Logging:Inactive

Select option (0 for previous menu):
```

- Number **1-Version** helps you identify the specific version of sonde software loaded in the sonde. This number is especially useful if you are calling YSI Customer Service. It may also be useful to you if you are comparing 2 or more sondes purchased at different times.

- Select **2-Date and 3-Time** to display current date and time. This is not a "live" display, but may be updated by pressing the 2 or 3 key again. This may be useful for viewing or setting real time. You may correct date or time from this submenu, by entering the corrected date or time as described in System setup. You cannot alter date format from this screen. And you must use the

24-hour clock time format. This interface functions identically to the System setup routine, yet provides convenience if you detect an error in the real time number entered.

- In options **4, 5, and 6**, you can view battery voltage, battery life, and available free memory in your sonde to help you evaluate whether the current setup is appropriate to complete an active logging or to begin a study in which you have defined your logging parameters. If you press key 4, 5 or 6 before you exit this screen, it may change, since this triggers the Status screen to update information.

- Number **7-Logging** provides one of two messages, active or inactive, indicating whether your sonde is in the unattended logging mode. This logging status indicator is not relevant to logging in the discrete mode, since there is no way to enter the Status screen without stopping discrete logging.

Press **0** or **Esc** to exit the Status screen and return to Main menu.

2.9.5 SYSTEM

Select number **5-System** (or **3- System** if you are working with a 600R, 600XL or 6820) from the Sonde Main menu to set the date and time, customize the sonde communication protocol, adjust how information appears on the screen, and enter an instrument identification number.

```
--------------System setup-------------
1-Date & time
2-Comm setup
3-Page length=25
4-Instrument ID=NotSet
5-SDI-12 address=0
6-(*)English
7-( )Fran‡ais

Select option (0 for previous menu):
```

Select **Date & time.** The 600R, 600XL and the 6820 do not have a date and time function or English or French selectability, please skip to the instructions for Comm Setup. An asterisk will appear next to each selection to confirm the entry. Press 4 and 5 to activate the date and time functions. Pay particular attention to the date format that you have chosen when entering date. Use the 24-hour clock format for entering time. Option **4- ( ) 4 digit** year may be chosen to have the date appear with a two or four digit year.

```
-----------Date & time setup-----------
1-(*)m/d/y              4-( )4 digit year
2-( )d/m/y              5-Date=08/11/98
3-( )y/m/d              6-Time=11:12:30

Select option (0 for previous menu):
```

Press **0** or **Esc** to return the System Setup menu.

Select **Comm setup** From the System Setup menu.

```
---------------Comm setup------------
1-(*)Auto baud          5-( )2400 baud
2-( )300 baud           6-( )4800 baud
3-( )600 baud           7-(*)9600 baud
4-( )1200 baud

Select option (0 for previous menu): 0
```

The default is 9600, but you may change it to match your host communication interface protocol by typing in the corresponding number, 1 through 7. An asterisk confirms the selection. Auto baud may be selected along with any of the choices. The Auto baud option allows the sonde to recognize and adjust to the received characters and we recommend that it is activated.

NOTE: If you change the baud rate, exit the sonde interaction and immediately change the baud rate in EcoWatch for Windows, Comm Settings. If you do not adjust the baud rate in the PC software, the sonde will not be able to communicate with the computer or any display/logger and your system will appear to be "locked-up."

Press **Esc** or **0** to return to the System Setup menu.

Select **Page length**, from the System Setup menu, to adjust the page length and press **Enter**. This will allow you to control how many lines of data are sent to your display before a new header is shown. The smaller the page number, the fewer the lines of data will be transmitted to your display between headers. However, if you set the page length to zero (0), only the initial header will be displayed. In many cases, a page length of zero is the preferred configuration if you choose to upload your data in an ASCII or CDF format. See **Section 2.9, Sonde Menu** for more details.

NOTE: The header itself takes 4 lines. Therefore, if the page length is set to 25, there will be 21 lines of data and one header. Any page length less than 5 will result in no header being transmitted.

Select **Instrument ID** from the System setup menu to record the instrument ID number (usually the instrument serial number), and press **Enter**. A prompt will appear which will allow you to type in the

serial number of your sonde. This will make sure that any data that is collected is associated with a particular sonde.

Press **Esc** or **0** to return to the System setup menu.

The SDI-12 default address is zero (0). This feature is fully described in **Section 7, Communication** and only utilized if the unit is to operate in a SDI-12 communication protocol network.

Then press **Esc** or **0** again to return to the Main menu.

2.9.6 REPORT

The Report menu allows you to configure all reports displayed by the sonde software. You will be able to select which parameters and units of measure that are displayed during operation.

Select number **6-Report** (or number **4-Report** if you are using a 600R, 600XL or 6820 sonde) from the sonde Main menu. The following menu, or a similar menu, will be displayed. The parameters listed depend on both the sensors installed and the sensors enabled. Therefore your screen may not be identical to that shown below.

Select **Report** from the Main sonde menu to setup the report section. The Report Setup menu will be displayed. The Report Setup for the 600R, 600XL and 6820 sondes is below.

```
---------------------Report setup---------------
1-(*) Temp C            D-( ) Sal ppt
2-( ) Temp F            E-(*) DO %
3-( ) Temp K            F-(*) DO mg/l
4-(*) SpCond mS/cm      G-( ) DO chrg
5-( ) SpCond uS/cm      H-( ) Press psia
6-(*) Cond mS/cm        I-(*) Press psir
7-( ) Cond uS/cm        J-( ) Depth meters
8-( ) Resist MOhm*cm    K-(*) Depth feet
9-( ) Resist KOhm*cm    L-(*) pH
A-( ) Resist Ohm*cm     M-( ) pH mv
B-( ) TDS g/L           N-(s*) Orp mv
C-( ) TDS kg/L

Select option (0 for previous menu):
```

The asterisks (*) that follow the numbers or letters indicate that the parameter will appear on all outputs and reports. To turn a parameter on or off type the number or letter, that corresponds to the parameter, after **Select option.**

For the 6600, 600XLM and 6920 sondes, the Report Setup display will appear as shown below.

```
--------------Report setup-------------
1-(*)Date m/d/y        D-( )pH mV
2-(*)Time hh:mm:ss     E-(*)Orp mV
3-(*)Temp C            F-(*)NH4+ N mg/L
4-(*)SpCond mS/cm      G-( )NH4+ N mV
5-( )Cond              H-( )NH3 N mg/L
6-( )Resist            I-(*)NO3- N mg/L
7-( )TDS               J-( )NO3- N mV
8-( )Sal ppt           K-(*)Cl- mg/L
9-(*)DOsat %           L-( )Cl- mV
A-(*)DO mg/L           M-(*)Turbid NTU
B-( )DOchrg            N-(*)Battery volts
C-(*)pH

Select option (0 for previous menu):
```

For most parameters, the selection process is identical to that show above in the Report Setup display. For parameters with multiple unit options such as temperature, conductivity, specific conductance, resistivity and TDS, a submenu will appear as shown below, allowing selection of desired units for this parameter.

```
--------------Select units-------------
1-(*)NONE
2-( )Temp C
3-( )Temp F
4-( )Temp K

Select option (0 for previous menu): 2
```

After configuring your display with the desired parameters, press **Esc or 0** to return to the Main menu.

Even if all of the sensors are enabled, the measurements for those sensors will not appear on your display unless the parameter is selected in Report setup. In order for a specific parameter to show up on a report:

1. The sensor must first be enabled (turned on).
2. That parameter must be activated in the Report setup.

The asterisk (*) following a given number or letter indicates that the parameter will appear on all outputs and reports. A blank ( ) following the number or letter indicates that the parameter will not appear on any output or report. To turn a parameter "on" or "off", type the number or letter of that parameter at the flashing cursor. Continue this process until all parameters with the desired units are either "on" or "off" as you wish.

In the above example, if the appropriate sensors have been activated in the Sensor setup section, the following parameters will be displayed to the computer screen or captured to a computer or data collection platform when the sonde is sampling: Temperature in C, Salinity in parts per thousand, Dissolved Oxygen in % air saturation, Dissolved Oxygen in mg/L, pH, ORP in millivolts, Ammonia-N, Nitrate-N, and Turbidity in NTUs. Date and time will also be displayed.

NOTE: Do not attempt to memorize or associate a number or letter with a particular parameter. The numbering scheme is dynamic and changes depending on the sensors which have been enabled.

The following list is a complete listing of the abbreviations utilized for the various parameters and units available in the Report setup menu.

Parameter description	
Date	Day/Month/Year (format selectable)
Time	Hour:Minute:Second (24-hour clock format)
Temp C	Temperature in degrees Celsius
Temp F	Temperature in degrees Fahrenheit
Temp K	Temperature in degrees Kelvin
SpCond mS/cm	Specific Conductance in milliSiemens per centimeter
SpCond uS/cm	Specific Conductance in microSiemens per centimeter
Cond mS/cm	Conductivity in milliSiemens per centimeter
Cond uS/cm	Conductivity in microSiemens per centimeter
Resist MOhm*cm	Resistivity in MegaOhms * centimeter
Resist Kohm*cm	Resistivity in KiloOhms * centimeter
Resist Ohm*cm	Resistivity in Ohms * centimeter
TDS g/L	Total dissolved solids in grams per liter
TDS kg/L	Total dissolved solids in kilograms per liter
Sal ppt	Salinity in parts per thousand
DO sat %	Dissolved oxygen in % air saturation
DO mg/L	Dissolved oxygen in milligrams per liter
DO chrg	Dissolved oxygen sensor charge
Press psia	Pressure in pounds per square inch absolute
Press psir	Pressure in pounds per square inch relative
Depth meters	Water column in meters
Depth feet	Water column in feet
pH	pH in standard units
pH mV	millivolts associated with the pH reading
Orp mV	Oxidation reduction potential value in millivolts
NH4+ N mg/L	Ammonium Nitrogen in milligrams/liter
NH4+ N mV	Ammonium Nitrogen in millivolt reading
NH3 N mg/L	Ammonia Nitrogen in milligrams/liter
NO3- N mg/L	Nitrate Nitrogen in milligrams/liter
NO3- N mV	Nitrate Nitrogen in millivolt reading
Cl- mg/L	Chloride in milligrams/liter
Cl- mV	Chloride in millivolt reading
Turbid NTU	Turbidity in nephelometric turbidity units

2.9.7 SENSOR

The Sensor menu allows you to Enable or Disable (turn on or off) any available sensor and, in some cases, to select the port in which your sensor is installed.

From the Sonde Main menu select number **7-Sensor** (or number **5-Sensor** if you are using a 600R, 600XL or 6820 sonde) and the following display will appear.

```
------------Sensors enabled------------
1-(*)Time                7-(*)ISE2 Orp
2-(*)Temperature         8-(*)ISE3 NH4+
3-(*)Conductivity        9-(*)ISE4 NO3-
4-(*)Dissolved Oxy       A-(*)ISE5 Cl-
5-( )Pressure-Abs        B-(*)Turbidity
6-(*)ISE1 pH             C-(*)Battery

Select option (0 for previous menu):
```

When a particular sensor is active, an asterisk will appear in the parentheses associated with the selection. The time, temperature, conductivity, dissolved oxygen, pH, ORP, ammonium, nitrate, chloride, turbidity and battery sensors are enabled. To disable a sensor, simply press the number of the active sensor or port, and the asterisk will disappear. For ISE2 to ISE5 press the appropriate number, and then enable or disable the sensor using the submenu choices. Be certain that the appropriate sensor is "enabled" in the submenu according to the sonde bulkhead port in which it is physically installed. For example, if an ammonium sensor is placed in the port labeled "3" on the bulkhead, enable the sensor as ISE3 in the menu structure.

The following screen is the submenu selection structure for ISE3, ISE4 and ISE5.

```
-------------Select type-------------
1-( )ISE3 NH4+        3-( )ISE3 Cl-
2-( )ISE3 NO3-

Select option (0 for previous menu):
```

For ISE2, the submenu selection structure will appear.

```
--------------Select type-------------
1-( )ISE2 Orp          3-( )ISE2 NO3-
2-( )ISE2 NH4+         4-( )ISE2 Cl-

Select option (0 for previous menu): 0
```

The probe corresponding to ISE2 is inserted in the bulkhead port characterized by the 4-pin Lemo connector. This port is different in appearance from the ISE3, ISE4, and ISE5 ports that are numbered on the bulkhead and use leaf-spring connectors. With the present configuration of the sonde and software, only an ORP probe can be assigned to ISE2 and thus either no selection or a selection of "1" must be made in the ISE2 submenu. Ammonium, nitrate and chloride sensors cannot be installed in the port corresponding to ISE2.

2.9.8 ADVANCED

From the Sonde Main menu select number **8-Advanced** (or number **6-Advanced** if you are using a 600R, 600XL or 6820 sonde) to display the sensor calibration constants, additional setup options, sensor coefficients and constants; and digital filtering options. The parameters listed depend on both the sensors installed and the sensors enabled, therefore your screen may not be identical to that shown below.

```
----------------Advanced-------------
1-Cal constants
2-Setup
3-Sensor
4-Data filter

Select option (0 for previous menu): 1
```

Select number **1-Cal constants** to display the calibration constants, as shown in the following example. Note that values only appear for the enabled sensors.

```
-------------Cal constants-------------
1-Cond:5                    B-NO3 A:2.543
2-DO gain:1.3048            C-Cl J:99.5
3-mV offset:0               D-Cl S:-0.195
4-pH offset:0               E-Cl A:2.543
5-pH gain:-5.05833          F-Turb Offset:0
6-NH4 J:51.2                G-Turb A1:500
7-NH4 S:0.195               H-Turb M1:500
8-NH4 A:1.092               I-Turb A2:1000
9-NO3 J:99.5                J-Turb M2:1000
A-NO3 S:-0.195

Select option (0 for previous menu): 0
```

The following table provides the default value, operating range, and comments relative to the calibration constants. Error messages will appear during calibration if values are outside the indicated operating range unless the designation is "not checked".

	Default	*Operating range*	*Comments*
Cond:	5	2.5 to 10.0	(traditional cond constant)
DO gain:	1	0.5 to 2.0	(relative to default)
Pres offset:			
if absolute	-14.7	-20.7 to -8.7	(not vented)
if gauge:	0.0	-6 to 6	(vented)
mV offset:	0.0	-100 to 100	
pH offset:	0.0	-400 to 400	
pH gain:	-5.0583	-6.07 to -4.22	
NH4 J	51.2	Not checked	
NH4 S	0.195	0.15 to 0.217	
NH4 A	1.092	Not checked	
NO3 J	99.5	Not checked	
NO3 S	-0.195	-0.217 to -0.15	
NO3 A	2.543	Not checked	
Cl J	99.5	Not checked	
Cl S	-0.195	-0.217 to -0.15	
Cl A	2.543	Not checked	
Turb Offset	0	-10 to 10	
Turb A1	500	0.6 to 1.5	Range is ratio of A1 to M1
Turb M1	500		
Turb A2	1000	0.6 to 1.5	Range is ratio of A2 to M2
Turb M2	1000		

To reset a calibration cell constant, access the sonde Calibrate menu. Then select the sensor and type "UNCAL" instead of the value. This action will change that sensors calibration constants back to the factory default.

From the Advanced menu, select **2-Setup** to display miscellaneous options. Type the appropriate number to activate/deactivate any of the displayed features.

```
-----------Advanced setup-----------
1-(*)VT100 emulation
2-( )Power up to Menu
3-( )Power up to Run
4-( )Comma radix
5-(*)Auto sleep RS232
6-( )Auto sleep SDI12
7-( )Multi SDI12
8-( )Full SDI12

Select option (0 for previous menu): 0
```

1-(*)VT100 emulation. Activate this option for VT100 terminal emulation. This feature allows the sonde to send escape sequences to clear the screen which in turn results in an improved display. Usually this feature should be activated, but, if your terminal or terminal emulator shows odd characters at the beginning of each menu title, then turn this item off. With the feature off, the sonde will send several carriage returns and line feeds to 'clear' the display. The number of <cr>'s and <lf>'s is determined by the page length setting.

2-(*)Power up to Menu. When this item is enabled, the sonde will go directly to menu mode when power is applied to the sonde. If the command line mode is not useful for your applications, then enabling this item will negate the need to type "Menu" and **Enter** at the # prompt to access the Main sonde menu.

3-(*)Power up to Run. When this item is enabled the sonde will start sampling and output data as soon as power is applied to the sonde. If "Power up to menu" is also enabled, the sonde will first enter the menu mode and then the run mode where it will start sampling. If "Power up to menu" is not enabled, the sonde will go to command line mode and then start the run function. With "Power up to Run" disabled, the sonde will wait for your command at power up (in either command line or menu mode) as set by "Power up to Menu". If you are using your sonde for Unattended sampling, do not activate this mode.

4-(*)Comma radix. When this item is enabled, the sonde will replace decimal points with commas when printing numbers. NOTE: Regardless of this setting, SDI-12 'D' commands will still respond using a decimal point.

5-(*)Auto sleep RS232. Activation of this feature enables a power savings system when communicating with the sonde in RS-232 mode. When enabled, power is only applied to the sensors during sampling or calibration. Additionally, if the sonde is not sampling or calibrating, it will "sleep"

after one minute with no communications. Any character sent to it when sleeping will "wake" it, although the character sent will be discarded. It takes the sonde about 30 milliseconds to wake up. Disabling this item allows for "instant" readings. Generally, this feature should be activated for long term monitoring studies in the RS-232 communication mode.

6-(*)Auto sleep SDI12. Activation of this feature enables the power savings system when communicating with the sonde in SDI-12 mode. This is basically the same as item 5 above except that it is used in communication via the SDI-12 interface. Also, the sonde will "sleep" in about 100 milliseconds in the absence of communication, rather that waiting one minute in the Auto sleep RS-232 mode.

7-(*) Multi SDI12. Modifies the SDI12 protocol as follows: (1) No SDI12 service request will be issued. (2) Break commands will not cause a measurement reading to be aborted. Normally, you should leave this feature "off".

8-(*) Full SDI12. Enabling this feature forces full SDI-12 specification in order to pass the NR Systems SDI-12 Verifier. Disabling this feature will allow the unit to be more fault tolerant and will save some power. We recommend that you leave this feature "off".

Select number **3-Sensor** to display and change user-configurable constants as shown in the following display. Type the appropriate number to change to these parameters.

```
------------Advanced sensor----------
1-TDS constant=0.65
2-Latitude=40
3-Altitude Ft=0
4-(*)Fixed probe
5-( )Moving probe
6-DO temp co %/C=1.1
7-DO warm up sec=40
8-(*)Wait for DO
9-Turb wipes=1
A-Twipe int=1
B-SDI12-M/twipe=1
C-Turb temp co %/C=0.3
D-(*)Turb spike filter

Select option (0 for previous menu):
```

NOTE: In the descriptions of each sensor parameter listed below, Salinity and Pres appear although neither appears in the display above. Salinity only appears if you disable the Conductivity Sensor, and Pres only appears if you disable the Pressure Sensor. Both of these are shown in the table below, but assigned with the letter x to show relative position in the display. Also, Flow is only available on those sondes that vented level. Flow will then appear as the number 2 choice.

1-TDS constant=0.65 This selection allows you to set the constant used to calculate TDS. TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm. This item will only appear if the conductivity sensor is enabled in the "Sensors enabled" menu.
X-Salinity=0 This selection allows you to input a manually-acquired value of salinity for calculating other parameters such as DO mg/L. *This item is not used or displayed if the conductivity sensor is enabled in the "Sensors enabled" menu.*

X-Pres=0 psi This selection allows you to set a value of pressure for calculating other parameters like salinity. *This item is not used or displayed if the pressure sensor is enabled in the "Sensors enabled" menu.*

2-Latitude=40 This selection allows you to input the global position (latitude) where the sonde is sampling. The units are degrees. For accuracy, enter the decimal equivalent to indicate degrees and minutes. For example, enter 41° 30 ' as 41.5. This value is used in the calculation of depth or level to account for global variations in the gravitational field. This item will only appear if the pressure sensor is enabled in the "Sensors enabled" menu.

X- Flow Setup... This selection allows you to setup the sonde to output flow information. See **Appendix F, Flow** for detailed information on how to setup the Flow parameter. Flow is only available on sondes that have shallow vented level.

3-Altitude=0 This selection allows you to input the local altitude (relative to sea level) where the sonde is sampling. The units are feet. You may enter positive or negative values (range is -276 to 29028) to represent altitudes above or below sea level. This value is used in the calculation of depth or level and will only appear if the pressure sensor is enabled in the "Sensors enabled" menu.

4-(*)Fixed probe This selection allows you to identify how your sonde is being used. If your sonde is "fixed" or secured to a dock, buoy, platform or similar, select this option. This information is used in the calculation of depth and level. This item will only appear if the Pressure-Abs sensor is enabled in the "Sensors enabled" menu.

5-(*)Moving probe This selection allows you to identify how your sonde is being used. If your sonde is being used in depth profiling and therefore changing as you monitor, select this option. This information is used in the calculation of depth and level. This item will only appear if the pressure sensor is enabled in the "Sensors enabled" menu.

6-DO temp co=1.1%/C This selection allows you to input the dissolved oxygen temperature coefficient. Do not change this value unless you consult YSI Customer Service. This item will only appear if the dissolved oxygen sensor is enabled in the "Sensors enabled" menu.

7-DO warm up=40 This selection allows you to set the amount of time allowed for DO warm up in seconds. Normally the default value of 40 seconds is adequate for most applications. However, there may be certain situations in which greater DO accuracy can be attained by increasing this time. Consult YSI Customer Service if you feel that your DO warm up time is incorrect. This item will only appear if the dissolved oxygen sensor is enabled in the "Sensors enabled" menu.

8-(*)Wait for DO When this feature is enabled, the sonde is forced to wait for the DO warm up time to expire before displaying any readings. Note that in SDI12 mode or while calibrating the DO sensor, the warm up time is used regardless of the activation of this item. Disabling this item allows you to

see data without having to wait during the DO warm up time. Under normal operating conditions, this item should be turned off. If you are using the sonde with a data logger in RS232 mode and will be turning the sonde "on" and "off" for each sample, then you may want to enable this item so that only stable DO data are recorded. This item will only appear if the dissolved oxygen sensor is enabled in the "Sensors enabled" menu.

9-Turb Wipes=1 If a 6026 turbidity sensor is installed, this selection will determine the number of cleaning cycles which will occur when the wiper is activated manually or automatically. Since the wiper functions bidirectionally, a selection of "1" results in two passes of the wiper over the optical face. In most applications, a single cleaning cycle is adequate to keep the optical surface free of bubbles and fouling. However, in particularly harsh environments additional cleaning cycles may be needed and can be selected here.

A-Twipe Int=1 In applications where a mechanically-cleaned 6026 turbidity probe is installed in the sonde and the instrument is collecting unattended data while attached to a data collection platform or computer, the wiper mechanism of the probe should be activated automatically in a periodic manner to clean the optical surface for fouling and bubbles. The value entered at this selection is the number of minutes between each automatic cleaning cycle. Thus, if Twipe Int is set to "5" and the instrument is in the Run mode, the wiper will activate every 5 minutes with no manual input.

The value of Twipe Int is sometimes overridden when the instrument is set up in the Unattended sampling mode. Under these conditions, the wiper will be automatically activated at the interval assigned in the Unattended setup rather than that assigned in Twipe Int. Thus, in an Unattended study setup at a 15 minute sampling interval, the wiper will be activated only once every 15 minutes rather than at the indicated Twipe Int of 1 minute.

CAUTION: If Twipe Int is set to zero, then no wiping will occur either in Discrete or Unattended Sampling. Make certain that Twipe Int is set to some finite value prior to setting up an Unattended study or no automatic cleaning will occur.

B-SDI12-M/Twipe=1 This is the number of wiping cycles when the sonde is in SDI12 mode. The wiper for a 6026 turbidity sensor will automatically wipe each time this many SDI12 "M" commands have been issued. If this value is set to zero, then no automatic wiping will occur.

C-Turb temp co %/C=0.3 This entry sets the coefficient for the temperature compensation of turbidity readings from the 6036 and 6026 sensors. The default value of 0.3 should not be changed by the user without consulting YSI Customer Service.

D-(*) Turb Spike Filter When this item is activated, the output of the turbidity sensor is mathematically processed to minimize the effect of unusual (or "bad") readings on the overall data presentation. In most cases, these "spike" events are the result of the fortuitous passage of large suspended particles across the probe optics just at the time a reading is taken. Activation of this option generally results in a better display of the "average" turbidity of the water under examination and its use is recommended for most sampling and unattended applications.

The following is a summary of the items listed under Sensor:

item:	*visible if:*	*default:*	*range:*
TDS constant	conductivity sensor is on	0.65	0-1000
Salinity	conductivity sensor is off	0	0-1000
Pres psi	pressure sensor is off	0	0-1000
Latitude	pressure sensor is on	40	0-90
Altitude	pressure sensor is on	0	-276 to 29028
Fixed probe	pressure sensor is on	on	on or off
Moving probe	pressure sensor is on	off	on or off
DO temp co %/C	DO sensor is on	1.1	0 -10
DO warm up sec	DO sensor is on	40	0-252, in steps of 4
Wait for DO	DO sensor is on	off	on or off
Turbidity wipes	Turbidity sensor is on	1	on or off
Twipe int	Turbidity sensor is on	1	on or off
SDI12-M/twipe	Turbidity sensor is on	1	on or off
Turb tempco %/C	Turbidity sensor is on	0.3	on or off
Turbidity spike filter	Turbidity sensor is on	off	on or off

From the Advanced menu, select **4-Data filter** to display filtering options. Type the appropriate number to activate/deactivate any of the displayed features.

```
-----------Data filter setup-----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant=12
4-Threshold=0.01

Select option (0 for previous menu): 0
```

1-(*) Enabled. Activating this item will result in data filtering according to the values set in (2), (3), and (4).

2-(*) Wait for filter. If this feature is activated, readings will be available for output only after the unit has warmed up for a time period equal to the Time Constant plus an extra 4 seconds. This feature is useful, for example, if you are operating in SDI12 mode and want to average the data over a particular period of time. In such a case, you would not want the filter to be engaging and disengaging, so the value of the Threshold should be set to a large value like 1. This feature should not be activated for normal use of the sonde.

3-Time Constant. This value is the time constant in seconds for the digital filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the apparent response of the sensors.

4-Threshold. This value determines when the digital filter will engage/disengage. For example, a value of 1.0 for the threshold roughly corresponds to the following changes in sensor readings:

Temp: 100 C
Conductivity: Full scale for given range (100, 10, 1, or 0.1 mS/cm)
Dissolved Oxygen: 200 percent air saturation
pH, ORP, Ammonium, Nitrate and Chloride: 600 mV
Turbidity: 1000 NTU

When the difference between 2 consecutive unfiltered readings drops below the threshold, the filter will engage. When the difference between 2 consecutive filtered readings rises above the threshold, the filter disengages.

When the filter is disengaged, the readings are unfiltered. When the filter engages, a "soft start" feature takes over for the first period of the time constant. During this time, the output reflects a simple average of all the readings from the time the filter engaged until the present. Once the filter has been engaged for the period of the time constant, it becomes a simple filter with a time constant equal to that set in **3-Time Constant**. Each time the filter disengages and then reengages, this process is repeated. Because of this feature, each sensor effectively has its own filter and thus one parameter may be filtered while another is not because of differences in the noise level on each of the sensors.

The filter for turbidity is somewhat different. For this sensor, the filter is temporarily disengaged during mechanical wiping so that when wiping is finished, the reading is the most current. The filter then reengages if possible. Turbidity readings are frozen to the output during wiping so that "bad" values are not output.

For general-purpose sampling and monitoring use, YSI recommends settings of 0.010 for the **Threshold** and 12 for the **Time Constant,** if a turbidity probe is present. If no turbidity probe is in use, settings of 0.001 for the **Threshold** and 4 for the **Time Constant** are recommended.

2.10 CARE, MAINTENANCE AND STORAGE

This section describes the proper procedure for storage of the sensors that will maximize their lifetime and minimize the time required to get the sonde ready for a new application. This section will describe interim or short-term storage between applications where the sonde is being used at a regular interval (daily, weekly, biweekly, etc.). and long term storage, (e.g., over-the-winter), where the sonde will not be used on a regular basis for several months.

In the descriptions and instructions below, it is assumed that the user has retained the vessels (bottles, boots, etc.) in which the individual sensors were stored on initial delivery. If these specific items have been misplaced or lost, they can be replaced by contacting YSI Customer Service. Alternatively, the user may have similar (and equally acceptable) storage equipment on hand even though it was not part of the original YSI package. Common sense should be the guide on substitution of storage vessels.

REMEMBER: DO NOT ATTEMPT TO GAIN ACCESS TO THE INTERNAL CIRCUITRY OF THE SONDE.

2.10.1 SONDE CARE AND MAINTENANCE

The Model 6570 Maintenance Kit is available for use with your sonde. The kit includes several items which will be helpful or necessary to perform the proper routine maintenance on your sonde.

The 6570 Maintenance Kit includes two types of O-rings (for probes and cable connector), probe/installation/replacement tools, two cleaning brushes for the conductivity sensor, O-ring lubricant, and a syringe for cleaning the depth sensor port.

The 6570 Maintenance Kit can be ordered from any authorized YSI dealer, or directly from YSI. See Appendix C for details.

When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

SONDE PROBE PORTS

Whenever you install, remove or replace a probe, it is extremely important that the entire sonde and all probes be thoroughly dried prior to the removal of a probe or a probe port plug. This will prevent water from entering the port. Once you remove a probe or plug, examine the connector inside the sonde probe port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the sonde to your dealer or directly to YSI Customer Service, see **Section 8, Warranty and Service Information**, for details. When you reinstall a probe or port plug, lightly grease the O-ring with lubricant supplied in the 6570 Maintenance Kit.

CABLE CONNECTOR PORT

The cable connector port at the top of the sonde should be covered at all times. While communicating with the sonde, a cable should be installed and tightened in place. This will assure that a proper connection is being made and prevent moisture and contaminants from entering.

When a communications cable is not connected to the cable connector port, the pressure cap supplied with the instrument should be securely tightened in place.

If moisture has entered the connector, dry the connector completely using compressed air, a clean cloth, or paper towel. Apply a very thin coat of lubricant from the 6570 Maintenance Kit to the O-ring inside the connector cap before each installation.

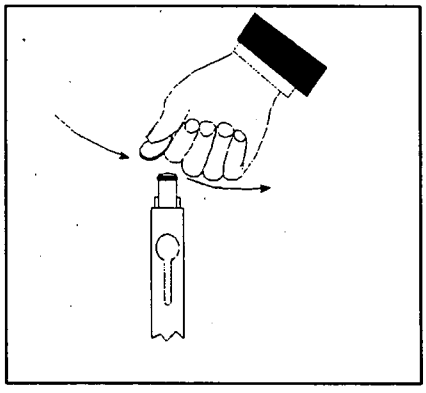
2.10.2 PROBE CARE AND MAINTENANCE

Once the probes have been properly installed, remember that periodic cleaning and DO membrane changes are required.

6562 DO PROBES

For best results, we recommend that the KCl solution and the Teflon membrane at the tip of the 6562 probe be changed prior to each sonde deployment and at least once every 30 days during the use of the sonde in sampling studies. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane or the O-ring; and (c) if the probe shows unstable readings or other probe-related symptoms. See Section 2.3 for instructions on changing the DO membrane.

After removing the used membrane from the tip of the 6562 probe, examine the electrodes at the tip of the probe. If either or both of the silver electrodes are black in color, the probe should be resurfaced using the fine sanding disks which are provided in the 6035 reconditioning kit.



To resurface the probe using the fine sanding disk, follow the instructions below.

First dry the probe tip completely with lens cleaning tissue. Next, hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode (located between the two silver electrodes). The motion is similar to that used in striking a match. Usually 10-15 strokes of the sanding disk are sufficient to remove black deposits on the silver electrodes. However, in extreme cases, more sanding may be required to regenerate the original silver surface.

After completing the sanding procedure, repeatedly rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane.

IMPORTANT: Be sure to: (1) Use *only* the fine sanding disks provided in the 6035 maintenance kit in the resurfacing operation and (2) Sand in a direction parallel to the gold electrode. *Not adhering to either of these instructions can seriously damage the electrodes.*

NOTE: If this procedure is unsuccessful, as indicated by improper probe performance, it may be necessary to return the probe to an authorized service center. See **Section 8, Warranty and Service Information**, for contact information.

6560 CONDUCTIVITY/TEMPERATURE PROBES

The openings which allow fluid access to the conductivity electrodes must also be cleaned regularly. The small cleaning brush included in the 6570 Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 15-20 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent with the brush. After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

NOTE: If this procedure is unsuccessful, or if probe performance is impaired, it may be necessary to return the probe to an authorized dealer service center See **Section 8, Warranty and Service Information** for contact information.

The temperature portion of the probe requires no maintenance.

6561 pH AND 6565 COMBINATION pH-ORP PROBES

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these probes or when the response of the probe becomes slow.

Remove the probe from the sonde. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (6561 and 6565) and platinum button (6561). Then use a moistened cotton swab to carefully remove any material which may be blocking the reference electrode junction of the sensor.

CAUTION: When using a cotton swab with the 6561 or 6565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress.

If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water.

If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the acid.

3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rerinse with clean water. To be certain that all traces of the acid are removed from the probe crevices, soak the probe in clean water for about an hour with occasional stirring.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the probe for approximately 1 hour in a 1 to 1 dilution of commercially-available chlorine bleach.

2. Rinse the probe with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the probe for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then rerinse the probe with clean water and retest.

Dry the sonde port and probe connector with compressed air and apply a very thin coat of O-ring lubricant to all O-rings before re-installation.

DEPTH SENSOR

The depth sensor modules are factory installed options that are located between the bulkhead and the sonde tube. For 600XL and 600XLM sondes, there is a circular protective cap with two small holes. The cap cannot be removed, but a syringe is supplied in the maintenance kit to aid in cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the pressure port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

CAUTION: Never try to remove the circular pressure port cap.

For 6920, 6600 and 6820 sondes, the depth sensor is exposed to the water by either a circular access port on the side of the sonde or a though-hole on a module just above the sonde bulkhead. A syringe is supplied in the maintenance kit to aid cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the access port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

CAUTION: Do not attempt to remove the depth module from the sonde body.

LEVEL SENSOR

For level sensors follow all the maintenance procedures given for depth sensors. In addition, ensure that the desiccant always remains active. Active desiccant is a distinctive blue color. When it can absorb no more moisture, it is a rose red or pink color. For either the cartridge or the canister, the end that is vented to atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated well before it is completely exhausted to ensure that it lasts the entire deployment.

You may regenerate the desiccant, replace the desiccant in the cartridge or canister, or replace the entire cartridge or canister. See **Appendix G, Using Vented Level**, for more information.

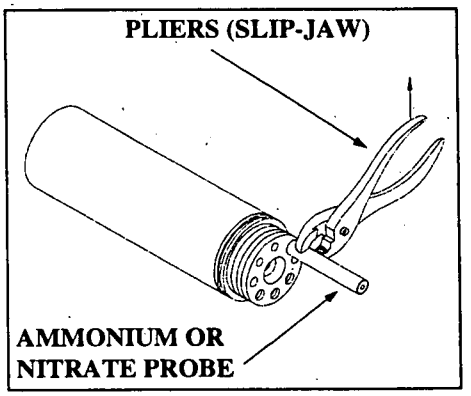
To regenerate the desiccant, remove it from the unit and spread it evenly, one granule deep, on a suitable tray. Heat for about one hour at about 200 degrees C (about 400 degrees F). The desiccant should then be cooled in a suitable, tight container before refilling the unit. The color of the desiccant will return to blue if the regeneration cycle has been successful. The felt filters should also be dried at about 100 degrees C (about 200 degrees F) for about 30 minutes before assembly.

Desiccant material is sold separately. Both the cartridge and canister can easily be opened, emptied, and refilled.

CAUTION: It is important to keep the tube in vented sondes and cables dry. They are supplied with caps for closing the volume when not in use. Keep the caps on until just before calibration and deployment. For storage, replace the caps.

6882 CHLORIDE, 6883 NITRATE AND 6884 AMMONIUM SENSORS

You should clean these probes whenever deposits or contaminants appear on the ion selective membranes located on the tips of these sensor modules. If possible, the module should be cleaned while installed in the sonde bulkhead. Use clean water and a moist piece of lens cleaning tissue to *gently* wipe the sensor membranes until no more contaminants are removed. However, under some conditions, it may be necessary to remove the module from the sonde bulkhead for cleaning and/or storage. To remove the module, follow the diagram at the side. Remove the module with finger pressure only, if possible. However, it is acceptable to use small pliers if necessary to loosen the module for final removal by hand. **Be very careful not to squeeze the module any more than is necessary for a firm grip. Use slipjaw pliers to minimize the chance of applying too much pressure on the module.** While the module is removed from the sonde, be sure to dry the sonde port and probe connector with compressed air and apply a very thin coat of lubricant to the O-ring before re-installation.

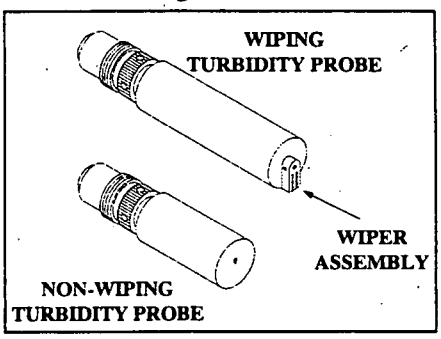


NOTE: The ion selective membranes are fragile. Be certain to: (1) Use only *moist*, high quality lens cleaning tissue for the cleaning procedure (not paper towels or other coarse materials); and (2) Stroke

the probe face very gently with the tissue during the procedure. *If you do not adhere to these instructions, you can seriously damage the sensors.*

6026 AND 6036 TURBIDITY PROBES

The 6026 and 6036 turbidity probes require only minimal maintenance. After each deployment, the optical surface on the tip of the turbidity probe should be inspected for fouling and cleaned if necessary by gently wiping the probe face with moist lens cleaning paper. In addition, for the 6026 probe, it is recommended that the wiper be replaced periodically. The frequency of this replacement depends on the quality of water under examination. A replacement wiper is supplied with the 6026 sensor, along with the small hex driver required for its removal and reinstallation. Follow the instructions supplied with the turbidity sensor to insure proper installation of the new wiper assembly. Additional wipers are available from YSI.



2.10.3 SONDE STORAGE

Since the introduction of the YSI Environmental Monitoring Systems (EMS) product line several years ago, YSI has learned a great deal about storage protocols which will maximize the lifetime of your sensors. This knowledge has come from our own extensive in-house testing programs as well as from feedback from a large number of customers and sales representatives.

Proper storage of the your Sonde between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

GENERAL RECOMMENDATIONS FOR SHORT TERM STORAGE

The recommended short term or interim storage procedure is simple and identical for all sondes, models 600R, 600XL, 600XLM, 6820, 6600 and 6920.

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid, which could cause some of them to drift or result in a shorter lifetime. For example, the reference junction of a pH sensor must be kept moist to minimize its response time during usage, but continued immersion in pure water may compromise the function of the glass sensor and/or result in long term leaching of the reference junction.

YSI recommends that short term storage of all multi parameter instruments be done **by placing approximately 0.5 inch of water in the calibration and/or calibration cup, that was supplied with the instrument, and by placing the sonde with all of the probes in place into the cup.** The use of a moist sponge instead of a half inch of water, is also acceptable, as long as its presence does not compromise the attachment of the calibration cup to the sonde. **The calibration cup should be sealed to prevent evaporation.**

The key for interim storage is to use a minimal amount of water so that the air in chamber remains at 100 percent humidity. The water level has to be low enough so that none of the sensors are actually immersed. Any type of water can be used in this protocol: Distilled, deionized, or tap water. If the storage water is inadvertently lost during field sampling studies, environmental water can be used to provide the humidity.

Sondes with level sensors have a tube that vents the pressure transducer to the atmosphere. **It is important that the air in the tube remains dry at all times.** Sondes with integral cables should be stored with the desiccant in place and the vented end of the desiccant system sealed. Sondes with connectors should be stored with the connector cap firmly in place. When disconnecting the cable, put the cap on immediately. Vented cables should be stored with their caps in place, in a bag containing desiccant.

- Interim multi parameter storage is easy. Simply remember the following key points:
- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.
- Check the vessel periodically to make certain that water is still present.
- For sondes with level sensors, keep the tube sealed and dry.

GENERAL RECOMMENDATIONS FOR LONG-TERM SONDE STORAGE

The following are long term storage recommendations listed by instrument type. They will be applicable for sondes with typical sensor configurations.

600XL, 600XLM -- Remove the pH or pH/ORP probe from the sonde and store it according to the instructions found in the following section on individual sensors. Cover the empty port with the provided plug. Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and seal with the cap/O-ring to minimize evaporation.

6820, 6920, 6600 -- Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Remove all other probes from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty ports with the provided plugs. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and tighten the threaded cup to attain a good seal and minimize evaporation.

600R (with Replaceable Reference Electrode Module) -- Instruments of this design were generally sold after January, 1996 and can be identified by the presence of 4 probes (temperature, dissolved oxygen, pH reference, and pH glass) in the bulkhead. Remove the reference module, store it as described below, and plug the open port with the insert that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Place approximately 300 mL of tap water in the storage vessel, insert the sonde, and seal the vessel with the cap and O-ring.

Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.

600 (with Combination pH Sensor) -- Instruments of this design were generally sold prior to January, 1996 and can be identified by the presence of only 3 probes (temperature, dissolved oxygen, pH) in the bulkhead. Be certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution that is 2 molar (2 M) in potassium chloride (KCl) to a level that completely covers the dissolved oxygen and pH probes. See the following section for instructions on preparation of the KCl storage solution. Seal the vessel with the cap and O-ring.

2.10.4 PROBE STORAGE

LONG-TERM STORAGE OF PROBES

The following sections provide additional details on the storage of individual sensors associated with instruments in the EMS product line from YSI.

TEMPERATURE

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with the thermistor probe are not corrosive (for example, chlorine bleach).

CONDUCTIVITY

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with thermistor probe and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage.

DISSOLVED OXYGEN

Rapid Pulse dissolved oxygen sensors should always be stored with a membrane and electrolyte in place and in such a way that the drying out of the electrolyte on the probe face is minimized. For long-term storage, the medium should be water rather than the moist air used in interim storage. The long-term storage protocol is also dependent on the instrument under consideration.

For the 600XL, 600XLM, 6820, 6600 and 6920, two long-term storage methods are equally acceptable.

1. Remove all probes other than dissolved oxygen, conductivity, and temperature from the sonde and seal the vacant ports with the provided port plugs. Leave the electrolyte and membrane in place on the dissolved oxygen sensor. Fill the calibration cup with water (tap, deionized, or distilled are equally acceptable) and insert the sonde. Make certain the water level is high enough to completely cover the DO sensor. Seal the vessel to prevent evaporation of the water. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

2. Remove the dissolved oxygen sensor from the sonde leaving the electrolyte and membrane in place. Store the probes in water (tap, deionized, or distilled are equally acceptable) in a beaker, flask, or other vessel of the user's choice. **Be sure not to damage the membrane or the probe tip when placing the probe on the bottom of the vessel.** If possible cover the vessel with parafilm or plastic wrap to minimize evaporation of the water during long-term storage. Monitor the water level in the storage vessel periodically and replenish if loss due to evaporation occurs. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

Because the user cannot remove the Model 600R's dissolved oxygen probe from the sonde, a slightly different long-term storage protocol is required:

For 600 systems equipped with a replaceable reference electrode module, remove the reference module, store it as described below and plug the open port with the port plug that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl), insert the sonde and seal the vessel with the cap and O-ring. This solution can be prepared by dissolving 74.6 g of KCl in 500 mL (approximately 1 pint) of water or 37.3 g of KCl in 250 mL (approximately 0.5 pint) of water. The water should be distilled or deionized. If KCl solution is unavailable, it is acceptable to store the dissolved oxygen and pH glass sensors in tap water. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor, which must remain in the sonde.** At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

- For 600 systems equipped with a combination pH probe (purchased prior to 1996), none of the probes are user-replaceable and a different storage technique is required. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution, which is 2 molar (2 M) in potassium chloride (KCl), to a level that completely covers the dissolved oxygen and pH probes. Seal the vessel with the cap and O-ring. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

pH

The key to pH probe storage, short or long-term, is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride (see dissolved oxygen section above for preparation of this solution). If potassium chloride solution is not available, soaking the sensor in tap water or commercial pH buffers may restore probe function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement. It is also important to remember not to store the pH sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

The long-term storage protocol is dependent on the instrument.

For Model 600XL, 6820, 6600 and 6920 systems, the recommended long-term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should

contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution. Electrical tape can be used to provide a removable seal between the boot and the module body.

For Model 600 systems equipped with a replaceable reference electrode module, remove the reference module and plug the open port with the provided insert. Place the module in the storage vessel boot, which was in place on delivery, and seal the vessel with electrical tape. The vessel should contain a solution which is 2 molar in potassium chloride and should be sealed to prevent evaporation of the storage solution. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided sonde storage vessel with tap water, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.**

For Model 600 systems equipped with a combination pH probe (purchased prior to 1996), a different storage technique is required. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar in potassium chloride (KCl) to a level which completely covers the dissolved oxygen and pH probes, insert the sonde, and seal the vessel with the cap and O-ring.

ORP

Long Term Storage: ORP is not available on the Model 600R. For the Models 600XL, 6820, 6600 and 6920 systems, the recommended long term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

AMMONIUM, NITRATE AND CHLORIDE

The active element in the ammonium and nitrate ion selective electrode (ISE) sensors is a polyvinyl chloride (PVC) membrane that is impregnated with the reagent that provides specificity for either ammonium or nitrate. The useful life of this sensor can be reduced if the membrane is stored immersed in water. Thus, storage in dry air is recommended for long term storage. While dry air is slightly preferable for general storage, the short-term storage of these sensors in the sonde, with the entire sensor array in moist air, will have no significant detrimental effect on the life of the membrane. Remove the sensor module (6820, 6600, 6920) or the probe from the sonde and cover the vacant port with the provided plug. Place the sensor back in the storage boot that was provided, and set aside in room air.

The chloride ISE sensor utilizes a solid state membrane that provides specificity. For long-term storage, the module should be removed from the sonde, wiped clean with moist lens cleaning tissue, and placed in its storage boot to prevent abrasion.

TURBIDITY

No special precautions are necessary for either the short or long-term storage of the turbidity sensors for the Models 6820, 6600 and 6920. However, for long-term storage, the user may wish to remove the

sensor from the sonde and store it dry in air to minimize any cosmetic degradation of the probe body and to maximize the life of the wiper on the 6026.

DEPTH AND LEVEL

No special precautions are required for the sensor itself, but see instructions above with regard to maintaining a dry atmosphere in the vent tube. Sensors can be stored dry or wet, as long as solutions in contact with the strain gauge sensor port are not corrosive (for example, chlorine bleach).

Recommendations are identical for short-term and long-term storage.

SECTION 5 PRINCIPLES OF OPERATION

5.1 CONDUCTIVITY

The sondes utilize a cell with four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milli-Siemens (millimhos). To convert this value to a conductivity value in milli-Siemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the sonde conductivity cell is approximately 5.0/cm. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed. Solutions with conductivities of 1.00, 10.0, 50.0, and 100.0 mS/cm, which have been prepared in accordance with recommendation 56-1981 of the Organization International De Metrologie Legale (OIML), are available from YSI. The instrument output is in mS/cm or uS/cm for both conductivity and specific conductance. The multiplication of cell constant times conductance is carried out automatically by the software.

CALIBRATION AND EFFECT OF TEMPERATURE

The conductivity of solutions of ionic species is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/°C). In addition, the temperature coefficient itself varies with the nature of the ionic species present.

Because the exact composition of a natural media is usually not known, it is best to report a conductivity at a particular temperature, e.g. 20.2 mS/cm at 14 °C. However, in many cases, it is also useful to compensate for the temperature dependence in order to determine at a glance if gross changes are occurring in the ionic content of the medium over time. For this reason, the sonde software also allows the user to output conductivity data in either raw or temperature compensated form. If Conductivity is selected, values of conductivity that are *NOT* compensated for temperature are output to the report. If Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C. The calculation is carried out as in equation (1) below, using a temperature coefficient of 1.91%/°C (TC = 0.0191):

$$\text{Specific Conductance } (25^\circ\text{C}) = \frac{\text{Conductivity}}{1 + TC * (T - 25)}$$

As noted above, unless the solution being measured consists of pure KCl in water, this temperature compensated value will be somewhat inaccurate, but the equation with a value of TC = 0.0191 will provide a close approximation for seawater and for solutions of many common salts such as NaCl and NH_4Cl.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - When filling the calibration vessel prior to performing the calibration procedure, make certain that the level of calibrant standard is high enough in the calibration cup or beaker to cover the entire conductivity cell.

2 - After placing the sonde in the calibration solution, agitate the sonde to remove any bubbles in the conductivity cell.

3 - During calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The readings after calibration are only as good as the calibration itself.

4 - Perform sensor calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

5.2 SALINITY

Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C. However, the unitless salinity values are very close to those determined by the previously used method where the mass of dissolved salts in a given mass of water (parts per thousand) was reported. Hence, the designation "ppt" is reported by the instrument to provide a more conventional output.

5.3 OXIDATION REDUCTION POTENTIAL (ORP)

The sondes determine the Oxidation Reduction Potential (ORP) of the media by measuring the difference in potential between an electrode which is relatively chemically inert and a reference electrode. To measure ORP with a sonde, a combination pH/ORP probe must be in place in the sonde bulkhead and ORP must be accessed via the ISE2 channel of the sonde. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

CALIBRATION AND EFFECT OF TEMPERATURE

Calibration may not be required for the ORP sensor of the sonde when it is new. However, older probes that have been deployed extensively may show some deviation from the theoretical ORP value. This deviation is usually due to a change in the concentration of the KCl in the reference electrode gel. To determine whether the sensor is functioning correctly, place the ORP probe in 3682 Zobell solution and monitor the millivolt reading. If the probe is functioning within

specifications, the ORP reading should be within the range of 221-241 at normal ambient temperature. If the reading is outside of this range, the probe can be calibrated to the correct value (231 mV at 25°C) using the calibration procedure outlined in **Section 2.6.1, Calibration.**

ORP readings for the same solution can vary up to 100 mv depending on the temperature. However, no standard compensation algorithms exist for this parameter. Be sure to take this factor into account when reporting ORP values and checking sensor calibration. For Zobell solution, consult the following chart:

TEMPERATURE, CELSIUS	ZOBELL SOLUTION VALUE, MV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - Instructions for preparation of ORP calibrator solutions (including Zobell reagent) can be found in Section 2580 A. of *Standard Methods for the Examination of Water and Wastewater.* Alternatively, the Zobell solution is available from YSI.

2 – Reagants to confirm ORP sensitivity are available. See **Appendix C, Accessories** for ordering information.

3 - ORP readings usually stabilize much more rapidly in standards (e.g., Zobell solution) than in most environmental water. Be certain to consider this factor when determining ORP in field studies.

4 - Clean and store the pH/ORP sensor by following the instructions in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.4 pH

The sondes employ a field replaceable pH electrode for the determination of hydrogen ion concentration. The probe is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode that utilizes electrolyte that is gelled. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons (H^+ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the glass membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media. The pH system of the 600R utilizes individual glass sensing and reference electrodes, but the operating principle is the same.

Our testing of the 6561 pH, 6565 pH/ORP sensors and 600R pH system indicates that they should provide long life, good response time, and accurate readings in most environmental waters, including freshwater of low ionic strength. Thus, no special sensor is required (nor offered) for water of low conductivity.

CALIBRATION AND EFFECT OF TEMPERATURE

The software of the sondes calculates pH from the established linear relationship between pH and the millivolt output as defined by a variation of the Nernst equation:

$$E = E_o + \frac{2.3RT}{nF} * pH$$

where E = millivolts output

E_o = a constant associated with the reference electrode

T = temperature of measurement in degrees Kelvin

R, n, and F are invariant constants

Thus, in simplified $y = mx + b$ form, it is (mv output) = (slope)x(pH) + (intercept). In order to quantify this simple relationship, the instrument must be calibrated properly using commercially available buffers of known pH values. In this procedure, the millivolt values for two standard buffer solutions are experimentally established and used by the sonde software to calculate the slope and intercept of the plot of millivolts vs. pH. Once this calibration procedure has been carried out, the millivolt output of the probe in any media can readily be converted by the sonde software into a pH value, *as long as the calibration and the reading are carried out at the same temperature.* This last qualifier is almost never met in actual environmental measurements since temperatures can vary several degrees during a deployment simply from a diurnal cycle. Thus, a mechanism must be in place to compensate for temperature or, in other words, to accurately convert the slope and intercept of the plot of pH vs. millivolts established at T_c (temperature of calibration) into a slope and intercept at T_m (temperature of measurement). Fortunately, the Nernst equation provides a basis for this conversion.

According to the Nernst equation as shown above, the slope of the plot of pH vs. millivolts is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mv/pH unit at 298 K (25 C), then the slope of the plot at 313 K (40 C) must be (313/298) * 59 = 62 mv/pH unit. At 283 K (10 C), the slope is calculated to be 56 mv/pH unit ((283/298) * 59). Determination of the slope of pH vs. mv plots at

temperatures different from T_c is thus relatively simple. In order to establish the intercept of the new plot, the point where plots of pH vs. mv at different temperatures intersect (the isopotential point) must be known. Using standard pH determination protocol, the sonde software assigns the isopotential point as the mv reading at pH 7 and then calculates the intercept using this assumption. Once the slope and intercept to the plot of pH vs. mv are assigned at the new temperature, the calculation of pH under the new temperature conditions is straightforward, and is automatically carried out by the sonde software.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1- When filling the calibration cup prior to performing the calibration procedure, make certain that the level of calibrant buffers is high enough in the calibration/storage cup to cover the 6561 or 6565 pH probe and the temperature sensor of the 6560 probe.

2 - Rinse the sensors with deionized water between changes of calibration buffer solutions.

3 - During pH calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The pH readings after calibration are only as good as the calibration itself.

4 - Clean and store the probe according to the instructions found in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.5 DEPTH AND LEVEL

The sondes can be equipped with either depth or level sensors. In fact, both sensors measure depth, but by convention, level refers to vented measurements and depth refers to non-vented measurements. Both measurements use a differential strain gauge transducer to measure pressure with one side of the transducer exposed to the water.

For depth measurements, the other side of the transducer is exposed to a vacuum. The transducer measures the pressure of the water column plus the atmospheric pressure above the water. Depth must be calculated from the pressure exerted by the water column alone; therefore, when depth is calibrated in air, the software records the atmospheric pressure and subtracts it from all subsequent measurements. This method of compensating for atmospheric pressure introduces a small error. Because the software uses the atmospheric pressure at the time of calibration, changes in atmospheric pressure between calibrations appear as changes in depth. The error is equal to 0.045 feet for every 1mm Hg change in atmospheric pressure. In sampling applications, frequent calibrations eliminate the error. Considering typical changes in barometer during long-term monitoring, errors of ± 0.6 feet (0.2m) would be common. In applications where this error is significant, we recommend using a level sensor in place of the depth sensor.

NOTE: If the dry sonde is exposed to radio frequency fields approaching 3 volts/meter, temporary diminished performance of the depth readings may occur. Please see **Appendix H, EMC Performance** for more information.

As with depth measurements, level uses a differential transducer with one side exposed to the water. However, the other side of the transducer is vented to the atmosphere. In this case, the transducer measures only the pressure exerted by the water column. Atmospheric pressure is ignored and changes in atmospheric pressure do not affect the reading at all.

The voltage output of the transducer is directly proportional to the pressure. The sonde software converts this voltage to a depth reading in feet or meters via calibration parameters that are factory installed. Readings are automatically compensated for the temperature and for the density of the environmental medium that is estimated from the measured salinity.

For more additional information on measuring level, see **Appendix G, Using Vented Level.**

CALIBRATION AND EFFECT OF TEMPERATURE

The depth sensor must be zeroed prior to deployment to account for atmospheric pressure. Level sensors may also require a small adjustment prior to their first use. This procedure is carried out by following the calibration menu instructions with the sonde in air only (do not submerge). The sensors can also be set to any known depth via the calibration routine after they are immersed. The temperature dependence of the sensor is automatically taken into account by the sonde software based on input from factory calibration.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) Be certain that the sonde is not immersed in water during the calibration procedure unless you know the exact distance between the sensor and the water surface. Calibration (zeroing) in air is usually the recommended method.

(2) Remember that the depth sensors for the sonde are not vented. In practical terms, this means that changes in barometric pressure after the sensor is calibrated will appear as changes in depth. This effect is significant, particularly for the 0-30 ft option of the depth probe. For example, a change of 1 mm of Hg in barometric pressure will change the apparent depth by approximately 0.045 feet (0.012 m). As noted above, this error is eliminated for level sensors because they are vented to the atmosphere.

5.6 TEMPERATURE

The sondes utilize a thermistor of sintered metallic oxide that changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built in to the sonde software, and accurate temperature readings in degrees Celsius, Kelvin, or Fahrenheit are provided automatically. No calibration or maintenance of the temperature sensor is required.

5.7 DISSOLVED OXYGEN

The sondes employ the patented YSI Rapid Pulse system for the measurement of dissolved oxygen (DO). Use of this technology provides major advantages for the *monitoring* of DO without significantly compromising the accuracy of *sampling* applications. Standard electrochemical detectors of DO are highly flow-dependent and therefore require external stirring of the medium being evaluated. This stirring must be supplied either by an auxiliary stirrer (which can consume much of the battery reserve in a portable system) or by manually agitating the sonde when carrying out spot sampling applications (which can be inconvenient). These disadvantages are overcome by the Rapid Pulse dissolved oxygen technology that is associated with the sonde because it needs no stirring to yield accurate readings. In addition, because of the nature of the technology, some effects of fouling of the sensor are minimized.

The Rapid Pulse system utilizes a Clark-type sensor that is similar to other membrane-covered steady-state dissolved oxygen probes. The system still measures the current associated with the reduction of oxygen which diffuses through a Teflon membrane, and this current is still proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. The membrane isolates the electrodes necessary for this reduction from the external media, encloses the thin layer of electrolyte required for current flow, and prevents other non-gaseous, electrochemically active species from interfering with the measurement. However, as the user will note from examination of the 6562 probe, the sensor consists of three electrodes (a cathode, anode, and reference electrode) while steady state Clark probes usually have only two electrodes (a cathode and a combined anode-reference electrode). In addition, the geometry of the sensor is novel, consisting of a thin linear gold cathode placed between two silver rectangles which serve as anode and reference electrodes. These sensor changes were required to implement the new Rapid Pulse method for DO measurement as described in the following section.

NOTE: If the sonde cable is lying parallel with industrial wiring or radio frequency cabling, temporary diminished performance of the DO sensor may occur. Please see **Appendix H, EMC Performance** for more information.

METHOD OF OPERATION

Standard Clark dissolved oxygen sensors, which are marketed by YSI and other manufacturers, are continuously polarized at a voltage sufficiently negative to cause oxygen to be reduced to hydroxide ion at the cathode and silver metal to be oxidized to silver chloride at the anode. The oxygen diffuses through the Teflon membrane. The current associated with this process is proportional to the oxygen present in the solution outside the membrane. However, as this electrochemical reaction proceeds, oxygen is consumed (or depleted) in the medium, resulting in a decrease in measured current (and apparent oxygen content) if the external solution is not stirred rapidly. To minimize this oxygen depletion, the probe electrodes in the YSI Rapid Pulse system are rapidly and reproducibly polarized (on) and depolarized (off) during a measurement sequence. The Rapid Pulse system thus measures the charge or coulombs (current summed over a specific time period) associated with the reduction of oxygen during a carefully controlled time interval. The coulombs due to charging of the cathode (capacitance), but not to reduction of oxygen, are subtracted during integration after the cathode has been turned off. The net charge, like the steady state current in a standard system, is proportional to the oxygen partial pressure in

the medium. Because oxygen is only being reduced 1/100th of the total measurement time, even if the probe is pulsed in this manner continuously, oxygen consumption outside the membrane is kept to a minimum, and the stirring dependence of the system is greatly reduced.

One key to the practicality of Rapid Pulse oxygen system is the fact that the "on time" is very short. This allows the "off time" to also be relatively short and still maintain the off to on ratio of 100 which is necessary to obtain relatively flow independent measurements. The second important aspect of the Rapid Pulse technology is the integration (summing of the current) over the total pulse (on and off). Because the charging current of the electrodes is subtracted in this process, the net signal is due only to the reduction of oxygen. From a practical point of view, this means that when there is zero oxygen partial pressure outside the membrane, the Rapid Pulse signal will also be zero; this in turn allows the system to be calibrated with a single medium (air or water) of known oxygen pressure.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde Rapid Pulse system is calibrated using the same basic methods employed for steady state oxygen sensors. However, the software that controls the calibration protocol is somewhat different depending on whether the unit will be used in sampling or deployment studies. For sampling studies using either a 610 display unit or a laptop computer, the Rapid Pulse system is allowed to run continuously when the Run mode is activated if "Autosleep" is turned off. Under these software conditions, the user views the DO readings in real time and confirms the calibration manually after the readings have stabilized.

For studies in which the sonde is deployed and readings are saved less frequently (5 – 60 minutes) to sonde memory, a computer or data collection platform, an appropriate warm up time is selected for the system during Sensor setup. Usually 40 seconds is adequate for this parameter, but, in some cases, larger values may result in more accurate results. Most importantly for deployment studies, "Autosleep" should be activated. With these software entries in place, the user will input the calibration value (concentration or barometric pressure), and the unit will automatically calibrate after the selected warm up time.

The description below is designed around deployment applications with "Autosleep" activated.

The two general calibration methods possible with the sonde are "DO mg/L" and "DO %". The former method is designed for calibration in solution while the latter utilizes water-saturated air as the medium. Since the percent saturation (DO %) and concentration (DO mg/L) values are related, calibration by either method results in correct outputs in both units.

If the mg/L method is selected from the sonde Calibrate menu, the oxygen concentration of an aqueous solution may be determined by several methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated, or
- Measurement with another instrument.

If this calibration method is employed, place the sonde into this known-value solution and wait 5-10 minutes for equilibration to occur. Then input the value (in mg/L) into the sonde software and

begin the calibration protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.

If the Percent Saturation method is selected, the sonde is simply placed in a calibration cup that contains a small quantity of water or a damp sponge. ***The probe sensor should not be in the water for this calibration procedure.*** The sonde should be left under these conditions for 10-15 minutes to allow temperature and humidity equilibration to occur. Then input the true barometric pressure into the sonde software and begin the calibration protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.

NOTE: Remember that control of the calibration will be manual rather than automatic if the unit is set up properly for spot sampling applications ("Autosleep" deactivated).

The DO readings of steady state oxygen systems are greatly affected by temperature (approximately 3% per degree Celsius) due to the effect of temperature on the diffusion of oxygen through the membrane. The Rapid Pulse system exhibits a greatly reduced effect of temperature (approximately 1% per degree Celsius), but this factor still must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. The sonde software automatically carries out this compensation.

In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air saturated water (100 percent saturated) at 20 °C contains 9.09 mg/L, but only 7.65 mg/L at 30 °C. The sonde software compensates for both of these temperature-related factors after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to a solubility in mg/L is carried out using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See **Appendix D, Solubility and Pressure/Altitude Tables** for dissolved oxygen solubility tables as a function of salinity and temperature.

FLOW DEPENDENCE

As noted above, oxygen readings acquired using the Rapid Pulse technology are much less affected by sample flow than steady state probes. However, there is a finite stirring dependence exhibited by the Rapid Pulse system if measurements are taken when the probe is being pulsed continuously. Our tests indicate that, under these sampling conditions, observed dissolved oxygen readings can be 2-3 percent lower than the true readings in very still water. Minimal movement of the water (which occurs during most environmental measurements) removes this effect.

This small flow dependence of the sensor is greatly reduced in longer term monitoring deployments where the sampling interval is longer, e.g. 15 minutes. Under these conditions, the sensor is pulsed for only approximately 40 seconds every 15 minutes, and normal diffusion of oxygen in the medium re-establishes the oxygen which has been depleted in the previous warm-up/read sequence.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

(2) Insure that the calibration cup being used is vented or pressure released.

(3) For short term storage (2 weeks or less), keep the probe moist when not in use, either by immersing in water or by placing a damp sponge in the calibration vessel. For longer-term storage, remove the probe from the sonde and store it in water with a membrane and electrolyte in place. If the membrane appears to be damaged or has dried out, be sure to replace it prior to calibration and deployment.

(4) For maximum accuracy, calibrate the Rapid Pulse system at a temperature as close as possible to that of the sample being measured. One method of accomplishing this involves immersing the calibration chamber (which contains either a small amount of water or a wet sponge) into the body of water that is later to be measured. ***Do not allow the sample water to seep into the calibration chamber.*** Monitor the readings. After thermal equilibrium has been established, proceed with the calibration. Note that under normal circumstances this procedure is not required.

(5) Before you install a new membrane, make sure that the O-ring groove and the probe tip are clean and smooth. If the KCl electrolyte solution leaks from the probe surface during monitoring studies, the readings are likely to be less accurate in a shorter period of time.

5.8 NITRATE

The sonde nitrate probe consists of a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with nitrate ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of nitrate in the sample and the internal filling solution. This potential is read relative to the Ag/AgCl reference electrode of the sonde pH probe. As for all ISEs, the linear relationship between the logarithm of the nitrate activity (or concentration in dilute solution) and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in nitrate activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 53-58 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known nitrate concentration (typically 1 mg/L and 100 mg/L NO_3-N). The slope of the plot of log (nitrate) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (nitrate) vs. voltage intersects the calibration plot is called the isopotential point. That is, the nitrate concentration at which changes in temperature cause no change in voltage.

Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and you should recalibrate the probe periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. For example, chloride ion binds in this way to the nitrate membrane and produces positive nitrate readings even when no nitrate is present in the medium. Fortunately, most fresh water does not usually contain significant quantities of ions that produce a large interference on the nitrate reading, such as azide, perchlorate, and nitrite. It usually does contain some chloride and carbonate ions, but the interference from these ions is relatively small. For example, if the all of the ionic content of water with a conductivity of 1.2 mS/cm (Sal = 0.6) were due to the presence of sodium chloride, the nitrate reading would be erroneously high by about 1.6 mg/L. If the conductivity in this sample were all due to sodium bicarbonate, the sensor output would indicate the presence of only 0.2 mg/L of non-existent nitrate from the interference.

Even though the interference from chloride is relatively small and thus tolerable at low salinity, the large quantity of this species in salt or brackish water creates interference so great as to make the sensor unsuitable for these media.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all-interfering species produce an artificially high nitrate reading. Thus, if the sonde indicates the presence of only small quantities of nitrate, it is unlikely that the reading is erroneously low because of interference. Unusually high nitrate readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ion selective electrodes have the greatest tendency to exhibit calibration drift over time of all the sensors available on the sonde. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if a nitrate sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another nitrate sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The nitrate sensor should be calibrated using solutions of known nitrate-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol

minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Nitrogen standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the nitrate sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during nitrate calibration after exposure to buffers.

CAUTION: *The nitrate membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor.*

5.9 AMMONIUM AND AMMONIA

The sonde ammonium probe employs a silver/silver chloride (Ag/AgCl) wire electrode in a custom filling solution. Nonactin membrane separates the internal solution from the sample medium and this membrane selectively interacts with ammonium ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of ammonium in the sample and the internal filling solution. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the ammonium activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in ammonium activity at 25°C. In practice, however, empirical calibration of the electrode is necessary to establish an accurate slope of the response. Typical empirical slopes are 53-58 mV

per decade for YSI sensors. This slope value is determined by calibration with two solutions of known ammonium concentration (typically 1 mg/L and 100 mg/L NH_4^+-N).

The slope of the plot of log (ammonium) vs. voltage is also a function of temperature. The slope changes by a factor that is the ratio of the absolute temperature of calibration to absolute temperature of measurement. The point where this new plot of log (ammonium) vs. voltage intersects the calibration plot is called the isopotential point. That is, the ammonium concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, use a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to interference from ions, which are similar in nature to the analyte. For example, sodium and potassium ions bind to the ammonium membrane and produce positive readings even when no ammonium is present. Fortunately, fresh water does not usually contain enough interfering ions to produce large errors. For example, a common conductivity for freshwater is about 1.2 mS/cm (Sal = 0.6). Even if the ionic content were due to sodium chloride, the ammonium reading would be erroneously high, about 0.4 mg/L.

However, brackish or seawater has enough sodium and potassium to cause interference so great as to make the sensor unsuitable for these media.

The sensor used in the sonde detects only ammonium ions (NH_4^+), the predominant form of total ammonium nitrogen in most environmental samples. However, using the concurrently determined values of pH, temperature, and conductivity, the sonde software can also provide the user with the concentration of free ammonia (NH_3) in the sample under investigation.

Ammonium ions and free ammonia are in equilibrium in any solution according to the following equation:

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The value of the equilibrium constant associated with this reaction, $K = [NH_3][H^+]/[NH_4^+]$, and its variation with temperature and salinity, is well known. This information allows the free ammonia concentration $[NH_3]$ to be automatically calculated by the sonde software and displayed if this parameter is activated.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost

certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Nitrogen standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the ammonium sensor will take longer to stabilize after exposure to buffers in a sonde pH calibration. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during ammonium calibration after exposure to buffers.

CAUTION: *The ammonium membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor.*

5.10 CHLORIDE

The sonde chloride probe employs a solid state membrane attached to a conductive wire. When the probe is immersed in water, a potential is established across the membrane that depends on the amount of chloride in the medium. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the chloride activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in chloride activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 45-55 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known chloride concentration (typically 10 mg/L and 1000 mg/L Cl^-).

The slope of the plot of log (chloride) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (chloride) vs. voltage intersects the calibration plot is called the isopotential point. That is, the chloride concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high chloride reading. Thus, if the sonde indicates the presence of only small quantities of chloride, it is unlikely that the reading is erroneously low because of interference. Unusually high chloride readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if a chloride sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another chloride sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 15 % of the reading or 5 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The chloride sensor should be calibrated using solutions of known chloride content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. Be sure to check for this drift by placing the sonde in a standard at the end of each deployment.

(4) Remember that the chloride sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 1000 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during chloride calibration after exposure to buffers.

5.11 TURBIDITY

Turbidity is the measurement of the content of suspended solids (cloudiness) in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the particles which are present. For turbidity systems capable of field deployment, the usual light source is a light emitting diode (LED) which produces radiation in the near infrared region of the spectrum. The detector is usually a photodiode of high sensitivity. The angle between the emitted and detected light varies (usually between 90 and 180 degrees) depending on the probe used. The International Standards Organization (ISO) recommends the use of a light source with a wavelength between 830 and 890 nm and an angle of 90 degrees between the emitted and detected radiation (ISO 7027).

The turbidity system available as an option for use with the sonde consists of a probe which conforms to the above ISO recommendations. The output of the sonde turbidity sensor is processed via the sonde software to provide readings in nephelometric turbidity units (NTUs).

Two probes are available for use with the sonde. The YSI 6026 is equipped with a mechanical wiper to periodically clean the sensor either by manual or automatic activation. This probe is designed for long term monitoring, but also works well for spot sampling applications.

The YSI 6036 has no mechanical wiper and thus dimensionally has a shorter profile. The 6036 works well for spot sampling, but is not recommended for long term monitoring applications. Its advantages include lower initial cost and the fact that the user can employ a shorter probe guard and storage cup (available as optional accessories).

NOTE: If the dry sonde is subjected to radio frequency fields of approaching 3 volts/meter, temporary diminished performance of the turbidity sensor may occur. Please see **Appendix H, EMC Performance** for more information.

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can generally be removed in short term sampling application by simply agitating the sonde manually. However, for studies longer than a few hours where the user is not present at the site, the quality of the turbidity data obtained with a turbidity sensor that has no capability of mechanical cleaning (e.g., the 6036) is likely to be poor. However, as noted above, the 6026 probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically during long term unattended sampling studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally one movement is sufficient for most environmental application, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde software offers the option of 1 point, 2 point, or 3 point calibrations procedures. For most applications, a 2-point calibration at 0 and 100 NTU is sufficient. However, because the calibration curve of the system exhibits a small nonlinearity below 10 NTU, a 3 point calibration at values of 0, 10 and 100 NTU can be carried out to provide maximum accuracy over the normally encountered environmental turbidity range (0-1000 NTU). Although a 1000 NTU calibration would be ideal, the sensor is extremely linear between 100 and 1000 NTU and, because of the cost of the reagents, the benefit of use of the higher standard is not significant. If the range of turbidity in the environmental sample is well known, standards of other turbidity values can be utilized (in either 3 point or 2 point routines). However, one of the standards must be 0 NTU. Note that, for all calibration procedures, it is very important that the standards used in the calibration should be based on either formazin or AMCO-AEPA styrene divinylbenzene beads as described in *Standard Methods for the Examination of Water and Wastewater.* Use of standards prepared from other materials may result in spurious and inaccurate readings. Note that YSI offers 100 NTU turbidity calibrant as a standard product (6073) and that this standard can be quantitatively diluted with turbidity-free water to provide a 10 NTU calibrant suspension.

The overall sensitivity (slope) of the optical sensor is generally less susceptible to drift than its offset (probe output at 0 NTU). The 1 point calibration is designed to reset this offset without affecting the slope and thus provide more accurate performance in water of low turbidity.

Usually, the 1 point calibration should be done at 0 NTU, but the sonde software will accept any value in the turbidity range of the instrument (0-1000 NTU)

While the effect of temperature on the turbidity sensor is small (approximately 0.3 % per °C), this factor is automatically taken into account by the sonde software providing temperature compensated readings. However, all sensors have slightly different temperature factors and thus to obtain the maximum accuracy in your readings, we recommend calibration at a temperature as close as possible to that of the environmental sample.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) For best results, use only freshly prepared turbidity standards. Under some conditions, degradation of standards can occur on standing particularly at lower (less than 20 NTU) values.

(2) If unusually high or jumpy readings are observed during the calibration protocol, it is likely that there are bubbles on the optics. Manually moving the sonde (up/down and back/forth) usually removes these bubbles. If the probe is a 6026, the surface can be cleaned by manually activating the wiper prior to each calibration input.

(3) The output of turbidity sensors is susceptible not only to the overall cloudiness of the environmental medium, but also to the particle size of the suspended solids which pass across the optics on the probe face. Thus, although the turbidity of an environmental sample may appear to the eye to be relatively stable, the displayed turbidity can vary significantly depending on the nature of the particles in the optical path at the instant of measurement. For example, if individual readings are taken every 4 seconds in a discrete sample study of environmental water, variations of 0.5-1.0 NTU are common between readings. In long term, unattended studies this effect can be even more exaggerated with spikes of up to 10 NTU sometimes observed. This apparent jumpiness is not observed for freshly prepared turbidity standards, since the particle size in these suspensions is homogeneous.

The sonde turbidity system allows the user to either observe these real turbidity events (while obtaining somewhat jumpy readings) or to apply a mathematical filter to the raw data so that the NTU output may be more reflective of the overall cloudiness of the environmental sample. From the 8-Advanced menu of the sonde software, the user can activate the data filter and "fine tune" its performance. For typical sampling and monitoring applications, YSI recommends that the 4-Data Filter settings be selected as follows: Enabled -- On; Wait for Filter -- Off; Time Constant = 12; Threshold = 0.010.

Remember that this data filter processing is applied to all sensors (not just turbidity) and may have a slight effect on the overall sensor package response time, but this is usually a minor inconvenience. The advantage of the data processing is a much more stable sequence of turbidity readings output to the screen.

For most unattended sampling applications, selection of the above filter settings should also be appropriate. However, an additional capability is also available which enhances the elimination of spurious single point spikes from the logged data and thus allows for a better presentation of the average turbidity during the deployment. This **"Turb Spike Filter"** is activated/deactivated in the **3-Sensor** submenu of the **Advanced** menu. Its capability is further described in **Section 2.9.8, Advanced**. YSI recommends the use of this feature for all unattended studies. The user

should determine from experience whether its activation is also appropriate for spot sampling studies at particular sites.

See **Appendix E, Turbidity Measurements** for additional practical information on the measurement of turbidity with the sonde.

5.12 FLOW

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. YSI sondes 600XLM, 6920, and 6600 that are equipped with shallow vented level can calculate flow based on several different methods.

Flow is only available in the ***Sensors*** *menu on those sondes that have shallow vented level.* The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use our sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly in this manual, it is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

WEIR AND FLUME

Many devices have been designed to place in an open channel to improve the determination of flow. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs, each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the channel, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes, each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are commonly 3 types of weirs and 7 types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

MANNING EQUATION

YSI 600XLM, 6920 and 6600 sondes can be used with the Manning equation. In an open channel without any restriction built explicitly for measuring flow, the Manning Equation can sometimes

be used to calculate flow. Under the right conditions the channel itself is the primary measurement device and flow can be calculated from the level of water in the channel. Careful use of the Manning equation under ideal conditions can be accurate to 10%. Less careful use under worse conditions can give errors of 50% or more. The formula is

$$Q = \frac{K \bullet A \bullet R^{\frac{2}{3}} \bullet S^{\frac{1}{2}}}{n}$$

Where: Q = Flow rate
A = Cross sectional area of flow
R = Hydraulic radius
S = slope
n = Manning coefficient of roughness
K = constant dependent on units

The Manning roughness coefficient n is an index of the frictional resistance to flow on the surface of the channel. Values of n are published for different materials. However, in the field, determination of n is perhaps the largest source of error. For example, n for a concrete channel can vary from 0.011 to 0.020 depending upon how the surface of the concrete was finished during construction. Occasional debris or vegetation in the channel also affects the value of n, and it most applications the value changes depending upon the depth of water in the channel.

Other uncertainties can also make the measurement inaccurate. Best results are obtained at the end of a straight channel 1000 feet (300 meters) long. In a channel that long, the slope and the value of n can vary considerably.

Even with all these uncertainties, the Manning equation can yield useful results as long as the user is aware of its limitations.

EQUATION

The YSI 600XLM, 6920 and 6600 sondes that are equipped with shallow vented level can also calculate flow based on an equation. The equation must be of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

This allows the use of primary measuring devices other than the standard ones already programmed. Users may enter values for K_1, P_1, K_2, and P_2 and the sonde will calculate flow. Note: if you do not need the second term in the equation, simply enter 0 for K_2.

TABLE

YSI 600XLM, 6920, and 6600 sondes that are equipped with shallow vented level can also calculate flow based on a table. Users can enter up to 50 pairs of (level, flow) data. The sonde will then calculate flow from the resulting table, linearly interpolating between points when necessary. This feature can be used with non-standard primary measuring devices for which there is a table rather than an equation. This data is often available for rivers and streams so that flow can be calculated from the level in a river at the proper location.

See Appendix F, Flow for additional practical information on the calculation of flow with a sonde.

SECTION 6 TROUBLESHOOTING

This section contains troubleshooting tables that will be helpful to identify the causes of the most common difficulties that may occur while operating the YSI 6-Series Sondes. The **Symptom** column describes the type of difficulty that you might experience. The **Possible cause** column describes the conditions that might cause the stated symptom. The **Action** column provides simple steps that can be followed to correct for the "possible cause" and cure the "symptom" being experienced. The column entitled **Ref** is the number of the reference section and subsection in the manual where you may find additional information.

Troubleshooting problems have been categorized into four general areas.

- Calibration Error Messages
- Sonde Communication
- Sensor Performance

If you need assistance that this Troubleshooting section can not provide, please contact YSI or your authorized dealer. See **Appendix C, Accessories and Calibration Standards**, for specific contact information.

6.1 CALIBRATION ERRORS

There are only three Calibration Error messages that are possible and are listed below, instead of in the troubleshooting table. Only two of the error messages are related to sensor performance.

High DO Charge: This message indicates a malfunction in the DO sensor that is generally due to the roughness of the electrodes on the surface of the probe face. The charge associated with the DO sensor must be in the range 25 to 100 or the error message will appear when calibration is attempted. If this error message is encountered, remove the DO probe from the sonde and resurface it according to the instructions in Section 2.10, **Care, Maintenance and Storage**. After resurfacing the probe, activate the DO charge parameter in the Report setup section of the sonde software and confirm that the value is within the acceptable range. After resurfacing, allow the sensor to pulse in the Run mode for at least 5 minutes, during which time the DO charge may be expected to drop in value if the sensor is still functional. If resurfacing according to the instructions in Section 2.10 does not result in a lowering of the charge, contact YSI Customer Service for additional help.

Out of Range: This message indicates that the output of the sensor being calibrated does not conform to the normal range for this parameter. This problem could be due to either a malfunctioning sensor or to a calibration solution that is out of specification. If this error message is encountered, first insure that your standards for pH, ORP, ammonium, nitrate, chloride, conductivity, and turbidity have not been contaminated and that your DO sensor is in air (DO % Cal) or in a solution of known dissolved oxygen concentration (DO mg/L). Also be certain that you have entered the correct value for the calibration solution. If the calibration error message continues to occur, contact YSI Customer Service to determine whether the sensor in question needs to be factory-serviced or replaced.

Illegal Entry: This message simply indicates that your keyboard input does not conform to the accepted format for this parameter. For example, you may have entered the "letter O" instead of "zero" for a calibration value. Return to the desired parameter in the Calibrate menu and repeat the calibration entry, being certain to enter only numbers.

The following troubleshooting tables can help you if you encounter problems with software, communication protocol, or sensor malfunctions other than calibration errors.

6.2 SONDE COMMUNICATION PROBLEMS

SYMPTOM	POSSIBLE CAUSE	ACTION	REF
Cannot communicate with sonde	Sonde not powered	Check 12 vdc source	7.2
	Cable connection is loose	Check both ends of cable; secure connectors	
	Damaged connectors	Check pins at both ends, insure they are straight, dry and clean.	
	Com port not selected	Change to other com port, other peripheral on the same port (Internal mouse). Try other PC, 610 display/logger or dumb terminal	2.4.3
Scrambled data	Unmatched baud rate between host and sonde	Match the baud rate	2.4.3
	Host is too slow	Use faster computer	
	Interface cable failure	Check cable for damage. If necessary, return for service	7
	Internal failure	Return sonde for service	7

6.3 SENSOR PERFORMANCE PROBLEMS

SYMPTOMS	POSSIBLE CAUSE	ACTION	REF
Dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO cal procedures	2.6.1
	Membrane not properly installed or may be punctured	Follow 6562 setup procedure	2.3.1
	DO probe electrodes require cleaning	Follow DO cleaning procedure. Use 6035 maint. kit	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Algae or other contaminant clinging to DO probe	Rinse DO probe with clean water	2.10.2
	Barometric pressure entry is incorrect	Repeat DO cal procedure	2.6.1
	Cal at extreme temperature	Recal at (or near) sample temperature	2.6.1
	DO Charge too high (>100) 1. Anodes polarized (tarnished) 2. Probe left on continuously	Enable DO charge parameter in the Sonde report menu. Run sonde, if charge is over 100, recondition probe with 6035 Maintenance Kit. Follow DO cleaning procedure.	2.7 2.7 2.10.2
	DO Charge too low (<25) Insufficient electrolyte.	Replace electrolyte and membrane.	2.3.1
	DO probe has been damaged	Replace 6562 probe	8/C
	Internal failure	Return sonde for service	8
pH, ORP, chloride, ammonium, or nitrate readings are unstable or inaccurate. Error messages appear during calibration.	Probe requires cleaning,	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	2.6.1 3.7.4
	pH probe reference junction has dried out from improper storage.	Soak probe in tap water or buffer until readings become stable	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace probe.	8/C
	Calibration solutions out of spec or contaminated with other solution	Use new calibration solutions	C
	ORP fails Zobell check	Take into account temperature dependence of Zobell solution readings	5.3

	Internal failure	Return sonde for service	8
Depth unstable or inaccurate	Depth sensor has not been zeroed	Follow depth zero procedure	2.6.1
	Depth sensor access hole is obstructed	Follow depth cleaning procedure	2.10.2
	Depth sensor has been damaged	Return sonde for service	8
	Internal failure	Return sonde for service	8
Conductivity unstable or inaccurate. Error messages appear during calibration.	Conductivity improperly calibrated.	Follow cal procedure	2.6.1
	Conductivity probe requires cleaning	Follow cleaning procedure	2.10.2
	Conductivity probe damaged	Replace probe	8/C
	Calibration solution out of spec or contaminated	Use new calibration solution	C
	Internal failure	Return sonde for service	8
	Calibration solution or sample does not cover entire sensor.	Immerse sensor fully.	2.6.1
Installed probe has no reading	The sensor has been disabled	Enable sensor	2.9.5
	Water in probe connector	Dry connector; reinstall probe	2.10.1
	Probe has been damaged	Replace the 6560 probe	8/C
	Report output improperly set up	Set up report output	2.9.4
	Internal failure	Return sonde for service.	8
Temperature, unstable or inaccurate	Water in connector	Dry connector; reinstall probe	2.10.2
	Probe has been damaged	Replace the 6560 probe	8/C
Tubidity probe unstable or inaccurate. Error messages appear during calibration	Probe requires cleaning.	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	8.4
	Probe has been damaged	Replace probe	8
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Calibration solutions out of spec	Use new calibration solutions	C
	Wiper is not turning or is not synchronized.	Activate wiper. Assure rotation. Make sure set screw is tight.	2.10.2
	Wiper is fouled or damaged.	Clean or replace wiper.	2.10.2
	Internal failure.	Return probe for service.	8

SECTION 8
WARRANTY AND SERVICE INFORMATION

The sondes are warranted for two years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. All cables are warranted for one year. The depth, dissolved oxygen, temperature/conductivity, pH, chloride, turbidity and pH/ORP combination probes are warranted for one year. Ammonium and Nitrate probes are warranted for six months. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

LIMITATION OF WARRANTY

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

AUTHORIZED U.S. SERVICE CENTERS

North Region
YSI Incorporated • Repair Center • 1725 Brannum Lane • Yellow Springs, Ohio • 45387 • Phone: (937) 767-7241• (800) 897-4151• Fax: (937) 767-9353 • E-Mail: ysi@info.com

South Region
C.C. Lynch & Associates • 212 E. 2nd Street • Suite 203 • Pass Christian, Mississippi • 39571 • Phone: (800) 333-2252 • (228) 452-4612 • Fax: (228) 452-2563

East Region
YSI Massachusetts, Inc. • 13 Atlantis Drive • Marion, MA • 02738 •Phone: (508)748-0366 • Fax (508)748-2543

West Region
EnviroServices & Repair • 1110 Burnett Avenue, Suite D • Concord, CA • 94520 • Phone: (800)550-5875 • Fax: (510)674-8655

Central Region
HydroTech Services, LLC • 4910 Iris Street Wheat Ridge, CO• 80033 • Phone: (877)467-0800 • Fax: (303) 467 0742 • E-Mail: 100735.423@compuserve.com

INTERNATIONAL SERVICE CENTERS

YSI Incorporated

YSI Incorporated • Repair Center • 1725 Brannum Lane • Yellow Springs, Ohio • 45387 • Phone: (937) 767-7241• E-Mail: info@ysi.com

Hydrodata Services Ltd.

Alexander Road • London, Colney • AL2 1JB • Phone: 011-44-2737-827-837 • Fax: 011-4401727-827-838

YSI Japan Ltd.

Sakura – Building 6-5-6-13 • Shinjuku, Shinjuku-ku, Tokyo • 160 • Phone: (81-3) 5360-3561 • Fax: (81-3) 5360-3565

CLEANING INSTRUCTIONS

NOTE: Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.
When service is required, either at the user's facility or at YSI, the following steps must be taken to insure the safety of our service personnel.

1. In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1-gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
2. The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
3. If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
4. Any product being returned to the YSI Repair Center, should be packed securely to prevent damage.
5. Cleaning must be completed and certified on any product before returning it to YSI.

PACKING INSTRUCTIONS

1. Clean and decontaminate items to insure the safety of the handler.
2. Complete and include the Cleaning Certificate.
3. Place the product in a plastic bag to keep out dirt and packing material.
4. Use a large carton, preferably the original, and surround the product completely with packing material.
5. Insure for the replacement value of the product.

Cleaning Certificate

Organization _____

Department _____

Address _____

City _____ State __ Zip _____

Country _____ Phone _____

Model No. of Device ____ Lot Number _____

Contaminant (if known) _____

Cleaning Agent(s) used _____

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure) _

Yes ____ No

Cleaning Certified By _____

Name Date

APPENDIX A HEALTH AND SAFETY

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169

INGREDIENTS:

- ❑ Iodine
- ❑ Potassium Chloride
- ❑ Water

WARNING: INHALATION MAY BE FATAL.

CAUTION: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.

Harmful if ingested or inhaled. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hyper-sensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

FIRST AID:

INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.

SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.

EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.

INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:
- ❑ Potassium Hydrogen Phthalate
- ❑ Formaldehyde
- ❑ Water

pH 7 INGREDIENTS:
- ❑ Sodium Phosphate, Dibasic
- ❑ Potassium Phosphate, Monobasic
- ❑ Water

pH 10 INGREDIENTS:
- ❑ Potassium Borate, Tetra
- ❑ Potassium Carbonate
- ❑ Potassium Hydroxide
- ❑ Sodium (di) Ethylenediamine Tetraacetate
- ❑ Water

CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:
- ❑ Potassium Chloride
- ❑ Potassium Ferrocyanide Trihydrate
- ❑ Potassium Ferricyanide

CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Ammonium Standard Solutions: 3841, 3842, and 3843

INGREDIENTS:

- ❑ Ammonium Chloride
- ❑ Lithium Acetate Dihydrate
- ❑ Sodium Azide (trace)
- ❑ Hydrochloric acid

CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities of lithium salts can affect the central nervous system producing symptoms ranging from dizziness to collapse. It may also cause kidney damage, nausea, and anorexia. Note that the ingestion of harmful quantitites form the solutions is considered unlikely given the low concentration of lithium and the volumes likely to be handled.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - Immediately rinse out mouth with large quantities of water. If reagent was swallowed, give 2 glasses of water and seek medical attention immediately.

YSI Nitrate Standard Solutions: 3885, 3886, and 3887

INGREDIENTS

- ❑ Potassium Nitrate
- ❑ Magnesium Sulfate
- ❑ Gentamycin Sulfate (Trace)

CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION.

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - Immediately rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention immediately.

YSI Turbidity Standards: 3845, 3846, 3487, 6072, and 6073

INGREDIENTS

- Styrene divinylbenzene copolymer spheres

The material is not volatile and has no known ill effects on skin, eyes, or on ingestion. Therefore, no special precautions are required when using the standards. General precautions should be adopted as required with all materials to minimize unnecessary contact. Note, however, that the chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

SKIN CONTACT - Remove contaminated clothing. Wash affected area with soap or mild detergent and water.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. If irritation occurs, seek medical attention immediately.

INGESTION - Rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention as a precaution.

YSI Replacement Desiccant 065802

INGREDIENTS

- Calcium Sulfate and Calcium Chloride

CAUTION - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.

FIRST AID:

SKIN CONTACT - Flush with water.

EYE CONTACT - . Flush with water. If irritation continues, obtain medical attention.

INGESTION - If patient is conscious, induce vomiting. Obtain medical attention.

APPENDIX B REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- ❑ Reorient the receiving antenna
- ❑ Relocate the computer with respect to the receiver
- ❑ Move the computer away from the receiver
- ❑ Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

APPENDIX C
ACCESSORIES AND CALIBRATION STANDARDS

Standard Equipment with YSI Sondes

- ❑ 600R, 600XL, 600XLM, 6820, 6600 or 6920 Sonde with Calibration Cup
- ❑ EcoWatch for Windows Software
- ❑ Operations Manual
- ❑ Guard for Probe Compartment
- ❑ 6570 Maintenance Kit
- ❑ 6560 Conductivity/Temperature Probe (not supplied with the 600R)

Probes for the Sondes

(see Appendix K, Sonde Specifications for the probes that your sonde supports)

- ❑ 6560 Conductivity/Temperature Probe
- ❑ 6561 pH Probe
- ❑ 6562 Rapid Pulse DO Probe
- ❑ 6565 Combination pH/ORP Probe
- ❑ 6026 Turbidity Probe, wiped
- ❑ 6036 Turbidity Probe, unwiped
- ❑ 6882 Chloride Probe
- ❑ 6883 Ammonium Probe
- ❑ 6884 Nitrate Probe

Optional Accessories for the Sondes

- ❑ 062781 PC6000 Software (Available at no cost)
- ❑ 6027 Turbidity Wiper Kit
- ❑ 6035 Probe Reconditioning Kit for 6562 Dissolved Oxygen Probe
- ❑ 062655 Carrying case
- ❑ 6038 12 VDC Power Supply with 110 VAC input
- ❑ 6037 12 VDC Power Supply with 220 VAC input
- ❑ 6100 External Power Connector, attaches to 6095B Field Cable
- ❑ 6570 Maintenance Kit
- ❑ 068230 Short Probe Compartment Guard, for 6036 turbidity probe (non-wiping) for 6820 & 6920
- ❑ 5775 Membrane Kit
- ❑ 6108 Desiccant Cartridge Kit
- ❑ 6109 Desiccant Canister Kit
- ❑ 065802 Replacement Desiccant
- ❑ 6120 6-Series Operations Manual, Spanish
- ❑ 6121 6-Series Operations Manual, German
- ❑ 6089 Non-Vented CE Cable Kit
- ❑ 6194 Vented CE Cable Kit

Cables for the Sondes

- ❑ 6093 Field Cable, 100 ft (30 m)
- ❑ 6092 Field Cable, 50 ft (15 m)
- ❑ 6091 Field Cable, 25 ft (7.5 m)
- ❑ 6090 Field Cable, 8 ft (2.4 m)
- ❑ 6191 Field Cable, Vented, 25 ft (7.5 m)
- ❑ 6192 Field Cable, Vented, 50 ft (15 m)
- ❑ 6067B Low Cost Calibration Cable, Dry use only; 10 ft (3m)
- ❑ 6077B CE Calibration Cable, 10 ft. (3m)
- ❑ SP6093-L Special field cables available in 25 ft (7.6 m) increments; Maximum 1000 ft (305 m)
- ❑ 6098B Field Cable to 610-D/610-DM adapter
- ❑ 6096 Field Cable to Flying Lead (wire) adapter, 15 ft (5m)
- ❑ 6095B Field Cable to Female DB-9 (PC Serial with Power Connector)
- ❑ 6099: 610 to Female DB-9 (PC Serial)
- ❑ 6100 External Power Connector, attaches to 6095B Field Cable (6ft)
- ❑ 6102: 610 to Portable Power Pack Adapter
- ❑ 6103 MS-8 Dust Cover (caps connector when not in use)

Conductivity Reagents

- ❑ 3161 Calibrator Solution, 1,000 uS/cm (quart)
- ❑ 3163 Calibrator Solution, 10,000 uS/cm (quart)
- ❑ 3165 Calibrator Solution, 100,000 uS/cm (quart)
- ❑ 3167 Calibrator Solution, 1,000 uS/cm (box of 8 pints)
- ❑ 3168 Calibrator Solution, 10,000 uS/cm (box of 8 pints)
- ❑ 3169 Calibrator Solution, 100,000 uS/cm (box of 8 pints)

pH Reagents

- ❑ 3821 pH 4 Buffer (box of 6 pints)
- ❑ 3822 pH 7 Buffer (box of 6 pints)
- ❑ 3823 pH 10 Buffer (box of 6 pints)

ORP Reagents

- ❑ 3682 Zobell Solution (125 ml)

Ammonium Reagents

- ❑ 3841 1 mg/L ammonium-nitrogen standard solution
- ❑ 3842 10 mg/L ammonium-nitrogen standard solution
- ❑ 3843 100 mg/L ammonium-nitrogen standard solution

Nitrate Reagents

- ❑ 3885 1 mg/L nitrate-nitrogen standard solution
- ❑ 3886 10 mg/L nitrate-nitrogen standard solution
- ❑ 3887 100 mg/L nitrate-nitrogen standard solution

Turbidity Reagents

- ❑ 3845 0 NTU standard
- ❑ 6073 100 NTU standard suspension
- ❑ 3846 200 NTU standard suspension
- ❑ 3847 800 NTU standard suspension

Displays, Loggers, and Accessories

- ❑ 610-D Handheld Field Display with Accessories
- ❑ 610-DM: 610-D with 128K of memory
- ❑ 610-DM: 610-D with 512K of memory
- ❑ 614 Ultraclamp, C-clamp Mount for 610
- ❑ 615 Leather Carrying Case for 610
- ❑ 616 Cigarette lighter adapter (powers and charges 610s)
- ❑ 617 Replacement Battery Pack for 610
- ❑ 6099: 610 to Female DB-9 (PC serial)
- ❑ 6097 Blank port plug for 610
- ❑ 6104 Replacement Charger Jack for 610
- ❑ 6042 Battery Charger for 610
- ❑ 6101 Portable Power Pack for 610 or sondes

Logger/Telemetry

- ❑ 1240: SDI-12 Logger for interfacing as many as 10 6-Series devices. Can also serve as RF telemetry platform (RF radio, battery, interface cable, junction box not included)
- ❑ 1240B1: 7 amp hour, lead acid 12 VDC rechargeable battery
- ❑ 1240B2: 20 amp hour, alkaline 6 VDC battery (2 required)
- ❑ 1240AC: 110 VAC charger/transformer assembly, charges 1240B1
- ❑ 1240SO: 1240 Solar Panel Assembly, includes panel, mount, cable
- ❑ 1240SE: 1240 Serial data interface cable, connects 1240 to PC
- ❑ 1240JU: 1240/6 series Junction Box, provides input of multiple SDI-12 devices (standard configuration is for 5 devices)

Note: For RF radio frequency telemetry system applications, contact Endeco/YSI Customer Support @ 1-800-363-3269 (USA) or 508-748-0366 or fax 508-748-2543.

Software

- ❑ PC6000: MS-DOS compatible communication, upload, plotting
- ❑ 610SOFT: Software upgrade for Model 610 D/DM
- ❑ 6920SOFT: Software upgrade for Model 6920
- ❑ EW-DOS EcoWatch for MS-DOS Applications
- ❑ EW-WIN EcoWatch for Windows (Use EW-WIN for 6-Series Applications)

APPENDIX D SOLUBILITY AND PRESSURE/ALTITUDE TABLES

Table 1: Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Salinity = Measure of quantity of dissolved salts in water.
Chlorinity = Measure of chloride content, by mass, of water.
S($^0/_{00}$) = 1.80655 x Chlorinity ($^0/_{00}$)

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
▼						▼

▼						▼
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

Table 2: Calibration Values for Various Atmospheric Pressures and Altitudes

PRESSURE			ALTITUDE		CALIBRATION VALUE
Inches Hg	mm Hg	Millibars	Feet	Meters	Percent Saturation
30.23	768	1023	-276	-84	101
29.92	760	1013	0	0	100
29.61	752	1003	278	85	99
29.33	745	993	558	170	98
29.02	737	983	841	256	97
28.74	730	973	1126	343	96
28.43	722	963	1413	431	95
28.11	714	952	1703	519	94
27.83	707	942	1995	608	93
27.52	699	932	2290	698	92
27.24	692	922	2587	789	91
26.93	684	912	2887	880	90
26.61	676	902	3190	972	89
26.34	669	892	3496	1066	88
26.02	661	882	3804	1160	87
25.75	654	871	4115	1254	86
25.43	646	861	4430	1350	85
25.12	638	851	4747	1447	84
24.84	631	841	5067	1544	83
24.53	623	831	5391	1643	82
24.25	616	821	5717	1743	81
23.94	608	811	6047	1843	80
23.62	600	800	6381	1945	79
23.35	593	790	6717	2047	78
23.03	585	780	7058	2151	77
22.76	578	770	7401	2256	76
22.44	570	760	7749	2362	75
22.13	562	750	8100	2469	74
21.85	555	740	8455	2577	73
21.54	547	730	8815	2687	72
21.26	540	719	9178	2797	71
20.94	532	709	9545	2909	70
20.63	524	699	9917	3023	69
20.35	517	689	10293	3137	68
20.04	509	679	10673	3253	67
19.76	502	669	11058	3371	66

Table 3. Conversion Factors for Feet/Meters, Celsius/Fahrenheit, mg/L/ppm

TO CONVERT FROM	TO	EQUATION
Feet	Meters	Multiply by 0.305
Meters	Feet	Multiply by 3.28
Degrees Celsius	Degrees Fahrenheit	5/9×(°F-32)
Degrees Fahrenheit	Degrees Celsius	9/5×(°C)+32
Milligrams per liter (mg/L)	Parts per million (ppm)	Multiply by 1

Table 4. Conversion Factors for Common Units of Pressure

	kilo Pascals	mm Hg	millibars	inches H_20	PSI	inches Hg
1 atm	101.325	760.000	1013.25	406.795	14.6960	29.921
1 kiloPascal	1.00000	7.50062	10.0000	4.01475	0.145038	0.2953
1 mmHg	0.133322	1.00000	1.33322	0.535257	0.0193368	0.03937
1 millibar	0.100000	0.750062	1.00000	0.401475	0.0145038	0.02953
1 inch H_20	0.249081	1.86826	2.49081	1.00000	.0361	0.07355
1 PSI	6.89473	51.7148	68.9473	27.6807	1.00000	2.0360
1 inch Hg	3.38642	25.4002	33.8642	13.5956	0.49116	1.00000
1 hectoPascal	0.100000	0.75006	1.00000	0.401475	0.0145038	0.02953
1 cm H_20	0.09806	0.7355	9.8×10^{-7}	0.3937	0.014223	0.02896

APPENDIX E TURBIDITY MEASUREMENTS

This is a question and answer guide that will help you optimize performance and trouble-shoot problems. The turbidity system of the YSI 6820, 6600 and 6920 is characterized by a great deal of flexibility from the point of view of the user.. Some examples are shown below.

- The probe can be purchased in two configurations, with or without a mechanical wiper. If the wiper is in place it can be activated manually or automatically via the sonde software.
- The data from the turbidity sensor can be processed via a sophisticated filtering algorithm that has variable parameters inputted by the user.
- The turbidity system can be used in spot sampling applications with a YSI 610-D or 610-DM display/logger or a portable computer.
- The turbidity system on all sondes can be used for long term deployment applications using cable attachment to a data collection platform.
- The turbidity system can be used for long-term deployment applications with the YSI 6920 and 6600 by logging readings directly to sonde memory since they contain 'on board' power.
- A number of calibration options are offered with the YSI turbidity system.

This section is designed to help the user attain the maximum possible benefit from the turbidity system by supplementing the discussion of turbidity which is provided in the other sections of this manual (Getting Started, Basic Operation, Principles of Operation, and Maintenance). The presentation is designed around a number of questions that may be asked by a typical user of the 6820, 6600 or 6920 with our 6036 and 6026 turbidity sensors. It does not deal with specific instructions for operation of the sondes at the level presented elsewhere in the manual.

Question 1: Do I need a sensor with mechanical cleaning?

It depends on your usage plans. For most **spot sampling** applications, our non-wiped 6036 sensor is adequate. With the 6036, you must be very careful to remove bubbles from the optical surface during calibration and general use, but this is usually done easily by agitating the sonde up and down, or in a circular motion while in the medium. If you plan on using the turbidity sensor at the end of a long cable (>50 feet), this agitation may be more difficult. You may want to consider the purchase of a 6026 sensor with a wiper that can be manually activated to clean the optical face of bubbles during **spot sampling**. The key advantages of the unwiped 6036 are its lower cost and smaller size. The bottom line is that you probably want an unwiped 6036 sensor for **spot sampling**, but there are a few reasons to consider the wiped 6026.

When conducting **unattended monitoring** studies, you should always use a mechanically cleaned 6026 sensor and the instrument's software to activate the wiper at about the same interval as the data is acquired. Even if fouling from chemical or biological sources is not a significant problem in your unattended application, bubbles may form on the optical surface during deployment that can result in the transmission of erroneous readings. Once bubbles have formed, they can remain in place for long periods of time, resulting in corrupted readings for the

majority of the study. There is no doubt with regard to your options for **unattended monitoring**: use a mechanically-cleaned probe.

Question 2: Where should I get my turbidity standards?

We recommend that you obtain your standards from YSI. We sell 100 NTU standard that is has been prepared from the AMCO-AEPA polymer which is suggested for use as a secondary turbidity standard by *Standard Methods for the Examination of Water and Wastewater.* This YSI standard has been certified to be 100 NTU by comparison of its turbidity output with that of freshly prepared formazin, the latter being the most accepted primary standard for turbidity. The YSI polymer standard can be linearly diluted with turbidity free water to generate standards that are lower than 100 NTU and can also be used as calibrants. For example, diluting 50 mL of 100 NTU standard to a total volume of 500 mL will yield a 10 NTU standard.

You can also use formazin as your source for turbidity standards. The formazin can be generated by the procedure found in *Standard Methods for the Examination of Water and Wastewater,* or it can be purchased as a 4000 NTU suspension that can be linearly diluted to form lower NTU standards. The advantage of the use of formazin is its cost; the primary disadvantage is that it is a hazardous reagent for which care must be taken in handling and disposal. In addition, formazin settles out much more rapidly than the AMCO-AEPA polymer and is less stable to degradation in dilute form. If you use formazin, we recommend that you purchase the 4000 NTU concentrate and dilute it, rather than generating the reagent from the chemical reaction described in *Standard Methods for the Examination of Water and Wastewater.* Whatever your source of formazin, be very safety conscious if you use it and be sure to follow the manufacturer's instructions with regard to its handling and disposal.

It is important that you do **not** use standards that are based on suspended materials other than formazin or AMCO-AEPA polymer. These standards may not read correctly when measured with the near infrared light source (860 nm) of the YSI Turbidity probes. If you have any doubts about the composition of your standards, consult your supplier and be certain that they are based on either formazin or AMCO-AEPA materials.

Question 3: Do I have to buy turbidity-free water for the 0 NTU calibration?

For most applications, purified water of any kind (distilled, deionized or filtered) will be acceptable for the 0 NTU standard. This water can be obtained from a laboratory or can be purchased at a local supermarket. It is not recommend that you use tap water as the 0 NTU standard. For maximum accuracy at very low NTU values (below the specification of the instrument), you may want to purchase turbidity-free water from YSI or another vendor.

Question 4: Should I carry out a 1-point, 2-point, or 3-point turbidity calibration, and what values should I use?

Even though the default calibration value in your sonde is reasonably appropriate for the "average" 6036 or 6026 sensor, you need to carry out some multi-point calibration (2- or 3-point) prior to your first usage. This will make certain that your system meets the YSI accuracy specifications provided in the Sonde's Operations manual. For the accuracy required in most environmental applications, a 2-point calibration is sufficient, and it recommended that the two points be a 0 and 100 NTU. The YSI turbidity sensor shows a minor degree of underlinearity

below 10 NTU which can be minimized by a 3-point calibration at 0, 10, and 100 NTU, but the effect on accuracy of this additional calibration point may not be worth the inconvenience for the average user. For example, if only a 0 and 100 NTU 2-point calibration is carried out, a sample that is actually 6.0 NTU would read about 5.4 NTU on the average probe.

Once the initial multi-point calibration has been carried out, we recommend that the accuracy of the sensor at low NTU be checked (or reset) by performing a **1-point** calibration at 0 NTU before each usage.

Question 5: How often should I perform additional multi-point calibrations?

Your frequency of calibration will depend on the conditions under which your sonde is used and on the degree of accuracy required in your application. Periodic calibration also confirms that the sensor is performing properly with regard to its sensitivity and general function.

Our empirical testing has indicated that the optical systems of the 6026 and 6036 probes are very stable and are likely to require only infrequent calibration to remain within the accuracy specifications of the instrument (+/- 5 % of reading or 2 NTU). Therefore, unless your sensor suffers catastrophic failure (usually indicated by jumpy or unreasonable field readings), you may only have to perform a multi-point calibration on a monthly basis. However, you should initially confirm the stability of the sensor for your typical sampling or monitoring application by frequently checking the sensor reading in a standard other than 0 NTU prior to increasing the time between multi-point calibrations.

Question 6: What about data filter and spike rejection settings for processing turbidity data from the YSI turbidity system?

As described in **Section 4, Principles of Operation**, some processing of raw turbidity data is usually beneficial in terms of outputting values which reflect the "average" turbidity at the site. Filter options designed to optimize this data processing are located in the sonde menu structure under both the 3-Sensor and the 4-Data Filter selections in the 6-Advanced submenu.

For most applications involving both spot sampling and monitoring, it is recommended the following settings with regard to data processing:

- ❑ In 3-Sensor, activate the "Turb Spike Filter"
- ❑ In 4-Data Filter, "Enable" the filter.
- ❑ In 4-Data Filter, "Disable" the "Wait for Filter" selection.
- ❑ In 4-Data Filter, set the Time Constant to 12
- ❑ In 4-Data Filter, set the Threshold to 0.010

These settings will normally produce data that is reflective of the "average" turbidity without having any significant effect on the response times of the other sensors. The turbidity values can be further smoothed by increasing the values of the time constant, threshold, or both. But the response time of all parameters is likely to be adversely affected to some degree.

Question 7: How do I set up the 6820, 6600 or 6920 system for use with a data collection platform or for logging to sonde memory?

First, as outlined above, use only a mechanically cleaned 6026 sensor with the sonde in this application. Second, set the data filter and turbidity spike filter settings as recommended in the previous question/answer. Third, access 2-Setup in the Advanced submenu and make certain that the "Turb Wipes" entry is set to "1". Finally, in the same submenu, set the "Twipe Int" parameter (in minutes) to the same value as the sample interval for which data will be transmitted to the logging device. Thus, if Sample Interval is set to 900 seconds (15 minutes) in the Run menu (either Discrete or Unattended), set "Twipe Int" to "15". Under these conditions, the turbidity wiper will be activated in a single bi-directional cleaning motion every 15 minutes to clean bubbles and fouling from the optics of the probe and minimize the chance of corrupted readings due to these factors. Note, however, that for Unattended applications with the sonde where data is being logged to internal sonde memory and "Autosleep RS232" is activated, it is only necessary that the value of Twipe Int be less than that of the sample interval selected for the Unattended study. Thus, if Twipe Int is set to 1 minute and the Unattended sample interval is set to 15 minutes, the sensor will only be cleaned every 15 minutes. For this reason, if you use your sonde primarily for Unattended monitoring, it is recommended that you leave Twipe Int at the default setting of "1", even though this is different from your sample interval. As outlined in the manual, in sites where fouling is more prevalent, it may be necessary to set "Turb Wipes" to a higher value, but a setting of "1" will be adequate for most water.

After sonde software setup is complete as outlined above, attach the sonde to a computer, 610-D, or 610-DM and calibrate according to the instructions in the manual and in Question 4 above. Then connect the sonde to the data collection platform using the proper cable/adapter and begin sampling according to the instruction manual. Alternatively, deploy the sonde without cable connections after setting the sampling dates, times, intervals, etc., as described in the instruction manual.

Question 8: How do I manually activate the turbidity wiper on a 6026 when the sonde is sampling?

If you are using the sonde with a 610, press the "T" key to activate the wiper. If the sonde is connected to a computer (sequential lines of data are present on the screen), press the "3" key to activate the wiper.

Question 9: What precautions should I take when using the sonde turbidity system with a 610-D or a 610-DM?

If you are using the 610 with an unwiped 6036 probe, the only special precaution is to make sure there are no bubbles on the optics during calibration and field use. As noted above, this can usually be accomplished by agitating the sonde. Beware of readings which are visually unreasonable, e.g. relatively clear water reading 100 NTU, or unstable. These symptoms are almost always due to bubbles and additional agitation of the sonde will be necessary to remove them.

If you are using the 610 with a mechanically cleaned 6026 probe in sampling operations, the wiper can be manually activated (Press "T" on the 610 keyboard) and sonde agitation is not required. However, the use of the wiper results in a relatively large surge of current that will

reduce the battery life of the 610 to a degree that depends on the number of wipes utilized. Occasionally, the 610 batteries may be discharged to a level such that they will power all of the sensors in the sonde (including turbidity), but will not be powerful enough to activate the wiper. You will be aware that the wiper is not turning by the length of the cleaning cycle displayed on the logger display after the "T" key has been pressed. If the cleaning cycle is approximately 12 seconds, the wiper is turning on command, if the cleaning cycle is approximately 24 seconds, the wiper is not being activated. Note, however, the cleaning cycle will always last 24 seconds the first time the wiper is activated for a sonde after being connected to power. If the wiper fails to activate, but the other sensors are functioning, you can continue to take readings until the LOBAT indicator of the display is visible. However, you will be forced to remove bubbles from the optics by agitating the sonde instead of using the wiper. Naturally, you should recharge the 610 batteries as soon as possible if this symptom occurs.

Question 10: What are the things most likely to give me problems when measuring turbidity with the YSI 6820, 6600 or 6920?

The turbidity system has been designed to be easy to calibrate, easy to use in both sampling and deployment applications, and trouble-free in normal usage. However, during our testing of prototype and production systems and sensors, we have observed occasional problems in calibration and in field applications. These difficulties are likely to be experienced only infrequently by users. In fact, most of these problems are not due to any malfunction in the turbidity system itself, but instead occur because of contaminated calibration solutions or the presence of bubbles on the optics of the probe. However, we have gained experience in separating problems which can be easily solved by the user from those which involve sensor malfunction and must be dealt with by YSI Customer Service and Product Repair. This section is intended to pass this experience along to the user.

You might see calibration errors. This problem could be due to bubbles on the optical surface, contamination of your 0 NTU standard, or a higher calibration standard which has not been prepared properly or has been contaminated or diluted inadvertently. The problem could also be due to an internal malfunction of the probe optical system. To troubleshoot the problem, do **not** override the cal error, return to the Main menu and activate data acquisition in the Run mode. Remove the sonde guard and place your thumb or finger over the optics of the probe while observing the data display. The reading should be large (either positive or negative) if the probe is responding correctly from an optical standpoint. If no response is noted, the probe must be returned to YSI Customer Service for repair or replacement. CAUTION: DO NOT ATTEMPT TO DISASSEMBLE THE PROBE YOURSELF. If the probe is functioning properly, replace the probe guard and place the sonde back into 0 NTU water. Agitate the sonde rapidly to remove bubbles and enter the calibration routine of choice (1-, 2-, or 3-point) from the **Calibrate** menu. Observe the readings for the 0 NTU standard. If values higher than about 5 NTU are observed, it is possible that your 0 NTU standard has been contaminated from debris that was retained on the sonde and probes from the previous field usage. Discard the water, rinse the sonde, and replace in new 0 NTU standard. After agitation, check the reading to see if it has been reduced. If so, proceed with the second calibration point. If not, contact YSI Customer Service for further assistance. If a calibration error occurs on the second point, use a new source of standard and try again. If an error still occurs, contact YSI Customer Service for further assistance.

You might observe readings during sampling which appear unreasonable from visual inspection of the water. The problem is usually caused by bubbles on the optics of the sensor.

Further agitate the sonde remove the bubbles. If the readings are still unreasonable, remove the sonde completely from the water and then replace in the water. If problems are still evident, remove the sonde guard and check general probe function by placing your finger or thumb over the optics as described above. If the probe does not respond, contact YSI Customer Service.

You might see readings during sampling that you think are too jumpy. If this occurs, the water may be non-homogeneous with regard to the size of the suspended particles. The jumpiness that you are observing is probably real. However, if you want to smooth it out, you can incrementally increase the Time Constant and Threshold settings in the Data Filter menu to obtain the noise level which you desire. Remember, however, that settings greater than those recommended above in Question 6 (Time Constant = 12; Threshold = 0.010) are likely to result in a slower response of all sensors and therefore you will be required to spend a longer time at each site to attain the correct readings. Be careful in altering the filter settings -- the recommended values are best for most applications.

You might observe single point spikes in data from deployment applications. These high readings may be real turbidity events caused by large particles passing over the optical surface at the time of measurement. As long as the spiking occurs only occasionally, there is no reason to believe that the turbidity system is malfunctioning. Depending on the site, these spikes may be a normal occurrence.

You might see a lot of positive and/or negative spikes in data from deployment applications. This symptom usually results from improper activation or parking of the wiper assembly. If it occurs with a new wiper assembly, make certain that the wiper rotates and parks correctly (opposite the optical surface) in 0 NTU standard. If the wiper does not rotate at all be certain that the setscrew of the assembly is contacting the flat part of the shaft and that the screw is securely tightened using the small hex key which is supplied with the wiper assembly. If the wiper still will not rotate on manual activation, contact YSI Customer Service. If the problem occurs with a wiper assembly which has been in the field for some time and is discolored or abraded, install a 6027 replacement with a new pad, assure function and correct parking in 0 NTU standard, and redeploy. If a high frequency of spikes still occurs in the deployment data, contact YSI Customer Service for further assistance.

APPENDIX F FLOW

Flow is only available in the **Sensors** menu on sondes that have vented level. The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use YSI's sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly here, this manual is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. Many devices are designed to be placed in an open channel to improve the determination of flow. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs, each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the flume, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are three common types of weirs and seven types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

The Manning Equation is also available to calculate flow in an open channel without any restriction built explicitly for measuring flow. In this case the channel itself is the primary measuring device.

F-1 SETTING UP YOUR SONDE

WEIR OR FLUME

Getting your sonde ready to calculate flow for a weir or a flume can be summarized in the following simple steps. Using EcoWatch or a 610 display/logger to communicate with the sonde:

1. Enable **Flow** in the **Sensors** menu.
2. Go to **Flow Setup** menu in **Advanced Sensor.**
3. Choose a method (flume or weir), then a type (V-notch, rectangular, Parshall, etc.).
4. Choose a size.
5. Verify proper setup, choosing preferred units.
6. Choose preferred units in **Report**.

The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu. Once in the **Flow Setup** menu you must define your primary measuring device by **Method, Type**, and **Size**. Note that the menus change depending upon your selection.

For example, after choosing **Flume** for your method, only types of flume are shown. So it is important to choose first the method, then the type, and finally the size. The following chart lists the primary devices that are programmed in the sonde.

Method	Type	Size
Weir	V-Notch	22½°, 30°, 45°, 60°, 90°, 120°
	Rectangular w/ End Contractions	Any size
	Rectangular w/o End Contractions	Any size
	Cipolletti	Any size
Flume	Parshall	1", 2", 3", 6", 9" 12", 18", 2', 3', 4', 5', 6', 8', 10', 12'
	Palmer-Bowlus	4", 6", 8", 10", 12", 15", 18", 21", 24", 27", 30"
	Leopold-Lagco	4", 6", 8", 10", 12", 15", 18", 21", 24", 30"
	Trapezoidal	Large 60° V, X-large 60° V, 2" 45° WSC, 12" 45° SRCRC
	Hs	0.4ft, 0.6ft, 0.8ft, 1ft,
	H	0.5ft, 0.75ft, 1 ft, 1.5ft, 2ft, 2.5ft, 3 ft, 4.5 ft
	HL	4 ft

After selecting the method, type and size of primary device, YSI strongly recommends that you verify that the sonde is set up properly. Find a chart that lists head versus flow for your primary measuring device. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that are on your chart. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against those found in the chart. Note that there may be minor differences in the least significant digit between the published values and the values given by the sonde. The difference is generally much less than the overall tolerance of the weir or flume being used.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

MANNING EQUATION

Once in the **Flow Setup** menu, choose **Manning** for the Method and then choose which type of channel the measurement is to be done in: closed pipe, U- channel, rectangular, or trapezoidal. Then choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. Finally choose **Setup Manning** and define the width of the channel, its roughness and slope. Roughness is given in many fluid hydraulics texts and other engineering references as the Manning coefficient, n. Empirical values for n are given in the same references for most commonly found materials used in open channel construction. Slope is the ratio of rise to run. For example, if a channel drops one foot every one hundred feet, the value of the slope would be 0.01.

After setting up the **Manning Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and judge whether the resulting **Test Flow** values are reasonable. You might even want to try doing the calculation yourself.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

EQUATION

Equation is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde. (**Table** is also sometimes useful for this purpose.)

Once in the **Flow Setup** menu you must define the equation. First choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. The equation is of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

Enter values for **K_1, P_1, K_2,** and **P_2.** Note: if you do not need the second term in the equation, simply enter zero for **K_2**.

After setting up the **Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values that you have calculated.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

TABLE

Table is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde (**Equation** is also sometimes useful for this purpose). **Table** can also be used to calculate flow in streams for which there is data relating flow to level.

Once in the **Flow Setup** menu you must define your **Table**. Do this by entering up to 50 pairs of **Head** and **Flow** data points. Choose **Setup Table**. Be sure to choose the units that match the data in your table. Then enter each pair of points one by one. It is not necessary to enter the points in order. The software will put them in order. There are items on the menu to edit the next point or the previous point, to enter a new point, to delete a point or to delete the entire table. Later, when the sonde is measuring level and calculating flow, it will linearly interpolate between points in the table.

After setting up the **Table**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units used in the table. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values in the original table.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

F-2 DEPLOYING YOUR SONDE

WEIR

Deployment of the sonde in a weir is normally very simple. Generally the point of level measurement is recommended to be at a distance upstream of the weir equal to 3 to 4 times the maximum level expected; however, do not deploy the sonde without knowing the design measurement point for the weir you are using. If flow is overly turbulent and readings are jumpy, then it may be necessary to install a stilling well for the sonde. If other water quality measurements are of interest (DO, pH, etc,) then take care that the stilling well does not overly isolate the sonde from the water in the channel.

Deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a weir. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure also to follow the instructions printed in Appendix G, **Using Vented Level**.

FLUME

Generally there is a staff gauge installed in a flume at the point where the level should be measured. Be certain that you know the location of the measurement for the flume you are using. Some flumes are built with a stilling well outside of the flume. Deploying the sonde in the stilling well will give accurate level readings, but readings of other parameters like DO and pH may not be equivalent to those in the main flow of the flume. Also be aware that many flumes are not much bigger than the sonde. Installing the sonde in the flume may change the way the flume behaves, thus causing errors in flow readings. An ideal deployment would include a flume with a recess for the sonde that locates the pressure sensor properly, allows the other sensors to measure the water flowing through the flume, and does not significantly alter the geometry of the flume. In a flume this means deploying the sonde horizontally. If possible, deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Also be aware that the pressure sensor in the sonde is along the side of the sonde and not at its very tip. If a sonde is deployed vertically in the flume, then it may not be able to make measurements when the water level is low. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a flume. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

USING THE MANNING EQUATION IN AN OPEN CHANNEL

The channel should be large enough that the sonde does not significantly alter the flow of water. Most deployments will require the sonde to be in the channel horizontally so that the pressure sensor remains submerged at all times. Be sure that the sonde cannot move during the measurement. After installation measure the depth of water in the channel with a ruler and use that measurement to calibrate depth on the sonde.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

APPENDIX G USING VENTED LEVEL

Sondes that are equipped with level sensors use vented cables. The vented level option eliminates errors due to changes in barometric pressure. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs up through the sonde and cable. The tube must remain open and vented to the outside atmosphere to function. All storage caps must be removed and no foreign matter can block the openings. Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant system in place. This prevents moisture from entering the vent tube.

Special field cables are used for the vented level. These cables have a vent tube that runs up the middle of the cable. Your sonde has a stainless steel connector on the top of it. In the center of this connector is the vent hole. When the cable is removed from the sonde, seal the sonde with the pressure cap provided with the sonde, to keep it clean and dry. The field cable should also be stored in a sealed plastic bag with some desiccant to keep it dry.

At the instrument end of every vented cable is a barbed fitting. This is to provide an attachment for a desiccant system. One of the two desiccant systems should always be attached to the sonde while exposed to the atmosphere to prevent moisture buildup in the vent tube. When dry and active, the desiccant is a distinct blue color. When exhausted it turns to a rose red or pink color. The desiccant can be regenerated in an oven. See Section 2.10, **Care, Maintenance and Storage** for the proper procedure.

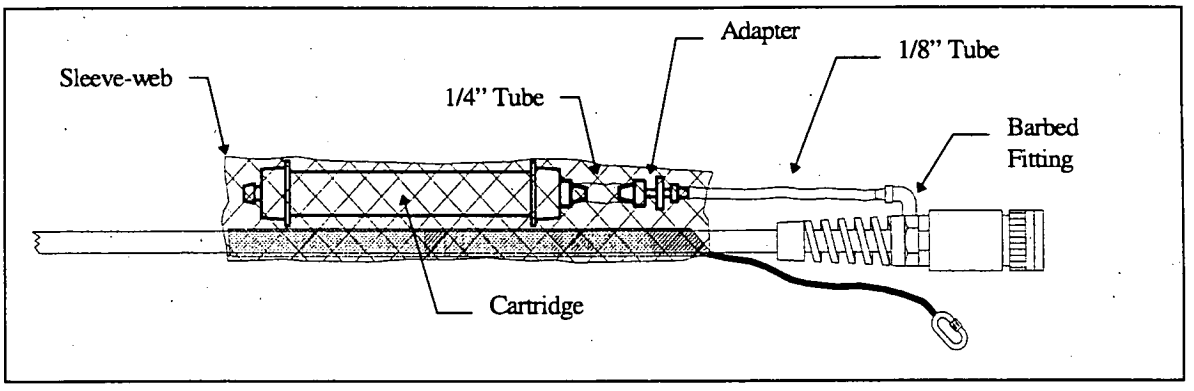
Avoid bending the cables sharply to prevent the vent tube from kinking.

Two desiccant systems are available, a cartridge kit and a canister kit. Either will keep moisture from entering the vent tube. The desiccant cartridge kit mounts right to the cable and is intended for short term applications. The desiccant canister contains a larger amount of desiccant and is intended for long term deployment. The desiccant canister kit contains mounting brackets for mounting the canister to a nearby structure. The length of time that the desiccant remains active depends on several factors including heat and humidity.

When using vented level, you must enter altitude and latitude. From the sonde Main menu, select Advanced, then 3-Sensor. Enter the altitude in feet and the latitude in degrees of the measurement site. These values need to be accurate within 500 feet and 1 degree, respectively.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

INSTALLING THE CARTRIDGE KIT



1. Place the short length of 1/4" tubing onto the 1/4" side of the 1/8" to 1/4" adapter fitting. Seat firmly.

2. Place the length of 1/8" tubing onto the 1/8" side of the adapter fitting. Seat firmly.

3. Remove one of the plugs from the end of the desiccant cartridge and place the open end of the short length of 1/4" tubing onto the open end of the desiccant cartridge. Seat firmly.

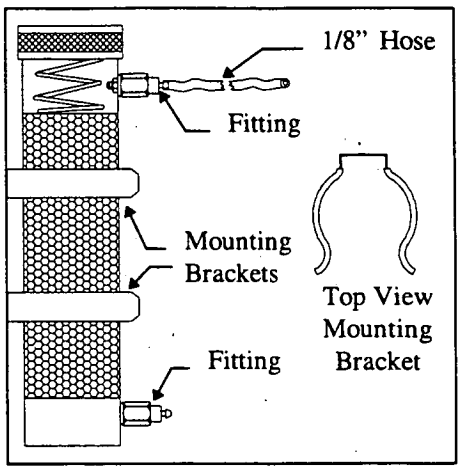
4. Remove the plug from the barbed fitting on the end of the cable and place the open end of the 1/8" tubing onto the cable fitting. Seat firmly.

5. Slide the sleeve-web over the end of the cable and the bail. Work the sleeve-web down the cable and over the cartridge taking care not to unplug the hose that connects the cartridge to the cable.

Optional: Using one of the tie-wraps, secure the hose to the cable taking care not to close off the hose.

The vent end of the cartridge should remain plugged until the sonde is ready for use. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

INSTALLING THE CANISTER KIT



1. Remove the 1/8" NPT plugs from the stainless steel fittings on the canister.

2. Install the 1/8" NPT to 1/8" hose fittings into the stainless steel fittings located on the side of the desiccant canister. CAUTION: Do not over-tighten!

3. Place the plugs over the fittings on the canister until you are ready to use the canister.

4. Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.

5. Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

APPENDIX H EMC PERFORMANCE/FERRITE BEAD INSTALLATION

EMC PERFORMANCE

When using the 6920, 6600 or 600XLM sondes in a European Community (CE) country, please be aware of the following electromagnetic compatibility (EMC) performance issues.

WARNING: Fields in excess of 6-Volts/meter may cause the dry-sonde to loose deployment instructions. The sonde is not at risk once it is deployed for unattended logging in a minimum of 40-gallons of water with the last fifteen-feet of cable, if used, immersed.

Diminished performance may be observed in the following situtations:

- Laboratory-procedures at ESD events.
- With DO measurements whenever the Sonde cable is lying parallel with industrial-wiring or radio-frequency cabling.
- With Turbidity and Depth measurements whenever the dry-sonde is subject to radio-frequency fields approaching 3-Volts/meter.

FERRRITE BEAD ASSEMBLY

If you are using your YSI 6920, 6600 or 600XLM in a European Community (CE) country, you must install two clamp-on ferrite bead assemblies to the sonde end of your cable. This will allow you to comply with the Residential, Commercial and Light Industrial Class B Limits for the 600XLM and 6920 and Class A Limits for the 6600, for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are not required in many areas of the world and therefore are not supplied as part of cables kits. Thus, the parts must to be ordered separately by European Community users.

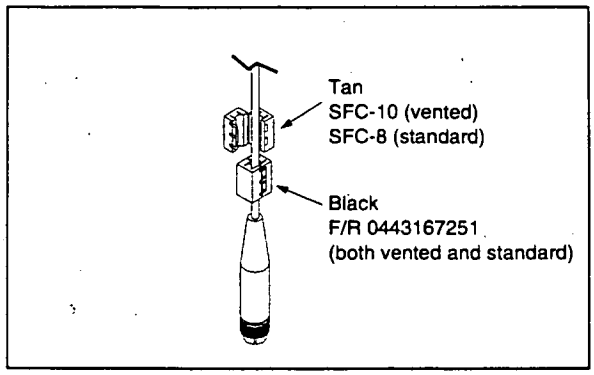
The required ferrite assemblies differ depending on whether your cable is vented or standard (non-vented) as detailed below:

- For vented cables, use YSI Ferrite Bead Kit 6194. The kit contains two beads of different types. Install in the physical configuration illustrated below.
- For standard (non-vented cables), use YSI Ferrite Bead Kit 6089. The kit contains two beads of different types. Install in the physical configuration illustrated below.

***CAUTION*:** Do not attempt to install the beads from a standard kit on a vented cable. Because of the the larger size of the cable, use of beads for the smaller standard cable can result in cable damage, the vent tube being pinched off, or both. Be sure to use only YSI kit 6194 on vented cables.

To install the beads, follow these easy steps:

- Using a small screwdriver, press and raise the tabs on the beads until the snap connector opens.
- Place the beads on the cable as shown in the diagram below. Make certain that the black bead (F/R 0443167251) is placed nearer to the connector than the tan bead (SFC-8 for standard; SFC-10 for vented).
- Snap the two pieces of the bead together making certain that the tabs lock securely.



APPENDIX I SPECIFICATIONS

SONDE SPECIFICATIONS

6600

Operating Environment

Medium:	fresh, sea, or polluted water
Temperature:	-5 to +45 °C
Depth:	0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-20 to +60 °C for pH and pH/ORP sensors

Material: PVC, Stainless Steel

Maximum Diameter: 3.5 inches (8.9 cm)
Maximum Length: 19.6 inches (49.7 cm) with no depth, 21.6 inches (54.8 cm) with depth
Maximum Weight: 7 pounds (31.8 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 75 days at 20 C at 15 minute logging intervals, a 40 second DO warm up time, and turbidity active.

6920

Operating Environment

Medium:	fresh, sea, or polluted water
Temperature:	-5 to +45 °C
Depth:	0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-20 to +60 °C for pH and pH/ORP sensors

Material: Polyurethane, PVC, Stainless Steel

Maximum Diameter: 2.9 inches (7.4 cm)
Maximum Length: 18.0 inches (45.7 cm)
Maximum Weight: 3.7 pounds (1.7 kg) with 6026 wiping turbidity sensor and without cable

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 AA-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 30 days at 20 °C at 15 minute logging intervals, a 40 second DO warm up time and turbidity active

6820

Operating Environment

Medium: fresh, sea, or polluted water
Temperature: -5 to +45 °C
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sondes and all sensors except pH and pH/ORP
-20 to +60 for pH and pH/ORP

Material: PVC, Stainless Steel

Maximum Diameter: 2.9 inches (7.4 cm)
Maximum Length: 13.6 inches (34.5 cm)
Maximum Weight: 3.4 pounds (1.5 kg) without cable and with 6036 turbidity sensor.

Computer Interface: RS-232C, SDI-12
Power: External 12 VDC (8 to 13.8 VDC)

600XLM

Operating Environment

Medium: fresh, sea, or polluted water
Temperature: -5 to +45 °C
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-20 to +60 °C for pH and pH/ORP sensors

Material: PVC, Stainless Steel

Diameter: 1.7 inches (4.4 cm)
Length: 21.3 inches (54.1 cm) with no depth; 23.3 inches (59.2 cm) with depth (top of connector to bottom of standard weight)
Weight: 1.48 pounds (0.67 kg) (with batteries, without bottom weight)

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 4 AA-size Alkaline Batteries or External 12 VDC

Battery Life: 25 to 30 days at 20 C with a 15 minute logging interval and a 40 second dissolved oxygen warm up

600XL

Operating Environment

Medium: fresh, sea, or polluted water
Temperature: -5 to +45 °C
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH and pH/ORP
-20 to +60 °C for pH and pH/ORP sensors

Material: Polyurethane, PVC, Stainless Steel

Maximum Diameter: 1.6 inches (4.06 cm)
Maximum Length: 20.75 inches (52.7 cm)
Maximum Weight: 4.9 pounds (2.22 kg)

Computer Interface: RS-232C, SDI-12

Power: External 12 VDC (8 to 13.8 VDC)

600R

Operating Environment

Medium: fresh, sea, or polluted water
Temperature: -5 to +45 °C
Depth: 0 to 200 (61 meters)

Storage Temperature: -40 to +60 °C (without pH installed)
-20 to +60 ° C (with pH installed)

Material: PVC, Stainless Steel

Diameter: 1.6 inches (4.06 cm)
Length: 14.25 inches (36.20 cm)
Weight: 1.43 pounds (0.65 kg)

Computer Interface: RS-232C, SDI-12

Power: External 12 VDC (8 to 13.8 VDC)

SENSOR SPECIFICATIONS

The following are typical performance specifications for each sensor.

Non-Vented Level – Deep
Sensor Type.....Stainless steel strain gauge
Range.....0 to 656 feet (200 m)
Accuracy.....+/- 1 ft (0.3 m)
Resolution.....0.001 ft (0.001 m)

Non-Vented Level - Medium
Sensor Type.....Stainless steel strain gauge
Range.....0 to 200 ft (61 m)
Accuracy.....+/- 0.4 ft (0.12 m)
Resolution.....0.001 ft (0.001 m)

Non-Vented Level - Shallow
Sensor Type.....Stainless steel strain gauge
Range.....0 to 30 ft (9.1 m)
Accuracy ..... +/- 0.06 ft (0.018 m)
Resolution.....0.001 ft (0.001 m)

Vented Level - Shallow
Sensor Type.....Stainless steel strain gauge
Range.....0 to 30 ft (9.1 m)
Accuracy, 0-10ft .....+/- 0.01 ft (0.003 m)
Accuracy, 10-30ft.....+/- 0.06 ft (0.018 m)
Resolution.....0.001 ft (0.001 m)

Temperature
Sensor Type.....Thermistor
Range.....-5 to 45 °C
Accuracy.....+/- 0.15 °C
Resolution.....0.01 °C
Depth.....200 meters

Dissolved Oxygen, % saturation
Sensor Type.....Rapid Pulse - Clark type, polarographic
Range.....0 to 500 % air saturation
Accuracy.....0-200 % air saturation, +/- 2 % of the reading or 2 % air saturation, whichever is greater
200-500 % air saturation, +/- 6 % of reading
Resolution.....0.1 % air saturation
Depth.....200 meters

Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type..... Rapid Pulse - Clark type, polarographic
Range.....0 to 50 mg/L
Accuracy.....0 to 20 mg/L, +/- 2 % of the reading or 0.2 mg/L, whichever is greater

20 to 50 mg/L, +/- 6 % of the reading
Resolution.....0.01 mg/L
Depth.....200 meters

Salinity
Sensor Type.....Calculated from conductivity and temperature
Range.....0 to 70 ppt
Accuracy.....+/- 1.0% of reading or 0.1 ppt, whichever is greater
Resolution.....0.01 ppt

pH
Sensor Type.....Glass combination electrode
Range.....0 to 14 units
Accuracy.....+/- 0.2 units
Resolution.....0.01 units
Depth.....200 meters

ORP
Sensor type..... Platinum button
Range.....-999 to +999 mV
Accuracy.....+/-20 mV
Resolution.....0.1 mV

Turbidity
Sensor type..... Optical, 90 ° scatter, with mechanical cleaning
Range..... 0 to 1000 NTU
Accuracy.....+/- 5% reading or 2 NTU (whichever is greater)
Resolution.....0.1 NTU
Depth.....66 meters

Conductivity*
Sensor Type.....4 electrode cell with autoranging
Range.....0 to 100 mS/cm
Accuracy.....+/- 0.5% of reading + 0.001 mS/cm
Resolution.....0.001 mS/cm to 0.1 mS/cm (range dependent)
Depth.....200 meters

Nitrate-Nitrogen
Sensor Type.....Ion-selective electrode
Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Depth.....15 meters

Ammonium-Nitrogen
Sensor Type.....Ion-selective electrode

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* Report outputs of specific conductance (conductivity corrected to 25 C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (Ed 1989).

Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Depth.....15 meters

Ammonia-Nitrogen
Sensor Type.....Calculated from ammonium, pH and temperature
Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Depth.....15 meters

Chloride
Sensor Type.....Solid state ion-selective electrode
Range.....0-1000 mg/L
Accuracy.....+/- 15% of reading or 5 mg/L (whichever is greater)
Resolution.....0.001 mg/L to 1 mg/L (range dependent)
Depth.....15 meters

SOFTWARE SPECIFICATIONS

EcoWatch for Windows (included)

IBM PC compatible computer with 3 1/2 inch floppy disk drive and with a 386 processor (or better) running Windows version 3.1 (or later).
Minimum RAM requirement: 4 megabytes

PC6000 (optional)

IBM PC compatible computer, 3 1/2 or 5 1/4 inch, high or low density floppy disk drive.
Minimum RAM requirement: 256 K bytes
Optional graphic adapter for plotting

APPENDIX J INDEX

A

About YSI 1
Accessories and Calibration Standards 219
Add Memory of the 610, Capture and 115
Advanced Menu, Sondes 81
Ammonium and Ammonia, Principles of Operation 184
Ammonium
- 3-Point calibration 36, 70
- Probe, Long Term Storage 98
- Sensor, Care and Maintenance 93

B

Batteries and Charging for the 610 101
Batteries, Installing in the Sondes 14
Bulkheads, Sondes 10, 11

C

Cable Connector Port 90
Calibration **194**
- Containers needed 29
- Cup, Recommended Volumes for use with 30
- Errors 194
- Getting Ready to 66
- Menu, Sondes 29
- Mode, 610 124
- Procedures 31
- Standards 219
- Tips for Good 29

Capture and Add Memory of the 610 115
Capture Data - All Sondes 45
Care, Maintenance and Storage of Probes and Sondes 89
Chloride
- Calibration 71
- Probe, Long-Term Storage 98
- Principles of Operation 187
- Sensor, Care and Maintenance 93
- 3-point calibration 36

Communication 199
Communications Menu, 610 122
Conductivity
- Principles of Operation 173
- Probe, Long Term Storage 96
- Calibration 33, 67

Conductivity/Temp Probe
- Installing 12
- Care and Maintenance 91

Connecting a Field Cable 16
Connecting a 610 to a Sonde 101
Connecting Your Sonde 3

D

Deploy Sonde, 610 125
Depth Sensor, Care and Maintenance 92
Depth and Level
Principles of Operation 177
Probe, Long Term Storage 99
Calibration 35
Discrete Sampling with the 600XLM, 6920 or 6600 39, 60
Displays and Loggers, 610D and 610 DM 101
Display Formats in EcoWatch, Changing 52,54
Dissolved Oxygen
Calibration 34, 67, 68
Principles of Operation 179
Probe, Long Term Storage 96
Probe, Installing 12
Probes, Care and Maintenance 90
Membrane, Installing 7

E

EcoWatch for Windows **131**
Applications Menu 170
Compatible Equipment 131
Communication Menu 154
Connecting a Sonde or 610 138
Data Acquistion and Analysis 138
Display Formats, Changing 52, 54
Edit Menu 150
File Menu 141
Getting Started 18, 131
Glossary 132
Graph Menu 161
Graph, Using the 140
Graph Data in Real-Time 141
Help Menu 171
Introduction 131
Installing 18
Main Menu 141
Real-Time Menu 160
Running 18
Setup Menu 162
Software Setup 18
Toolbar, Using the 135
Tutorial 134
Typical Application 136
Upload a File from a 610DM 139

Uploading a File from a 600XLM, 6920 or 6000UPG 139
View menu 151
Window Menu 171
Electromagnetic Compatiblity Performance 243

F

Ferrite Bead Installation 243
Field Cable, Connecting 16
File Menu, Sondes 72
Files on the 610 112
File System of the 610 126
Flow **233**
Principles of Operation 191

G

Getting Started with a Sonde 3
Getting Started with the 610 101

H

Hardware Interface 199
Health and Safety 29, 209
How to Use This Manual 2

I

Introduction 1
APPENDIX J INDEX **251**
Port Plugs, Removing 9
Power for
Lab Calibration 14
Sondes 13
Powering Up the 610 103
Preparing the Sonde for Use 7
Pressure/Altitude Tables, Solubility and 223
Pressure, Calibrating 68
Principles of Operation 173
Probes
Installing 9,12
Guard, Installing 13
Care and Maintenance 90
Storage 96
Long-Term Storage 96

R

Readings to Display on the 610, Choosing Which 104
Report Menu, Sondes 77
Reporting and Plotting Data with EcoWatch 47
Required Notice 217
Run Menu, 610 104,120

Run Menu, Sondes 58
Running EcoWatch Software 18
RS-232 Interface 200

S

Salinity, Principles of Operation 174
Sampling with the 610 113
SDI-12 Interface 200
Sensors of the 610, Setup Parameters and Setup 125
Sensor Menu, Sondes 80
Sensors, Enabling 24
Sensor Performance Problems 196
Sensor Specifications 248
Service
- Information 205
- Centers, Authorized US 206
- Centers, International 207

Setting Up a Sonde for Unattended Logging with the 610 110
Setup 610 122
Site List
- Setting Up and Using, on the 610 105
- Using with the Marked File 105
- Using for Capture, Log and Add Files 107

Software Specifications 250
Software in the 610, Loading New 128
Software Updates for the 610 128
Solubility/ Altitude Tables 223
Sondes **3**
- Advanced Menu 81
- Bulkheads 10,11
- Care and Maintenance 89
- Communication Problems 195
- Connecting 4
- Getting Started 3
- Long-Term Storage Recommendations 95
- Menu 58
- Preparing for Use 7
- Probe Ports 89
- Report Menu 77
- Storage 94
- Short Term Storage Recommendations 94
- Specifications 245
- Software Setup 20
- Status Menu 74
- System Menu 75
- System Setup 22

Specifications 245
Stash Memory of the 610 114
Storage of Probes and Sondes, Care, Maintenance and 89

T

Taking Readings 38
Technical Information of the 610 128
Temperature
Principles of Operation 178
Probe, Long Term Storage 96
Transferring Files to a Computer from the 610 113
Troubleshooting 193
Turbidity
Cleaning, Using the 610 121
Measurements 227
Principles of Operation 188
Probe, Installing 12
Probe, Care and Maintenance 94
Probe, Long Term Storage 98
2-Point calibration 37, 71

U

Unattended Logging, Setting up a Sonde for 110
Unattended Sampling with the 600XLM, 6920 or 6600 41, 62
Unpacking and Inspection 2
Uploading Data - 600XLM, 6920 or 6600 Sondes 45
Uploading Logged Files with the 610 112

V

Vented Level, Using 239
Viewing Data in EcoWatch 49

W

Warranty and Service Information 205
Weather, Recording in the 610 120

Y

YSI, About 1

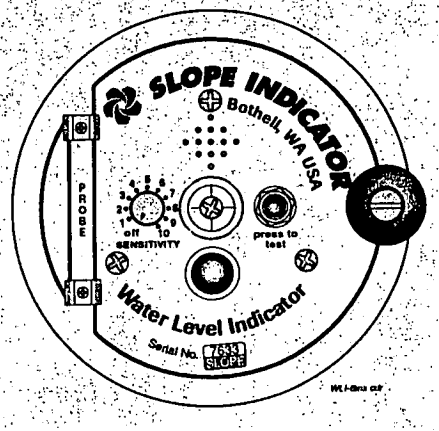
YSI *incorporated*

1700/1725 Brannum Lane
Yellow Springs, Ohio 45387 USA
(800) 765-4974 (937) 767-7241
FAX: (937) 767-9320
Website: http://www.ysi.com
E-mail: info@ysi.com

Item # 069301
Drawing # A69301
Revision A
August 1998

WATER LEVEL METER

Cable-Type Water Level Indicator



Operating Instructions

Step 1: Switch On and Set Sensitivity
Turn sensitivity knob clockwise to switch indicator on and set sensitivity.

Setting 1, the lowest sensitivity, is for saline or contaminated water. Setting 10, the highest sensitivity, is for pure water.

To determine proper setting, turn sensitivity knob to 10. Lower probe into well until light and buzzer activate. Raise probe out of water. If light and buzzer stay active, decrease sensitivity setting until they turn off. Note setting, then repeat process with slightly higher setting. Sensitivity is set properly when light and buzzer turn off promptly when probe is withdrawn from water.

For highest accuracy, determine sensitivity setting for each monitoring well.

Step 2: Take Reading
Lower probe into well until light and buzzer turn on. With your fingers, pinch the cable where it emerges from the top of the well. This marks the water level, assuming that the top of the well is used as the reference.

White graduations are 1/100 ft; white numbers are 1/10 ft; and yellow numbers are feet. Foot numbers are set off with two marks. Use the lower mark (toward probe).

Step 3: Switch Off
Turn the indicator off with the sensitivity knob. This prevents accidental draining of the battery.

Cleaning the Indicator

Probe: Wash the probe with detergent. Stronger cleaning agents are also acceptable, so long as they are not used on the cable.

Cable: Wash the cable with a laboratory-grade detergent such as Alconox or Liquinox. Rinse with distilled water as required. Remove oily deposits with dish-washing detergent, after testing its effect on a short length of cable. Do not leave the cable immersed in detergent for a long time. Rinse in distilled water.

Do not use nitric acid, hydrochloric acid, MEK, Acetone, Toluene, or alcohol to clean the cable. Even short-term exposure to these substances can damage the polyurethane cable jacket.

Reel: Wipe off the reel with a damp cloth. Do not let water enter electronics area.

Testing Batteries

The indicator uses three AA-size batteries. To test the batteries, turn up sensitivity and press the test button. If batteries are good, the light comes on and the buzzer sounds.

Replacing Batteries
Position the reel with the face plate up. Remove the center screw and the three peripheral screws.

Remove the face plate or component panel. Take care not to damage wires. The battery holder is mounted on the back of the face plate.

Insert fresh batteries. Polarity is marked on battery holder. Replace the face plate and tighten screws.

SLOPE INDICATOR
3450 Monte Villa Parkway, PO Box 3015, Bothell, WA, 98041-3015 USA
Tel: 425-806-2200 Order Desk: 800-331-0703 Fax: 425-806-2250
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LIMITED WARRANTY

The Slope Indicator Company warrants all products manufactured by it to be free of defects of workmanship and material for a period of one year from the date of delivery to the customer, unless the customer is an authorized distributor of the Company Products in which event the warranty shall be for a period of one year from the date of delivery to the authorized distributor's customer. The **OBLIGATION OF THE SLOPE INDICATOR COMPANY** is hereafter **LIMITED** to **REPLACEMENT** or, **AT ITS OPTION, REPAIR** of products returned to it with transportation charges to and from the Company paid by customer (including prepayment of transportation charges to the Company) and which the Company's examination shall disclose, to its satisfaction, was/were not free from such defects.

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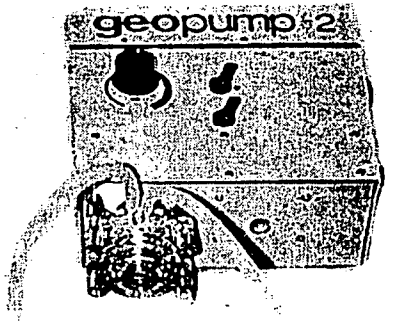
SLOPE INDICATOR
Slope Indicator Company
A Boart Longyear group company

SINCO 1197-WLI-0498

PERISTALTIC PUMP

Geotech Environmental Equipment, Inc.
1441 West 46th Avenue Unit # 17
Denver, Colorado 80211
(303)433-7101 ● (800) 833-7958 ● FAX (303) 477-1230
email: geotech@ix.netcom.com
website: www.geotechenv.com

geotech



Instruction Manual for Geopump Peristaltic Pumps

Rev: 010998

The Warranty

For a period of 1 year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair, or replace, at Geotech's option the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abuse, misuse, negligence or accident. User assumes all other risk, if any, including the risk of injury, loss or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Table of Contents

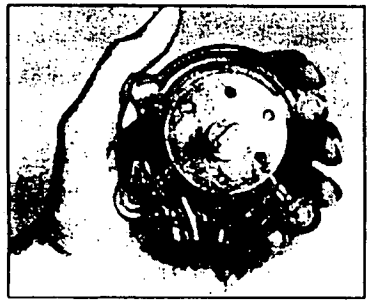
About the geopump . . . . . .Page 1

Operating the geopump . . . . . .Page 2

Specifications . . . . . .Page 3

Standard Pump Head instructions . .Page 4

Standard Pump Head Instructions



#1

Separate pump halves. Hold the pump head as shown, with the rollers in the 2, 6, and 10 o'clock positions.

#3

With the key firmly pressed against the rotor, turn (counterclockwise) and push down while turning until tubing has surrounded the rotor.

#2

Place the tubing in the outer port and against the two rollers shown, keeping your thumb on the tubing to hold it in place. Insert tubing key on the back of the rotor shaft and push in as far as possible. Tubing is now positioned deep into the cavity.

#4

Tubing is now in place. Remove key and position other pump half onto the motor shaft and snap shut. Be careful not to pinch tubing between plastic halves.

About the Geopump Peristaltic Pump

The Geotech Series I and II Peristaltic Pumps were designed for single and multi-stage pressure or vacuum pumping of liquids for field or laboratory use. Because they operate to a depth of 27 feet at sea level, they are ideally suited for sample removal from shallow wells and all surface water sources. They operate by mechanical peristalsis, so the sample comes in contact only with the tubing. This allows for sample integrity as well as easy cleaning and replacement. With the optional stainless steel tubing weight, tubing can be lowered to a specific depth without curling or floating on the surface of the water.

Differences between the two models affect only the number of pump heads which may be used with the Geopump at one time, and the speed or speeds at which the pump heads operate. Therefore, instructions for general operations will be covered only once. The primary differences

SERIES I Peristaltic Pumps are available in AC only, DC only, or an AC/DC combination. These units have one pumping station which can also be piggy-backed for multi-station pumping. They are variable speed from 60 RPM to 350 RPM.

SERIES II Peristaltic Pumps are available in AC only, DC only, or an AC/DC combination. They have two pumping stations which can also be piggy-backed. The first pumping station is rated at 30 RPM to 300 RPM and the second station at 60 RPM to 600 RPM. Each pumping station works in conjunction with the other.

Operating the Geopump

The pump arrives packed in the hard shelled peristaltic pump carry case with the pump head properly attached to the pump. See section on Pump Parts.

To put into service:

1. Remove the pump from the case, be sure pump is turned "OFF" (red, open circle)
2. Plug in the approriate power cord into the outlet in the back of the pump & the other end of the power cord into the power source.
3. Insert the tubing into the pump head.
4. Put one end of the tubing into the sample source (well, river, ditch, lagoon, etc.) and the other end into the sample container.
5. Determine the desired direction of flow and turn the direction toggle switch in that direction.
6. Turn the pump "ON" (the black, filled circle).
7. When pumping has begun, the speed dial can be adjusted to the speed desired.

SPECIFICATIONS

Operating range	27 feet at sea level
Principle of Operation	mechanical peristalsis
Dimensions	3.5 x 8 x 8 inches
Power source	any external 12 VDC or 120 VAC
Power cord	12 VDC adapter cord or standard AC power cord
Power cord length	AC cord: 8 feet; DC cord 15 feet
Range of speed: Series I	60 to 350 rpm
Range of speed: Series II	first pumping station 30 to 300 rpm second pumping station 60 to 600 rpm
Speed control	stepless variable speed control
Liquid delivery rate	1.67 ml per revolution (for size 15 tubing)
Pumping options	pressure or vacuum (reversible flow)
Pump head rotor	cold rolled steel

OPTIONS

Models:	Geopump1, Geopump 2
Tubing:	Silicon, Tygon
Pump heads:	Standard, Easyload, Quickload

DIGITAL TITRATOR

16900-08

Digital Titrator

Model 16900

© Hach Company, 1980-1997. Digital Titrator manufactured under U.S. Patent 4.086.062
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al/cth 8/25/97 23 ed

Note: Strikethrough sections are not used on this job and have been removed from the Operations Manual.

TABLE OF CONTENTS

SPECIFICATIONS vii

OPERATION

GENERAL DESCRIPTION 3

1.1 Introduction 3
- 1.1.1 Following a Procedure for the First Time 4

1.2 Step-By-Step 5

1.3 Helpful Hints 10
- 1.3.1 To Reuse a Partially Emptied Cartridge 10
- 1.3.2 To Calculate Titrant Volume Used 10
- 1.3.3 To Fill Your Own Titration Cartridges 10
- 1.3.4 Verifying Technique 11

1.4 Adapting a Buret Titration to the Digital Titrator 14

1.5 Using PermaChem® Powder Pillows 15

1.6 Safety 16

TITRATION PROCEDURES

~~ACID-BASE~~
~~Acid Determination ..... 21~~
~~Base Determination ..... 23~~

~~ACIDITY~~
~~Methyl Orange Method ..... 27~~
~~Phenolphthalein (Total) Method ..... 29~~

ALKALINITY
Phenolphthalein and Total Method 33

CARBON DIOXIDE
Using Sodium Hydroxide 41

~~CHELANT, FREE~~
~~Using Magnesium Chloride ..... 45~~

~~CHELANT, TOTAL~~
Using Bismuth Nitrate 49

~~CHLORIDE~~
~~Mercuric Nitrate Method ..... 53~~
~~Silver Nitrate Method ..... 54~~

~~CHLORINE, FREE AND TOTAL~~
~~DPD-FEAS Method ..... 61~~

TABLE OF CONTENTS, continued

~~CHLORINE, TOTAL~~
~~Iodometric Method (1 - 400 mg/L as Cl_2 Using Sodium Thiosulfate) ..... 65~~
~~Iodometric Method (20 - 70,000 mg/L as Cl_2 Using Sodium Thiosulfate) ..... 68~~

~~CHLORINE, FREE~~
~~Amperometric Forward Titration ..... 73~~

~~CHLORINE, TOTAL~~
~~Amperometric Back Titration ..... 79~~

~~CHLORINE, TOTAL~~
~~Amperometric Forward Titration ..... 89~~

~~CHROMATE~~
~~Using Sodium Thiosulfate ..... 95~~

~~HARDNESS DECISION TREE ..... 99~~

~~HARDNESS, CALCIUM~~
~~Using EDTA ..... 101~~

~~HARDNESS, TOTAL~~
~~Using EDTA ..... 107~~

~~HARDNESS, TOTAL, SEQUENTIAL~~
~~Sequential Titration Procedure (Limited Sample) ..... 115~~

~~HYPOCHLORITE (Bleach)~~
~~Iodometric Method ..... 123~~

~~IRON~~
~~Using the TitraVer® Titration Cartridge ..... 127~~

NITRITE
~~Using Ceric Standard Solution ..... 131~~

OXYGEN, DISSOLVED
Azide Modification of Winkler Method 135
Using a 300-mL BOD Bottle 135
Using a 60-mL BOD Bottle 137

~~SALINITY~~
~~Using Mercuric Nitrate ..... 141~~

~~SULFITE~~
~~Using Iodate-Iodide ..... 143~~

~~TURBIDITY STANDARDS~~
~~Preparing Turbidity-Free Water ..... 147~~

~~VOLATILE ACIDS~~
~~Using Sodium Hydroxide ..... 153~~

TABLE OF CONTENTS, continued

APPENDIX A
ACCURACY CHECK AND STANDARD ADDITIONS 157

GENERAL INFORMATION

REPLACEMENT PARTS AND ACCESSORIES 169

ORDERING INFORMATION 171

SPECIFICATIONS

Digital Titrator

Delivery: 800 digits/mL or 0.00125 mL/digit

Accuracy*: ±1% for readings over 100 digits. (Uncertainty of readings is 1 digit. Most samples require more than 100 digits.)

Weight: 132 g (4.7 oz.)

Cartridges for the Digital Titrator

Volume: 13 mL

Number of tests: Most reagents are formulated to provide 100 typical titrations; the number may vary depending on sample concentration.

Weight (full): 56.75 g (2 oz.)

* Overall method accuracy includes: in addition to the Digital Titrator, other sources of error controlled by the analyst. The other sources of error include: sampling, sample volume, dilution (if required), end point detection, reagent quality, and interferences.

OPERATION

WARNING

Handling chemical samples, standards, and reagents can be dangerous. Review the necessary Material Safety Data Sheets and become familiar with all safety procedures before handling any chemicals.

ADVERTÊNCIA

A manipulação de amostras, padrões e reagentes químicos pode ser perigosa. Reveja as necessárias Fichas Técnicas de Segurança do Material e familiarizese com os procedimentos de segurança antes de manipular quaisquer substâncias químicas.

ADVERTENCIA

La manipulación de muestras químicas, patrones y reactivos puede ser peligrosa. Antes de manipular cualquier productor químico, conviene leer las Fichas Técnicas de Seguridad y familiarizarse con los procedimientos de seguridad.

ATTENTION

La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les fiches de données de sécurité des produits nécessaires et se familiariser avec toutes les procédures de sécurité avant de manipuler tout produit chimique.

WARNUNG

Da das Arbeiten mit chemikalischen Proben, Standards, Reagenzien und Abfällen mit Gefahren verbunden ist, empfiehlt die Hach Company dem Benutzer dieser Produkte dringend, sich vor der Arbeit mit sicheren Verfahrensweisen und dem richtigen Gebrauch der Chemikalien oder Biogefahrgut vertraut zu machen und alle entsprechenden Materialsicherheitsdatenblätter aufmerksam zu lesen.

GENERAL DESCRIPTION

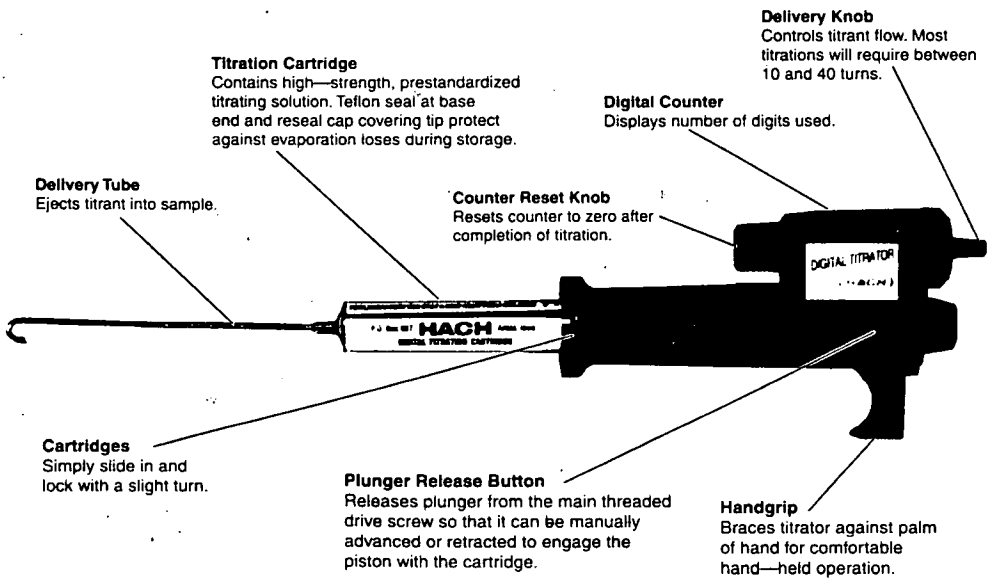
1.1 Introduction

Hach's Digital Titrator is a new concept in titrimetric analysis. It is a precision dispensing device fitted with compact cartridges that contain concentrated titrants. Accurate titrations are made without the bulk and fragility of conventional burets.

A main drive screw in the Digital Titrator controls a plunger which forces the solution from a titration cartridge in a carefully regulated flow. The titrator body is constructed of precision-molded, heavy-duty, chemical- and impact-resistant acetal plastic. Accuracy is rated at ±1% or better for a titration of more than 100 digits. For titrations less than 100 digits the accuracy is ±1 digit.

Titration solutions (titrants) are packaged in disposable polypropylene or Kynar® containers with Teflon-covered neoprene seals and polyethylene resealable closures to cover the cartridge tips. Each cartridge contains approximately 13 mL of titrating solution, enough for 50-100 average titrations. Titrant solutions are typically controlled to ±0.5% concentration with normality and tolerances listed on the label. Titrant concentrations are designed for titrations of 10 to 40 turns (100 to 400 digits) of the delivery knob. For the most commonly used concentration ranges, the digits appearing in the counter window correspond to the sample concentration.

Figure 1 Hach Digital Titrator



Both portable and fixed-position titrations are possible with the Digital Titrator. The instrument has a grip for hand-held operation or it can be clamped to a TitraStir® Stir Plate or laboratory stand for stationary setups. See *Figure 1*.

Each Digital Titrator comes with five delivery tubes and a methods manual, which covers the most commonly tested parameters and the corresponding titrant cartridges. Right-angle (ninety-degree) delivery tubes for stationary setups are available as an optional accessory.

1.1.1 Following a Procedure for the First Time

Each method is divided into five sections: Procedure, Accuracy Check, Interferences, Summary of Method, and Reagents and Apparatus. For more information about how to select a procedure or for answers to chemical questions, see Hach's *Water Analysis Handbook* (literature 8376). For more information about chlorine measurement, also see the technical booklet titled, *Current Technology of Chlorine Analysis for Water and Wastewater* (literature 7019).

The **Procedure** details how to perform the method step-by-step. To select the appropriate sample volume and titration cartridge based on expected sample concentration, use the tables provided in each procedure. If the expected sample concentration is not known, start with one of the smaller sample volumes and determine its approximate concentration. Retest with the appropriate sample size.

The ranges in the table overlap to offer more flexibility. In most procedures, the number of digits used for each concentration range will be 100 to 400 digits.

To determine the actual concentration of the sample, use the correct digit multiplier for the sample volume and titration cartridge used.

Throughout the procedure, the notes will provide additional information.

The **Accuracy Check** provides a way to verify the results and determine if interferences are present. It also provides a method for checking the performance of reagents, the Digital Titrator and the operator's technique. Further information is provided in *APPENDIX A, ACCURACY CHECK AND STANDARD ADDITIONS*.

The **Interferences** section identifies common interferences causing inaccurate results and describes how to eliminate their effects. The interference levels are based on the sample volume that has 1.0 as the digit multiplier. Higher interference levels may be tolerated if a smaller sample is used.

The **Summary of Method** section discusses the chemical reaction taking place and information that applies to the entire procedure.

The **Reagents and Apparatus** list concludes the procedure. All the items required to perform the test are listed first and are available from Hach. The items listed in the notes or interferences sections are included in the optional listings.

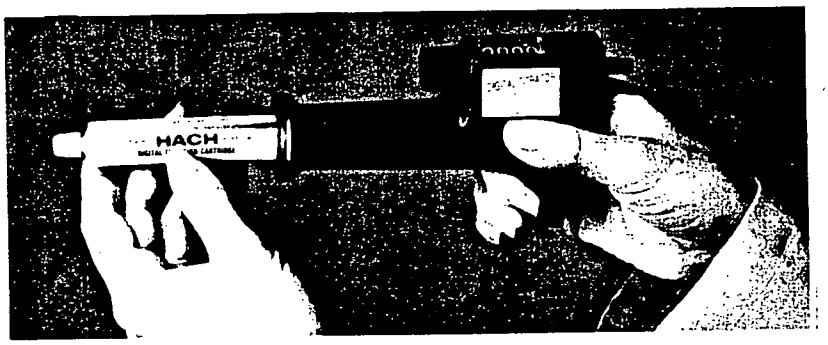
1.2 Step-By-Step

1. Select a sample volume and titration cartridge corresponding to the expected sample concentration from the table given in each procedure.

   If the expected sample concentration is not known, start with one of the smaller sample volumes and determine its approximate concentration. Retest with the appropriate sample size.

2. Slide the cartridge into the titrator receptacle and lock in position with a slight turn. See *Figure 2*.

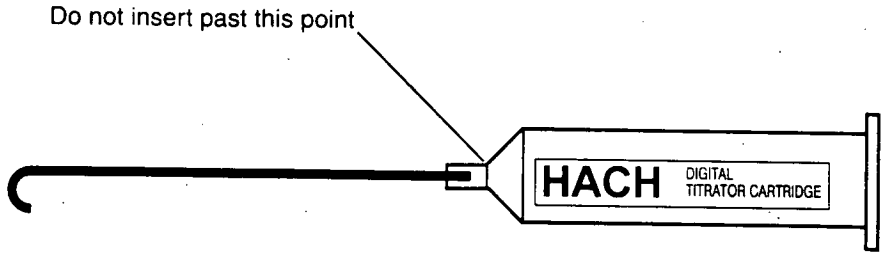
Figure 2 Sliding the Cartridge into Place



3. Remove the polyethylene cap and insert a clean delivery tube into the end of the cartridge until it is tight. See *Figure 3*. Use a straight tube with a hook at the end for hand-held titrations; use a 90° tube with a hook at the end for stationary setups.

   Do not insert tube past cartridge extension; see illustration below. In some instances, it might be necessary to remove a small burr on the leading edge of the tube before insertion.

Figure 3 Inserting the Delivery Tube



4. For stationary titrations, use a TitraStir Stir Plate or a clamp holder and clamp to attach the titrator to a laboratory stand. See *Figure 4* and *Figure 5*.

   The TitraStir Stir Plate holds the Digital Titrator during the titration and also stirs the sample at a constant speed, leaving the analyst free to detect the endpoint. When a TitraStir Stir Plate is used, substitute or add the following Optional Apparatus.

APPARATUS

Description	Quantity Required Per Test	Unit	Cat. No.
Delivery Tubes, 90° with hook for TitraStir Stir Plate	1	5/pkg	41578-00
Flask, Erlenmeyer, 125 mL	1	each	505-43
Flask, Erlenmeyer, 250 mL	1	each	505-46
Stir Bar, 28.6 x 7.9 mm	1	each	20953-52
TitraStir Stir Plate, 115 Vac	1	each	19400-00
TitraStir Stir Plate, 230 Vac	1	each	19400-10

Figure 4 Using the TitraStir Stir Plate

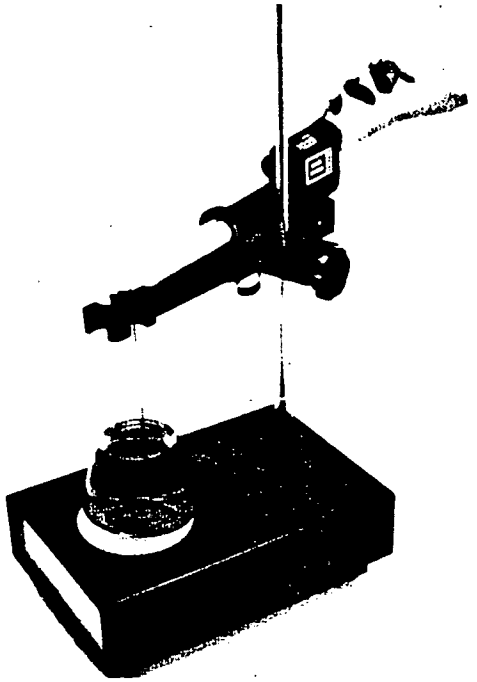
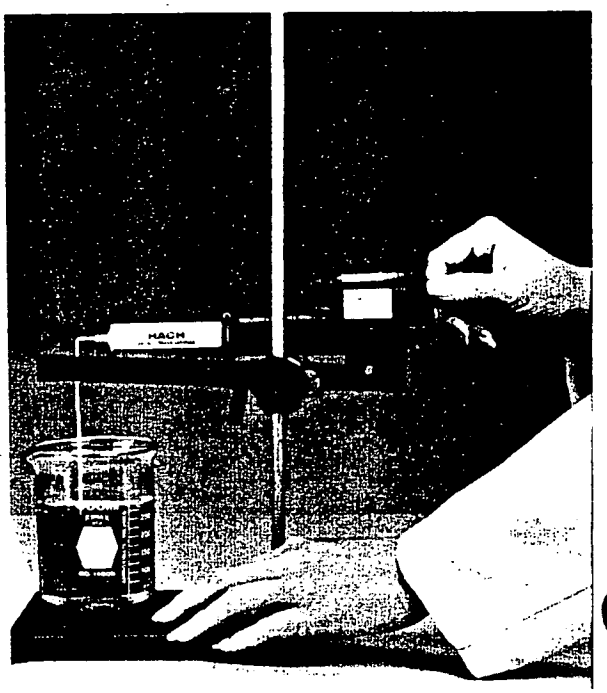


Figure 5 Using a Laboratory Stand



5. To start titrant flowing and flush the delivery tube, hold the tip of the cartridge up. Advance the plunger release button to engage the piston with the cartridge (push the button in and toward the cartridge). Do not expel solution when pushing the piston toward the cartridge. Turn the delivery knob until air is expelled and several drops of solution flow from the tip. As you turn the knob a drive screw pushes a piston against the cartridge seal and forces liquid out through the delivery tube. Then use the counter reset knob to turn the digital counter back to zero and wipe the tip. The tip can be rinsed with deionized water rather than wiped, if desired.

Figure 6 Titrating the Sample

6. Use the smallest appropriate graduated cylinder or pipet to measure the sample volume from the given table. Transfer the sample into a 125-mL or 250-mL Erlenmeyer flask. Dilute to the appropriate total volume with deionized water if necessary.

Note: *Sample volume measurements and dilutions (if required) must be made accurately. However, final total volume of titrated solution is not critical.*

7. Add the necessary reagents to the sample and swirl to mix.

8. Immerse the delivery tube tip in the solution and swirl the flask while titrating. Titrate by turning the delivery knob. Keep turning the knob and swirling the sample until the end point is reached. Record the number of digits that appear in the digital counter window. See *Figure 6.*

Note: *The number of digits required will usually range from 100 to 400. In nearly all of the procedures if the digits required is less than 100 or more than 400, an alternate sample volume or titrant cartridge should be used.*

Note: *Inaccurate results will occur if the delivery tube tip is held out of the solution rather than under the solution surface.*

9. Calculate the concentration of your sample by using the following formula:

Digits Required × Digit Multiplier = Sample Concentration

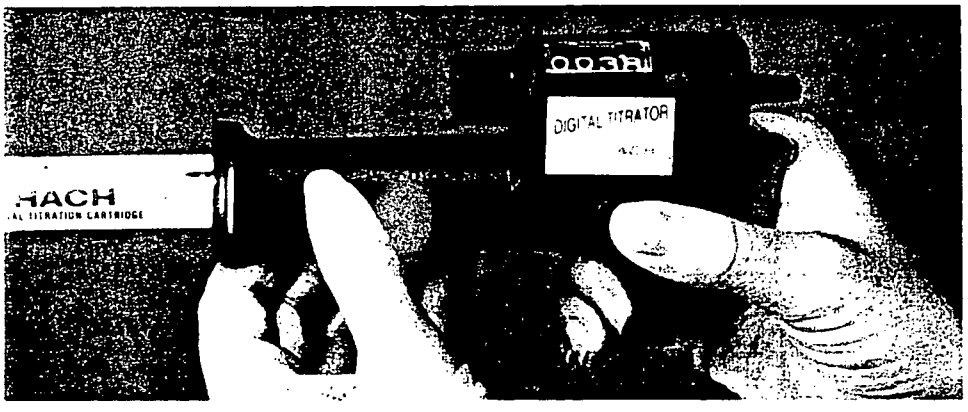
Where:

Digits Required = the number that appeared in the digital counter window in Step 8.

Digit Multiplier = the number from the table given in the procedure. It takes into account the sample dilution and titrant strength.

10. After completing testing for the day, press the plunger release button and manually retract the plunger into the body of the titrator. Remove the cartridge. Remove the delivery tube and reseal the cartridge with the polyethylene cap. See *Figure 7.*

Figure 7 Retracting the Plunger



11. Discard or clean the delivery tube immediately after use.
    To clean, force water, then air, into the tube opening with a syringe or wash bottle.

1.3 Helpful Hints

1.3.1 To Reuse a Partially Emptied Cartridge

1. With the plunger fully retracted, attach cartridge to the titrator.
2. Press the plunger release; then manually push the plunger against the cartridge seal.
3. Attach a delivery tube. Hold the tip of the cartridge up. Eject air and a few drops of titrant, zero the counter, and wipe the tip.
4. Titrate as usual.

1.3.2 To Calculate Titrant Volume Used

Normalities of many Hach titration cartridge solutions have been designed so that the number of digits used in a titration corresponds to the sample concentration in mg/L. To determine the volume used in mL, divide the Digital Titrator reading by 800.

1.3.3 To Fill Your Own Titration Cartridges

Cartridges may be cleaned and refilled, or new empty cartridges, Cat. No. 14495-01, can be purchased from Hach Company. See *Figure 8*. When preparing to refill old cartridges, push the cartridge seal out of the cartridge with air pressure applied through the tip. Cap the tip, fill with solution and reinsert the cartridge seal using care to avoid wrinkling the Teflon sheath. Filling also can be accomplished at the tip with a syringe.

Figure 8 Digital Titrator Cartridges

1.3.4 Verifying Technique

Whenever procedures are changed or new equipment is used, it is helpful to run a sample of known concentration. This technique will confirm the operator is following the procedure correctly and the new equipment is working properly. One objective important to Hach Company is making our tests self-verifying. This means Hach makes the tools available so the operator can check their own work for accurate results without relying on an outside lab or chemist.

For most of the tests in this manual, Table 1 on page 12 lists each procedure, the suggested standard, the volume of standard needed, the titration cartridge used, and the number of expected digits when the test is performed correctly. The suggested standards are Voluette® or PourRite® Ampules whenever possible because of their superior accuracy and stability.

To use titration standards follow these steps:

1. Select the procedure of interest and order the appropriate standard. Use the given catalog numbers.

2. Measure the volume of standard to be used as the sample in the procedure using a TenSette® Pipet or Class A pipet.

3. Perform the procedure as written, adding deionized water as necessary.

4. After titrating, the required number of digits should approximately equal the expected digits.

Call Hach Technical and Customer Service (1-800-227-4224) for additional help.

Table 1 Titration Standards

Procedure (Parameter)	Standard Description (Cat. No.)	Volume of Standard (mL)	Titration Cartridge (Cat. No.)	Expected Digits
Acid-Base: Acid	0.500 N H_2SO_4 (2121-26)	1.0	1.600 N NaOH (14379-01)	250
		5.0	8.00 N NaOH (14381-01)	250
Base	0.500 N Na_2CO_3 (14278-10)	1.0	1.600 N H_2SO_4 (14389-01)	250
		5.0	8.00 N H_2SO_4 (14391-01)	250
Acidity	0.500 N H_2SO_4 (2121-26)	0.1	0.1600 N NaOH (14377-01)	250
		1.0	1.600 N NaOH (14379-01)	250
Alkalinity	0.500 N Na_2CO_3 (14278-10)	0.1	0.1600 N H_2SO_4 (14388-01)	250
		1.0	1.600 N H_2SO_4 (14389-01)	250
Calcium[1]: mg/L $CaCO_3$	10,000 mg/L $CaCO_3$ (2187-10)	0.1	0.0800 M EDTA (14364-01)	100
		1.0	0.800 M EDTA (14399-01)	100
G.d.h.	10,000 mg/L $CaCO_3$ (2187-10)	0.2	0.1428 M EDTA (14960-01)	112
		1.0	0.714 M EDTA (14959-01)	112
Carbon Dioxide	10,000 mg/L CO_2 (14275-10)	0.2	0.3636 N NaOH (14378-01)	100
		2.0	3.636 N NaOH (14380-01)	
Chloride	12,500 mg/L Cl (14250-10)	0.1	0.2256 N $Hg(NO_3)_2$ (14393-01)	125
		0.1	0.2256 N $AgNO_3$ (14396-01)	125
		1.0	1.128 N $AgNO_3$ (14397-01)	250
		1.0	2.256 N $Hg(NO_3)_2$ (921-01)	125

Table 1 Titration Standards (Continued)

Procedure (Parameter)	Standard Description (Cat. No.)	Volume of Standard (mL)	Titration Cartridge (Cat. No.)	Expected Digits
Chlorine	~50 mg/L Cl_2 (14268-20) (see certificate)	2.0	0.02256 N $Na_2S_2O_3$ (24091-01)	varies[2]
	~25 mg/L Cl_2 (26300-20)	0.5	0.00564 N FEAS (22923-01)	varies[3]
Chromate	1000 mg/L Cr (2231 mg/L CrO_4) (14664-42)	1.0	0.2068 N $Na_2S_2O_3$ (22676-01)	223
Hardness: mg/L $CaCO_3$	10,000 mg/L $CaCO_3$ (2187-10)	0.1	0.0800 M EDTA (14364-01)	100
		0.1	0.0800 M CDTA (14402-01)	100
		1.0	0.800 M EDTA (14399-01)	100
		1.0	0.800 M CDTA (14403-01)	100
G.d.h.	10,000 mg/L $CaCO_3$ (2187-10)	0.2	0.1428 M EDTA (14960-01)	112
		1.0	0.714 M EDTA (14959-01)	112
Iron	50 mg/L Fe (14254-10)	10.0	0.0716 M TitraVer (20817-01)	200
	1000 mg/L Fe (2271-42)	10.0	0.716 M TitraVer (20818-01)	100
Oxygen, Dissolved[4]	10 mg/L as DO (401-11)	100	0.2000 N $Na_2S_2O_3$ (22675-01)	500
		200	2.00 N $Na_2S_2O_3$ (14401-01)	100
Sulfite	5000 mg/L SO_3 (22674-10)	1.0	0.3998 N $KIO_3 \cdot KI$ (14961-01)	250

1 One to two drops of Magnesium Standard Solution (10 g/L as $CaCO_3$) must be added to get a sharp endpoint. These added drops will not change the results.

2 The expected digits equal the volume of standard times the concentration on the certificate (e.g., 2 mL x 50 mg/L = 100 digits).

3 The expected digits equals the volume of standard times the concentration on the certificate times the constant. 4. (Example: 0.5 mL x 50 mg/L x 4 = 100 digits)

4 Add one Sulfamic Acid Powder Pillow to the volume of standard and follow Steps 10 to 12 in the Dissolved Oxygen Procedure. It is not necessary to add the first two reagents.

1.4 Adapting a Buret Titration to the Digital Titrator

Adapt any standard titration procedure using a buret to the Digital Titrator by using the following procedure.

1. Determine the approximate number of digits required. The Digital Titrator dispenses 1 mL per 800 digits on the counter. Using the following equation, determine the digits required for your buret method.

$$\text{Digits Required} = \frac{N_t \times mL_t \times 800}{N_c}$$

Where:

N_t = Normality of buret titrant
mL_t = milliliters of buret titrant required for an average titration
N_c = Normality of Digital Titrator cartridge

2. If the number of digits required is within the range of 70 to 350, you can use the procedure as written, substituting the Digital Titrator directly for the buret. Or, if the number of digits is outside of this range, make the following modifications:

   a) If the number of digits required is more than 350, reduce the sample size to save titrant.

   b) If the number of digits required is less than 70, increase the sample size to increase precision.

   c) If the sample size is altered, adjust the amount of buffering or indicating reagents by the same proportion.

3. When using the Digital Titrator for your buret method, note the number of digits required for a sample titration. To convert the digits required to the equivalent number of milliliters if the buret method was used, calculate:

$$\text{Equivalent Buret Milliliters} = \text{Digits Required} \times \frac{N_c}{800 \times N_t}$$

If the sample size was changed, adjust the equivalent buret milliliters accordingly. If the sample size was increased, reduce the equivalent buret milliliters; if the sample size was reduced increase the equivalent buret milliliters. Multiply the equivalent buret milliliters by any normally used factors to calculate concentration in oz/gal, g/L, etc.

Example: Adapt a buret procedure, which normally requires about 20 mL of a 0.4 N titrant, to the Digital Titrator. Try an 8.0 N titration cartridge. The first equation above gives:

$$\text{Digits Required} = \frac{0.4 \times 20 \times 800}{8.0} = 800 \text{ digits}$$

Because this would use excessive titrant, reduce the sample size to one fourth its normal size to reduce the digits required to 200, well within the recommended range.

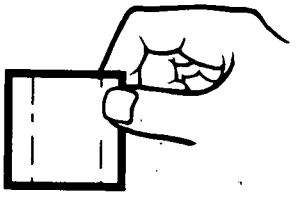
Upon completion of the titration using the smaller sample size, calculate the equivalent buret milliliters by the second equation above. If 205 were the digits required:

$$\text{Equivalent Buret Milliliters} = \frac{205 \times 8.0}{800 \times 0.4} = 5.13 \text{ mL}$$

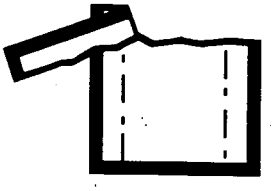
Multiply the 5.13 mL by 4 to account for the reduction in sample size to give the true equivalent buret milliliters of 20.5 mL. If the buret method called for multiplying the number of milliliters of titrant by a factor to calculate the concentration of a sample component, then multiply 20.5 by that factor.

1.5 Using PermaChem® Powder Pillows

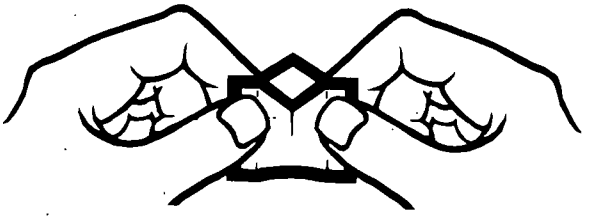
1. **Tap** the PermaChem on a hard surface to collect the powdered reagent in the bottom.



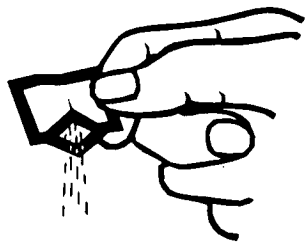
2. **Tear** across on the dotted pillow line marked 'TEAR' holding the pillow away from your face.



3. Using two hands, **Push** both sides toward each other until thumbs and forefingers form a diamond. Make sure to **Crease** the foil pack, so that it forms a spout.



4. **Pour** the pillow contents into the sample. The polyfilm lining is specially formulated to deliver all the powder necessary for accurate results (no tapping on the vessel edge is necessary).



1.6 Safety

Safety is the responsibility of each individual when performing analysis procedures, and the analyst must develop and maintain good safety habits. Because many of the procedures in this methods handbook use potentially hazardous chemicals and apparatus, it is important that the analyst practice good laboratory techniques to minimize accidents. The following paragraphs present several techniques applicable to water analysis in the laboratory and in the field. They are not all inclusive, of course, nor do they apply only to the procedures provided in this handbook. They are general in nature but emphasize practices that are often key factors in personal injury incidents.

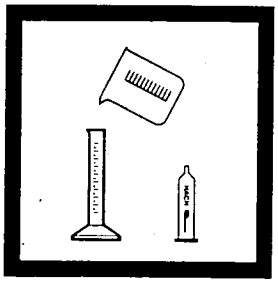
- Read labels carefully. Never remove the label from a reagent container. When preparing a reagent or standard solution, be sure to label the container clearly and date it.
- A Material Safety Data Sheet (MSDS) comes with each reagent. This sheet contains helpful information on first aid, spill and disposal procedures, and precautionary measures and should be read before using the product.
- Warning labels also appear on some of the apparatus used with the test procedures.
- Wear protective clothing when handling chemicals that cause irritation or burns. Eye protection in particular is important to guard against spattering and splashes from accidental spills when caustic materials are being used.
- Use tongs or finger cots when transferring apparatus that is hot.

- Use mechanical pipetters: Mouth pipetting could result in accidentally ingesting dangerous chemicals. Make a habit of using mechanical pipet fillers for all pipetting. This will avoid mistakes that could cause serious injury.
- Use special care with dangerous chemicals and apparatus.
- Follow the test procedure steps carefully and observe all precautionary measures. It is good practice to read the entire procedure carefully before beginning the procedure. Use safety equipment, such as pipet fillers, protective clothing, and ventilating hoods, appropriate for the test being conducted. Wipe up all spills promptly. Do not smoke or eat in an area where toxic or irritating chemicals are used. Use reagents and apparatus only as they were meant to be used and use them only as directed in the test procedure. Do not use damaged labware and malfunctioning equipment.

TITRATION PROCEDURES

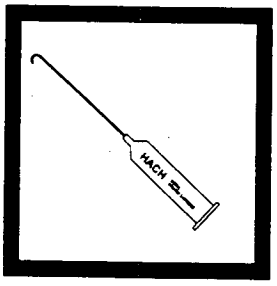
ALKALINITY (10 - 4000 mg/L as $CaCO_3$)

Phenolphthalein and Total Method

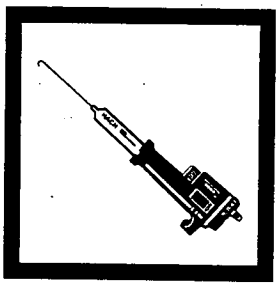


1. Select the sample volume and Sulfuric Acid (H_2SO_4) Titration Cartridge corresponding to the expected alkalinity concentration as mg/L calcium carbonate ($CaCO_3$) from *Table 1*.

Note: See Sampling and Storage following these steps.

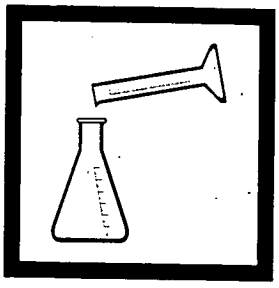


2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body. See *General Description, Step-by-Step* for assembly instructions, if necessary.



3. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

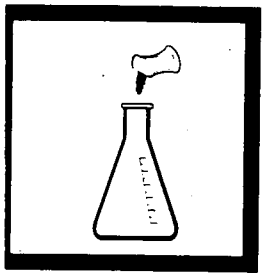
Note: For added convenience use the TitraStir Stir Plate. See General Description, Step 3 in Step-by-Step.



4. Use a graduated cylinder or pipet to measure the sample volume from *Table 1*. Transfer the sample into a clean 250-mL Erlenmeyer flask. Dilute to about the 100-mL mark with deionized water, if necessary.

Table 1

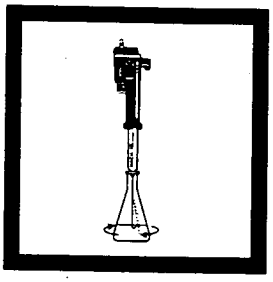
Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (H_2SO_4)	Catalog Number	Digit Multiplier
10-40	100	0.1600	14388-01	0.1
40-160	25	0.1600	14388-01	0.4
100-400	100	1.600	14389-01	1.0
200-800	50	1.600	14389-01	2.0
500-2000	20	1.600	14389-01	5.0
1000-4000	10	1.600	14389-01	10.0



5. Add the contents of one Phenolphthalein Indicator Powder Pillow and swirl to mix.

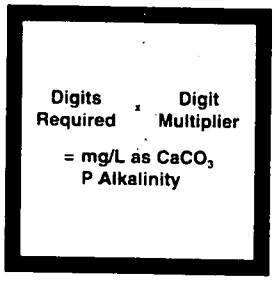
Note: A solution of one pH 8.3 Buffer Powder Pillow and one Phenolphthalein Powder Pillow in 50 mL of deionized water is recommended as a comparison for determining the proper end-point color.

Note: Four drops of Phenolphthalein Indicator Solution may be substituted for the Phenolphthalein Indicator Powder Pillow.



6. If the solution turns pink, titrate to a colorless end point. Place the delivery tube tip into the solution and swirl the flask while titrating with sulfuric acid. Record the number of digits required.

Note: If the solution is colorless before titrating with sulfuric acid, the Phenolphthalein (P) Alkalinity is zero; proceed with Step 8.



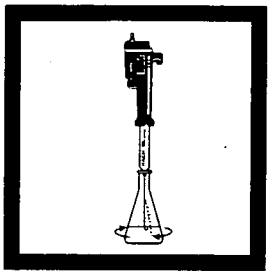
7. Calculate:

Digits Required x Digit Multiplier = mg/L $CaCO_3$ P Alkalinity

8. Add the contents of one Bromcresol Green-Methyl Red Indicator Powder Pillow to the flask and swirl to mix.

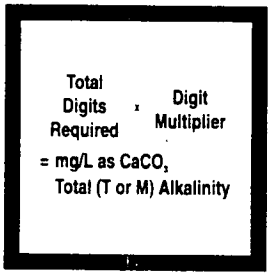
Note: Four drops of Methyl Purple Indicator Solution may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow. Titrate from green to a gray end point (pH 5.1).

Note: Four drops of Bromcresol Green-Methyl Red Indicator Solution may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow.



9. Continue the titration with sulfuric acid to a light greenish blue-gray (pH 5.1), a light violet-gray (pH 4.8), or a light pink (pH 4.5) color, as required by the sample composition; see *Table 2*. Record the number of digits required.

Note: *A solution of one Bromcresol Green-Methyl Red Powder Pillow and one pillow of the appropriate pH buffer in 50 mL of deionized water is recommended as a comparison for judging the proper end-point color. If the pH 3.7 end point is used, use a Bromphenol Blue Powder Pillow instead of a Bromcresol Green-Methyl Red and titrate to a green end point.*



10. Calculate:

Total Digits Required x Digit Multiplier = mg/L as $CaCO_3$ Total (T or M) Alkalinity

Note: *Carbonate, bicarbonate and hydroxide concentrations may be expressed individually using the relationships shown in Table 3.*

Note: *meq/L Alkalinity = mg/L as $CaCO_3$ ÷ 50.*

Table 2

Sample Composition	End Point
Alkalinity about 30 mg/L	pH 5.1
Alkalinity about 150 mg/L	pH 4.8
Alkalinity about 500 mg/L	pH 4.5
Silicates or Phosphates present	pH 4.5
Industrial waste or complex system	pH 3.7

Sampling and Storage

Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Samples should be analyzed as soon as possible after collection but can be stored at least 24 hours by cooling to 4 °C (39 °F) or below. Warm to room temperature before analyzing.

Alkalinity Relationship Table

Total alkalinity primarily includes hydroxide, carbonate and bicarbonate alkalinities. The concentration of these alkalinities in a sample may be determined when the phenolphthalein and total alkalinities are known (see *Table 3*).

Table 3 Alkalinity Relationship

Row	Result of Titration	Hydroxide Alkalinity is equal to:	Carbonate Alkalinity is equal to:	Bicarbonate Alkalinity is equal to:
1	Phenolphthalein Alkalinity = 0	0	0	Total Alkalinity
2	Phenolphthalein Alkalinity equal to Total Alkalinity	Total Alkalinity	0	0
3	Phenolphthalein Alkalinity less than one half of Total Alkalinity	0	2 times the Phenolphthalein Alkalinity	Total Alkalinity minus two times Phenolphthalein Alkalinity
4	Phenolphthalein Alkalinity equal to one half of Total Alkalinity	0	Total Alkalinity	0
5	Phenolphthalein Alkalinity greater than one half of Total Alkalinity	2 times the Phenolphthalein minus Total Alkalinity	2 times the difference between Total and Phenolphthalein Alkalinity	0

To use the table follow these steps:

a) Does the phenolphthalein alkalinity equal zero? If yes, use Row 1.

b) Does the phenolphthalein alkalinity equal total alkalinity? If yes, use Row 2.

c) Multiply the phenolphthalein alkalinity by 2.

d) Select Row 3, 4, or 5 based on comparing the result of Step c with the total alkalinity.

e) Perform the required calculations in the appropriate row, if any.

f) Check your results. The sum of the three alkalinity types will equal the total alkalinity.

For example:

A sample has 170 mg/L as $CaCO_3$ phenolphthalein alkalinity and 250 mg/L as $CaCO_3$ total alkalinity. What is the concentration of hydroxide, carbonate and bicarbonate alkalinities?

The phenolphthalein alkalinity does not equal 0 (it is 170 mg/L), see Step a.

The phenolphthalein alkalinity does not equal total alkalinity (170 mg/L vs. 250 mg/L), see Step b.

The phenolphthalein alkalinity multiplied by 2 = 340 mg/L, see Step c.

Because 340 mg/L is greater than 250 mg/L, select Row 5, see Step d.

The hydroxide alkalinity is equal to: (See Step e)

340 – 250 = 90 mg/L hydroxide alkalinity

The carbonate alkalinity is equal to:

250 – 170 = 80

80 × 2 = 160 mg/L carbonate alkalinity

The bicarbonate alkalinity equals 0 mg/L.

Check: (See Step f)

90 mg/L hydroxide alkalinity + 160 mg/L carbonate alkalinity + 0 mg/L bicarbonate alkalinity = 250 mg/L

The above answer is correct; the sum of each type equals the total alkalinity.

Accuracy Check

Standard Additions Method

This accuracy check should be performed when interferences are suspected or to verify analytical technique.

1. Snap the neck off an Alkalinity Standard Solution Voluette Ampule, 0.500 N.

2. Use a TenSette Pipet to add 0.1 mL of standard to the sample titrated in Steps 6 or 9. Resume titration back to the same end point. Record the number of digits needed.

3. Repeat, using two more additions of 0.1 mL. Titrate to the end point after each addition.

4. Each 0.1 mL addition of standard should require 25 additional digits of 1.600 N titrant or 250 digits of 0.1600 N titrant. If these uniform increases do not occur, refer to *APPENDIX A, ACCURACY CHECK AND STANDARD ADDITIONS.*

ıterferences

- Highly colored or turbid samples may mask the color change at the end point. Use a pH meter for these samples.
- Chlorine may interfere with the indicators. Add one drop of 0.1 N Sodium Thiosulfate to eliminate this interference.

ımmary of Method

The sample is titrated with sulfuric acid to a colorimetric end point corresponding to a specific pH. Phenolphthalein alkalinity is determined by titration to a pH of 8.3, as evidenced by the color change of phenolphthalein indicator, and indicates the total hydroxide and one half the carbonate present. M (methyl orange) or T (total) alkalinity is determined by titration to a pH between 3.7 and 5.1, and includes all carbonate, bicarbonate and hydroxide.

ƷQUIRED REAGENTS

ıries with sample characteristics)

kalinity Reagent Set (about 100 tests) 22719-00

Includes: (1) 942-99, (1) 943-99, (1) 14388-01, (1) 14389-01

scription	Unit	Cat. No
omcresol Green-Methyl Red Powder Pillows	100/pkg	943-99
enolphthalein Powder Pillows	100/pkg	942-99
lfuric Acid Titration Cartridge, 1.600 N	each	14389-01
lfuric Acid Titration Cartridge, 0.1600 N	each	14388-01
ıter, deionized	4 L	272-56

REQUIRED APPARATUS

Description	Unit	Cat. No
Digital Titrator	each	16900-01
Flask, Erlenmeyer, 250 mL	each	505-46
Select one or more based on sample concentration		
Cylinder, graduated, 10 mL	each	508-38
Cylinder, graduated, 25 mL	each	508-40
Cylinder, graduated, 50 mL	each	508-41
Cylinder, graduated, 100 mL	each	508-42

OPTIONAL REAGENTS

Alkalinity Standard Solution, Voluette Ampule, 0.500 N Na_2CO_3, 10 mL	16/pkg	14278-10
Bromcresol Green-Methyl Red Indicator Solution	100 mL MDB	23292-32
Bromphenol Blue Indicator Solution	100 mL MDB	14552-32
Bromphenol Blue Powder Pillows	100/pkg	14550-99
Buffer Powder Pillows, pH 3.7	25/pkg	14551-68
Buffer Powder Pillows, pH 4.5	25/pkg	895-68
Buffer Powder Pillows, pH 4.8	25/pkg	896-68
Buffer Powder Pillows, pH 5.1	25/pkg	897-68
Buffer Powder Pillows, pH 8.3	25/pkg	898-68
Methyl Purple Indicator Solution	100 mL MDB	21934-32
Phenolphthalein Indicator Solution, 5 g/L	100 mL MDB*	162-32
Sodium Thiosulfate Standard Solution, 0.1 N	100 mL MDB	323-32

OPTIONAL APPARATUS

Bottle, wash, poly, 500 mL	each	620-11
Clamp, 2-prong extension, 38 mm	each	21145-00
Clamp Holder	each	326-00
Demineralizer Assembly, 473 mL	each	21846-00
Delivery Tubes, with 180° hook	5/pkg	17205-00
Delivery Tubes, 90° with hook for TitraStir Stir Plate	5/pkg	41578-00
Hach One Combination pH Electrode with Temp	each	48600-22
pH Meter, EC10, portable	each	50050-60
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet Tips for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 10 mL	each	14515-38
Pipet, volumetric, Class A, 20 mL	each	14515-20
Pipet, volumetric, Class A, 25 mL	each	14515-40
Pipet, volumetric, Class A, 50 mL	each	14515-41
Pipet, volumetric, Class A, 100 mL	each	14515-42
Pipet Filler, safety bulb	each	14651-00

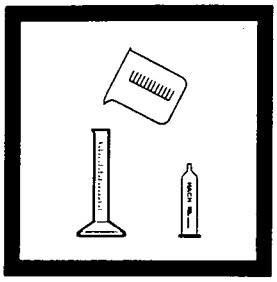
* Contact Hach for larger sizes.

OPTIONAL APPARATUS, continued

Description	Unit	Cat. No
upport Ring Stand	each	563-00
itraStir Stir Plate, 115 Vac	each	19400-00
itraStir Stir Plate, 230 Vac	each	19400-10
oluette Ampule Breaker Kit	each	21968-00

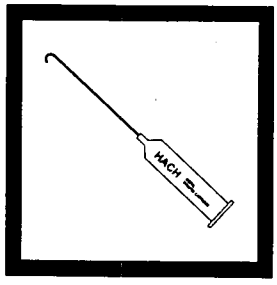
CARBON DIOXIDE (10 - 1000 mg/L as CO_2)

Using Sodium Hydroxide

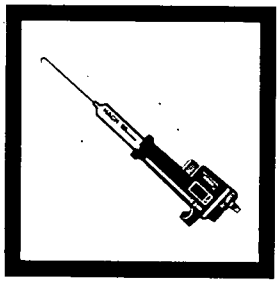


1. Select a sample size and a Sodium Hydroxide (NaOH) Titration Cartridge corresponding to the expected carbon dioxide (CO_2) concentration; see *Table 1*.

Note: *See Sampling and Storage following these steps.*



2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body. See *General Description, Step-by-Step* for assembly instructions if necessary.



3. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

Note: *For added convenience use the TitraStir Stir Plate. See General Description, Step 3 in Step-by-Step.*

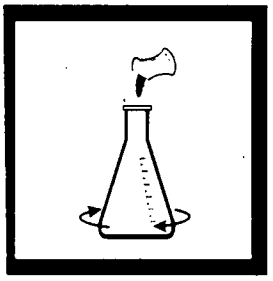
4. Collect a water sample directly into the titration flask by filling to the appropriate mark.

Note: *Minimize agitation because carbon dioxide may be lost.*

Note: *For most accurate results, check the calibration of the Erlenmeyer flask by measuring the proper volume in a graduated cylinder. Mark the proper volume on the flask with a permanent marker.*

Table 1

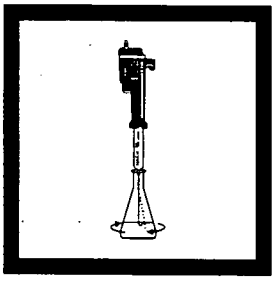
Range (mg/L as CO_2)	Sample Volume (mL)	Titration Cartridge (N NaOH)	Catalog Number	Digit Multiplier
10-50	200	0.3636	14378-01	0.1
20-100	100	0.3636	14378-01	0.2
100-400	200	3.636	14380-01	1.0
200-1000	100	3.636	14380-01	2.0



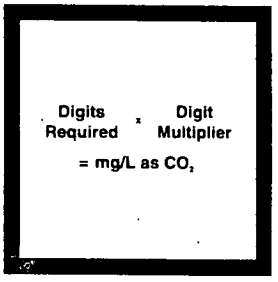
5. Add the contents of one Phenolphthalein Indicator Powder Pillow and mix.

Note: Four drops of Phenolphthalein Indicator Solution may be substituted for the Phenolphthalein Indicator Powder Pillow.

Note: If a pink color forms, no carbon dioxide is present.



6. Place the delivery tube tip into the solution and swirl the flask gently while titrating with sodium hydroxide from colorless to a light pink color that persists for 30 seconds. Record the number of digits required.



7. Calculate:

Total Digits Required x Digit Multiplier = mg/L as CO_2

Sampling and Storage

Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Analyze samples as soon as possible after collection. If immediate analysis is not possible, the samples may be stored for at least 24 hours by cooling to 4 °C (39 °F) or below. Before analysis, warm the samples to room temperature.

Accuracy Check

Standard Additions Method

This accuracy check should be performed when interferences are suspected or to verify analytical technique.

1. Snap the neck off a Carbon Dioxide Standard Solution Voluette Ampule, 10,000 mg/L CO_2.

2. Use a TenSette Pipet to add 0.1 mL of standard to the sample titrated in Step 6. Resume titration back to the same end point. Record the number of digits required.

3. Repeat, using additions of 0.2 mL and 0.3 mL. Titrate to the same end point after each addition.

4. Each 0.1 addition of standard should require 50 additional digits of 0.3636 N titrant or five digits of 3.636 N titrant. If these uniform increases do not occur, refer to *APPENDIX A, ACCURACY CHECK AND STANDARD ADDITIONS.*

Interferences

- Other acid components in the sample will be titrated and interfere directly in this determination.
- Sodium hydroxide standard solutions tend to lose strength slowly with age and should be checked periodically by titrating a known standard. Check the solution frequently (monthly) by titrating 50 mL of Potassium Acid Phthalate Standard Solution, 100 mg/L CO_2, using Phenolphthalein Indicator Solution. The titration should require 5.00 mL of titrant. If the volume required for this titration is greater than 5.25 mL, discard the sodium hydroxide and replace it with a fresh supply.

Summary of Method

Acidity due to carbon dioxide in a sample is titrated with sodium hydroxide to a phenolphthalein end point. Strong acids are assumed to be absent or of insignificant concentration. Request *Hach Water Analysis Handbook*, Publication 8376, to obtain additional information on carbon dioxide determinations.

REQUIRED REAGENTS

(varies with sample characteristics)

Carbon Dioxide Reagent Set (about 100 tests) 22727-00
Includes: (1) 942-99, (1) 14378-01, (1) 14380-01

Description	Unit	Cat. No.
Phenolphthalein Powder Pillows	100/pkg	942-99
Sodium Hydroxide Titration Cartridge, 0.3636 N	each	14378-01
Sodium Hydroxide Titration Cartridge, 3.636 N	each	14380-01
Water, deionized	4 L	272-56

CARBON DIOXIDE, continued

REQUIRED APPARATUS

Description	Unit	Cat. No.
Digital Titrator	each	16900-01
Select one or more based on sample concentration		
Flask, Erlenmeyer, 250 mL	each	505-46
Flask, Erlenmeyer, 125 mL	each	505-43

OPTIONAL REAGENTS

Carbon Dioxide Standard Solution, Voluette Ampule, 10,000 mg/L as CO_2, 10 mL	16/pkg	14275-10
Phenolphthalein Indicator Solution, 5 g/L	100 mL MDB*	162-32
Potassium Acid Phthalate Standard Solution, 100 mg/L as CO_2	100 mL	2261-42
Potassium Acid Phthalate Standard Solution, 400 mg/L as CO_2	500 mL	1885-49

OPTIONAL APPARATUS

Clamp, 2-prong extension, 38 mm	each	21145-00
Clamp Holder	each	326-00
Delivery Tubes, with 180° hook	5/pkg	17205-00
Delivery Tubes, 90° with hook for TitraStir Stir Plate	5/pkg	41578-00
pH Meter, EC 10, portable	each	50050-00
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet Tips for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet Filler, safety bulb	each	14651-00
Support Ring Stand	each	563-00
TitraStir Stir Plate, 115 Vac	each	19400-00
TitraStir Stir Plate, 230 Vac	each	19400-10
Voluette Ampule Breaker Kit	each	21968-00

* Contact Hach for larger sizes.

OXYGEN, DISSOLVED (1 to greater than 10 mg/L as DO)

Azide Modification of Winkler Method

Using a 300-mL BOD Bottle

Method 8215

1. Collect a water sample in a clean 300-mL BOD Bottle.

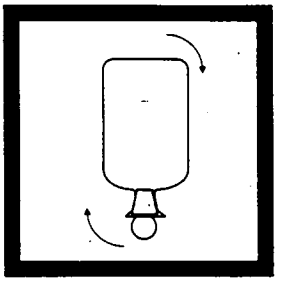
Note: Allow the sample to overflow the bottle for 2-3 minutes to ensure air bubbles are not trapped.

Note: If samples cannot be analyzed immediately, see Sampling and Storage following these steps.

2. Add the contents of one Manganous Sulfate Powder Pillow and one Alkaline Iodide-Azide Reagent Powder Pillow.

3. Immediately insert the stopper so air is not trapped in the bottle. Invert several times to mix.

Note: A flocculent precipitate will form. It will be orange-brown if oxygen is present or white if oxygen is absent. The floc settles slowly in salt water and normally requires 5 additional minutes before proceeding to Step 5.

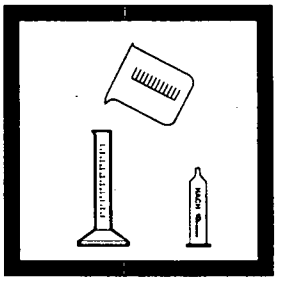


4. Wait until the floc in the solution has settled. Again invert the bottle several times and wait until the floc has settled.

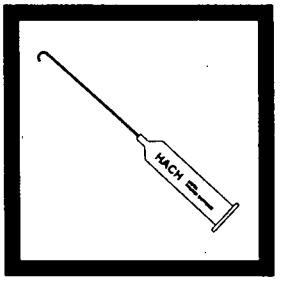
Note: Waiting until floc has settled twice assures complete reaction of the sample and reagents.

5. Remove the stopper and add the contents of one Sulfamic Acid Powder Pillow. Replace the stopper without trapping air in the bottle and invert the prepared sample several times to mix.

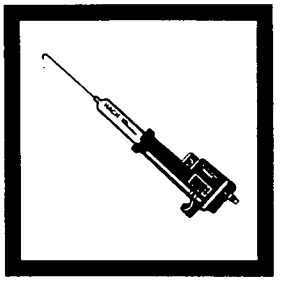
Note: The floc will dissolve and leave a yellow color if oxygen is present.



6. Select a sample volume and Sodium Thiosulfate Titration Cartridge corresponding to the expected dissolved oxygen (D.O.) concentration from *Table 1*.



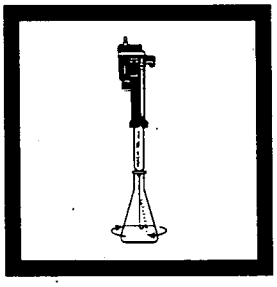
7. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body. See *General Description, Step-by-Step* for assembly instructions, if necessary.



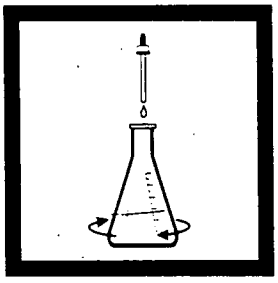
8. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

Note: For added convenience use the TitraStir Stir Plate. See General Description, Step 3 in Step-by-Step.

9. Use a graduated cylinder to measure the sample volume from *Table 1*. Transfer the sample into a 250-mL Erlenmeyer flask.

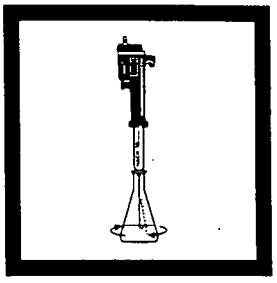


10. Place the delivery tube tip into the solution and swirl the flask while titrating with sodium thiosulfate to a pale yellow color.



11. Add two 1-mL droppers of Starch Indicator Solution and swirl to mix.

Note: A dark blue color will develop.



12. Continue the titration to a colorless end point. Record the number of digits required.

Digits Required x Digit Multiplier

= mg/L Dissolved Oxygen

13. Calculate:

Digits Required x Digit Multiplier
= mg/L Dissolved Oxygen

Table 1

Range (mg/L D.O.)	Sample Volume (mL)	Titration Cartridge (N $Na_2S_2O_3$)	Catalog Number	Digit Multiplier
1-5	200	0.200	22675-01	0.01
2-10	100	0.200	22675-01	0.02
>10	200	2.000	14401-01	0.1

Using a 60-mL BOD Bottle

Method 8332

1. Collect a water sample in a clean 60-mL glass-stoppered BOD Bottle.

Note: *Allow the sample to overflow the bottle for 2-3 minutes to ensure air bubbles are not trapped.*

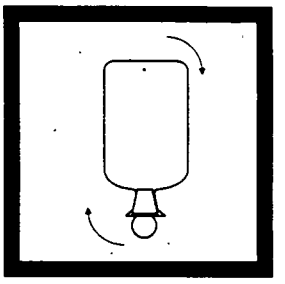
Note: *If samples cannot be analyzed immediately, see Sampling and Storage following these steps.*

Note: *Follow this procedure when using the 60-mL glass-stoppered BOD Bottle supplied with DREL Portable Laboratories.*

2. Add the contents of one Dissolved Oxygen 1 Reagent Powder Pillow and one Dissolved Oxygen 2 Reagent Powder Pillow.

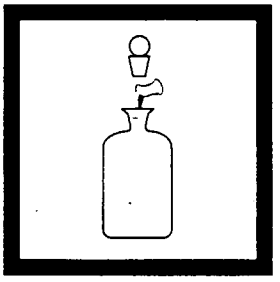
3. Immediately insert the stopper so air is not trapped in the bottle. Invert several times to mix.

Note: *A flocculent precipitate will form. It will be orange-brown if oxygen is present or white if oxygen is absent. The floc settles slowly in salt water and normally requires 5 additional minutes before proceeding to Step 5.*



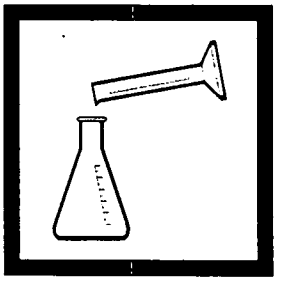
4. Wait until the floc in the solution has settled and the top half of the solution is clear. Again invert the bottle several times and wait until the floc has settled.

Note: *Results are not affected if the floc does not settle or if some of the reagent powder does not dissolve.*

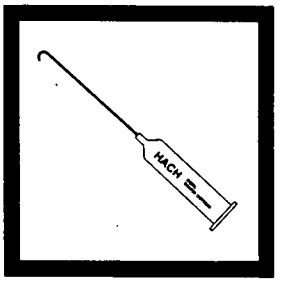


5. Remove the stopper and add the contents of one Dissolved Oxygen 3 Powder Pillow. Replace the stopper without trapping air in the bottle and invert several times to mix.

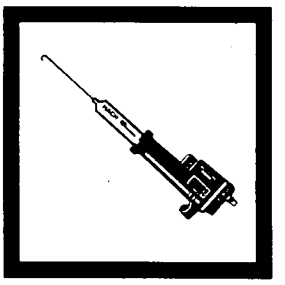
Note: *The floc will dissolve and leave a yellow color if oxygen is present.*



6. Accurately measure 20 mL of the prepared sample and transfer it to a 250-mL Erlenmeyer flask.

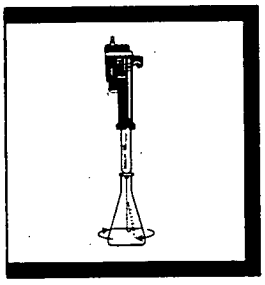


7. Attach a clean straight-stem delivery tube to a 0.2000 N Sodium Thiosulfate Titration Cartridge. Twist the cartridge onto the titrator body. See *General Description, Step-by-Step* for assembly instructions, if necessary

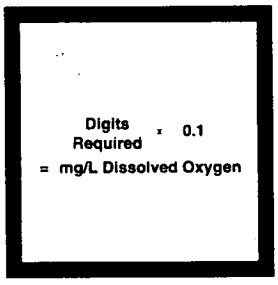


8. Flush the delivery tube by turning the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

Note: *For added convenience use the TitraStir Stir Plate. See General Description, Step 3 in Step-by-Step.*



. Titrate the prepared olution with 0.2000 N odium Thiosulfate ntil the sample hanges from yellow) colorless. Record the umber of digits.



10. Calculate:

Digits required x 0.1 = mg/L Dissolved Oxygen

ampling and Storage

Sampling and sample handling are important in obtaining meaningful results. The dissolved oxygen content of the sample changes with depth, turbulence, temperature, sludge deposits, light, microbial action, mixing, travel time, and other factors. A single dissolved oxygen test rarely reflects the over-all condition of a body of water. Several samples taken at different times, locations and depths are recommended for most reliable results.

Collect samples in clean BOD Bottles (see Step 1). If storage is necessary, run Steps 1-5 of the procedure and store in the dark at 10-20 °C. Seal the bottle with water by pouring a small volume of water into the flared lip area of a stopper bottle. Snap a BOD Bottle Cap over the flared lip. Samples preserved like this can be held 4-8 hours. Begin with Step 6 when analyzing.

ccuracy Check

Check the strength of the Sodium Thiosulfate Solution by using an Iodate-Iodide Standard Solution which is equivalent to 10 mg/L dissolved oxygen. For the 300-mL procedure, begin at Step 5, adding the Sulfamic Acid Powder Pillow. For the 60-mg/L procedure, begin the analysis at Step 5, adding the Dissolved Oxygen 3 Powder Pillow. The titration should take 10 mL. If more than 10.5 mL is required to reach the end point, replace the Sodium Thiosulfate Solution.

Interferences

Nitrite interference is eliminated by the azide in the reagents. Other reducing or oxidizing substances may interfere. If these are present, use an alternate method, such as the High Range Dissolved Oxygen Method (colorimetric) in this manual, or a dissolved oxygen electrode.

Summary of Method

Samples are treated with manganous sulfate and alkaline iodide-azide reagent to form an orange-brown precipitate. Upon acidification of the sample, this floc reacts with iodide to produce free iodine as triiodide in proportion to the oxygen concentration. The iodine is titrated with sodium thiosulfate to a colorless end point.

REQUIRED REAGENTS for 300-mL BOD Bottle

(Varies with sample characteristics)

Dissolved Oxygen Reagent Set (about 50 tests) 22722-00
Includes: (1) 349-32, (2) 1071-68, (2) 1072-68, (1) 22675-01, (2) 20762-68

Description	Unit	Cat. No.
Alkaline Iodide-Azide Powder Pillows	25/pkg	1072-68
Manganous Sulfate Powder Pillows	25/pkg	1071-68
Sodium Thiosulfate Titration Cartridge, 0.2000 N	each	22675-01
Sodium Thiosulfate Titration Cartridge. 2.00 N	each	14401-01
Starch Indicator Solution	100 mL MDB*	349-32
Sulfamic Acid Powder Pillows	25/pkg	20762-68

REQUIRED APPARATUS for 300-mL BOD Bottle

Bottle, with stopper, BOD, 300-mL	each	621-00
Clippers, for opening pillows	each	968-00
Cylinder, graduated, 250-mL	each	508-46
Digital Titrator	each	16900-01
Flask, Erlenmeyer, 250-mL	each	505-46

REQUIRED REAGENTS for 60-mL BOD Bottle

Dissolved Oxygen 1 Reagent Powder Pillows	100/pkg	981-99
Dissolved Oxygen 2 Reagent Powder Pillows	100/pkg	982-99
Dissolved Oxygen 3 Reagent Powder Pillows	25/pkg	987-68
Sodium Thiosulfate Titration Cartridge, 0.2000 N	each	22675-01

* Contact Hach for larger sizes.

REQUIRED APPARATUS for 60-mL BOD Bottle

Description	Unit	Cat. No
Bottle, with stopper, BOD, 60-mL	each	1909-02
Clippers, for opening pillows	each	968-00
Cylinder, graduated, 50-mL	each	1081-41
Digital Titrator	each	16900-01
Flask, Erlenmeyer, 125 mL	each	505-43

OPTIONAL REAGENTS

Iodate-Iodide Standard Solution, 10 mg/L as DO	500 mL*	401-49

OPTIONAL APPARATUS

Cap, BOD Bottle, plastic	6/pkg	2419-06
Clamp Holder	each	326-00
Clamp, 2-prong, extension, 38 mm	each	21145-00
Delivery Tubes, with 180° hook	5/pkg	17205-00
Delivery Tubes, 90° with hook	5/pkg	41578-00
Sewage Sampler, Lab-Line	each	427-00
Support Ring Stand	each	563-00
TitraStir Stir Plate, 115 Vac	each	19400-00
TitraStir Stir Plate, 230 Vac	each	19400-10

Procedures and kits for portable dissolved oxygen measurements using this method are available from Hach.

* Contact Hach for larger sizes.

APPENDIX A
ACCURACY CHECK AND STANDARD ADDITIONS

Most of the procedures in this manual have an accuracy check based on the standard additions method. Standard additions is a widely accepted technique for checking the validity of test results. Also known as "spiking" and "known additions," the technique adds a small amount of the component (parameter) being measured to an analyzed sample and the analysis is repeated. The increase in the test results should equal the amount of the standard added. The results can be used to check the performance of the reagents, the apparatus, and the procedure.

First Step - The Accuracy Check

Perform the procedure and accuracy check as described in this manual. In each accuracy check the number of digits expected for each increment is given. If the actual number of digits required is within 1% of the expected number of digits, the analyst can conclude the answer for the sample is accurate and the reagents, apparatus, and method used are working properly.

Second Step - The Decision Tree

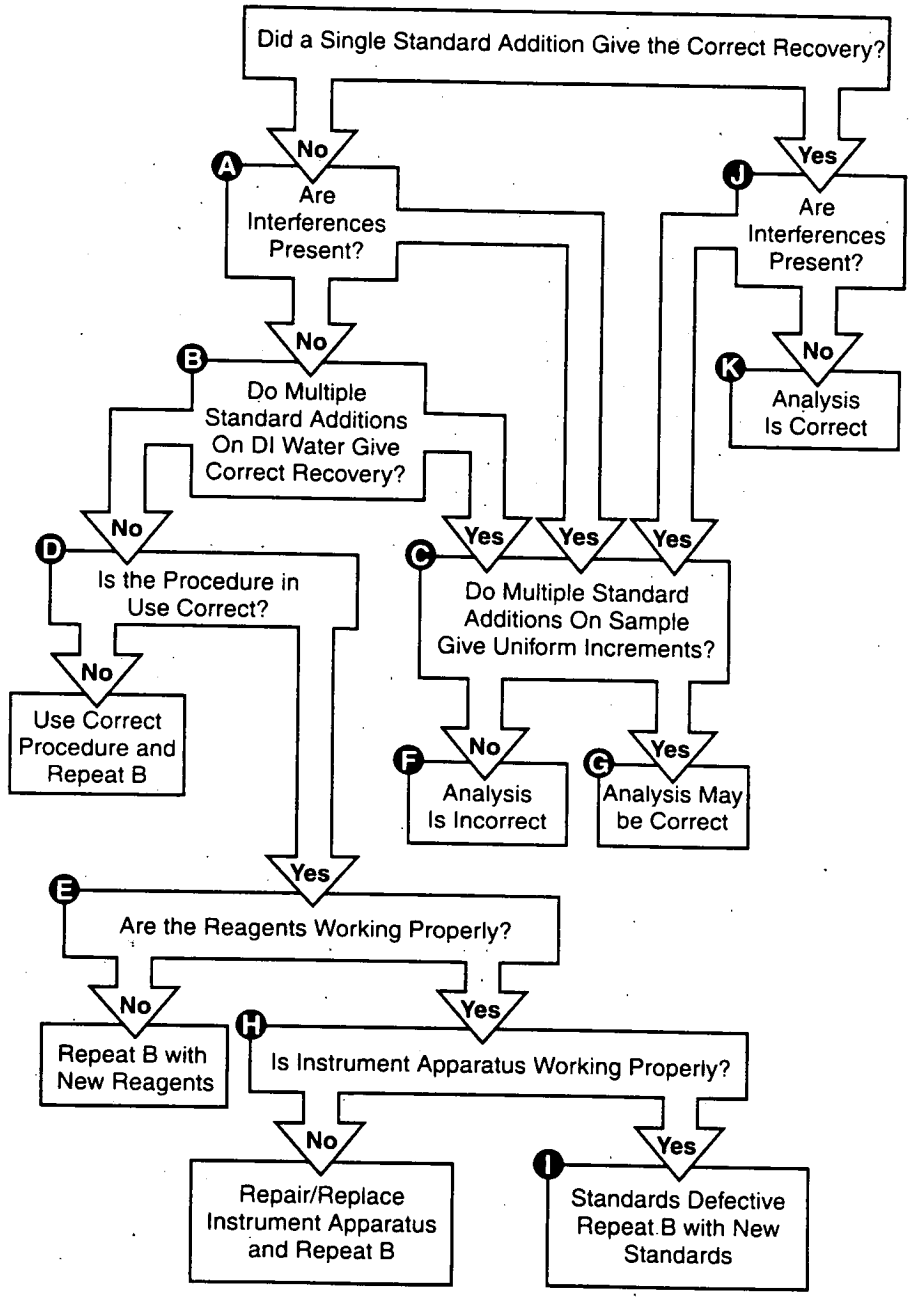
If the actual number of digits varies noticeably, then it must be concluded the problem was caused by either the reagents, the apparatus, the procedure or an interfering substance. By following a logical troubleshooting approach, the source of the problem can be systematically determined. Using the step-by-step decision tree in *Figure 1* will greatly ease identifying the problem. An explanation of each step in the decision tree follows.

Third Step - The Branches

Branch A

Suppose the first, or all three standard additions to the sample did not give the correct incremental digit increase. A possible cause for this could be the presence of interferences. Other causes could be defective reagents, an incorrect procedure, defective apparatus or a defective standard used for standard addition. If interferences are either absent or assumed to be absent, proceed to Branch B. If interferences are present, proceed to Branch C. The Chloride Procedure, Silver Nitrate Method, is used as an example throughout these steps.

Figure 1
Decision Tree



Branch B

Repeat the Accuracy Check given in the procedure substituting the same volume of deionized water for the sample. For example, using the Chloride Procedure, Silver Nitrate Method:

1. Take a 50.0-mL sample of deionized water and follow the Chloride Procedure, Silver Nitrate Method. Record the number of digits required for the titration.
2. Add 0.10 mL of Chloride Standard Solution, 12,500 mg/L, and titrate to the end point. Record the number of digits required for the titration.
3. Repeat, using two more additions of 0.1 mL of 12,500 chloride standard, titrating to the end point after each addition. Record the number of digits required.
4. Tabulate the date as shown below:

Table 1

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	_____	0	_____
0.1	_____	_____	_____
0.2	_____	_____	_____
0:3	_____	_____	_____

The **Total Standard Added (mL)** will vary depending on the procedure used.

The **Total Number of Digits Used** are the total digits recorded after each titration.

The **Total Standard Added (mg/L)** is determined for each addition by the following equation:

$$\frac{\text{Total Standard Added (mL)}}{\text{Sample Volume (mL)}} \times \text{Standard Concentration (mg/L)}$$
$$= \text{Total Standard Added (mg/L)}$$

The **Total Parameter Found (mg/L)** is determined by following the calculation step of the procedure used. Use the same volume of deionized water as used for the sample. The addition of standard will not change the digit multiplier.

Performing the above procedure, the completed table would look like this:

Table 2

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	25
0.2	50	50	50
0.3	75	75	75

To complete the table the following calculations were made based on the above formula:

First Addition

$$\frac{0.1}{50} \times 12{,}500 = \text{Total Standard Added (mg/L)} = 25 \text{ mg/L}$$

Second Addition

$$0.1 + 0.1 = 0.2 \text{ mL} = \text{Total Standard Added (mL)}$$

0.2 mL in the above formula gives 50 mg/L total standard added.

Third Addition

$$0.1 + 0.1 + 0.1 = 0.3 \text{ mL} = \text{Total Standard Added (mL)}$$

0.3 mL in the above formula gives 75 mg/L total standard added.

The data shown above reveals several points:

- The chemicals, apparatus, procedures and standards are in good working condition. This conclusion is made because chloride added to the deionized water sample was recovered entirely in the same uniform steps of addition.
- Because chloride added to deionized water was recovered, but was not recovered during the Accuracy Check, one may conclude the sample contains interferences which prevent the test reagents from operating properly.
- The first analysis of the water sample gave an incorrect result.

If the above results gave the expected increments between additions, proceed to Branch C. If the results did not give the expected increments, proceed to Branch D.

Branch C

If interfering ions are present, it may be concluded the analysis is incorrect. However, with the completed accuracy check it may be possible to arrive at an approximation of the correct result. Tabulate the results as follows:

Table 3

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	_____	0	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

The **Total Standard Added (mL)** will vary depending on the procedure used.

The **Total Number of Digits Used** are the total digits recorded after each addition of standard as specified in the accuracy check.

The **Total Standard Added (mg/L)** is determined for each addition by the following equation:

$$\frac{\text{Total Standard Added (mL)}}{\text{Sample Volume (mL)}} \times \text{Standard Concentration (mg/L)} = \text{Total Standard Added (mg/L)}$$

The **Total Parameter Found (mg/L)** is determined by following the calculation step of the procedure used. Use the same volume of deionized water as used for the sample. The addition of standard will not change the digit multiplier.

If steps between each addition are roughly uniform (i.e., 25 digits or 25 mg/L difference between each addition), proceed to Branch G. If the results are not uniform (i.e., 13, 10, and 6 mg/L), proceed to Branch F.

For example, a sample of water was analyzed for chloride with the result being 100 mg/L. The analyst, suspecting interferences, made one standard addition of 0.10 mL of 12,500-mg/L chloride standard to 50.0 mL of

sample. Rather than an increase of 25 mg/L as expected, the analyst found an increase of 13 mg/L.

The analyst added a second and third addition of 0.1 mL of standard. The titrations were made and the results tabulated. The increments were 10 (123 minus 113) and 6 (129 minus 123) mg/L, respectively. The analyst proceeded to Branch F.

Table 4

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L
0	100	0	100
0.1	113	25	113
0.2	123	50	123
0.3	129	75	129

To complete the table the following calculations were made based on the above formula:

First Addition

$$\frac{0.1}{50} \times 12{,}500 = \text{Total Standard Added (mg/L)} = 25 \text{ mg/L}$$

Second Addition

$$0.1 + 0.1 = 0.2 \text{ mL} = \text{Total Standard Added (mL)}$$

0.2 mL in the above formula gives 50 mg/L Total Standard Added.

Third Addition

$$0.1 + 0.1 + 0.1 = 0.3 \text{ mL} = \text{Total Standard Added (mL)}$$

0.3 mL in the above formula gives 75 mg/L Total Standard Added.

Branch D

Carefully check the instructions or directions for use of the procedure, making sure the proper techniques, reagents, titrant, sample volume, and digit multiplier were used. Verify there is no air or liquid, other than the titrant being used, in the delivery tube by ejecting several drops of solution. If the procedure in use is found to be in error, repeat Branch B using the correct procedure. If the procedure is found to be correct, proceed to Branch E.

Branch E

Check the performance of the reagents. This may be done easily by usin a known standard solution to run the test or by obtaining a new fresh lot c the reagent. A list of known standard solutions is given in *Table 1* on pag 12 of Verifying Technique in Part 1. If it is determined reagents ar defective, repeat Branch B with new reagents. If the reagents are prove in good condition, proceed with Branch H.

Branch F

Examples of non-uniform increments between standard additions on sample are shown below in *Table 5*, *Table 6* and *Figure 2* on page 165 These plots illustrate the effect of interferences upon the standard additio and upon substances in the sample. The plots were made by graphing th Total Standard Added (mg/L) on the X axis and the Total Paramete Found (mg/L) on the Y axis as shown in *Figure 2* on page 165.

Table 5 Plot A

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	100	0	100
0.1	113	25	113
0.2	123	50	123
0.3	129	75	129

Table 6 Plot B

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	0
0.2	50	50	25
0.3	75	75	50

Both of these plots show that the four data points do not lie on a straigh line. Plot A illustrates an interference which becomes progressively worse as the concentration of the standard increases. This type of interference is not common and may be caused by an error or malfunction of the procedure, reagents or apparatus. Perform Branch B to ensure that the supposed interference is present.

Plot B illustrates a common chemical interference which becomes less or even zero as the concentration of the standard increases. The plot shows the first standard addition was consumed by the interference and the remaining additions gave the correct increase of 25 mg/L for each additional 0.1 mL of standard added. The apparent interference in Plot B could be the result of an error made in the standard addition, and the analysis should be repeated with a fresh portion of sample.

The two examples illustrate chemical interferences which most certainly mean the result of the first analysis of the water sample was incorrect. When this type of interference is encountered, review the Interference section for the procedure for corrective steps. If this fails, the analyst should attempt to analyze the sample with an alternate method which, if possible, uses a different type of chemistry.

Branch G

Examples of uniform increments between standard additions on a sample are shown below in *Table 7* and *Table 8* on page 165. These plots illustrate the effect of interferences upon the standard addition and upon substances in the sample. The plots were made by graphing the Total Standard Added (mg/L) on the X axis and the Total Parameter Found (mg/L) on the Y axis as shown in *Figure 2* on page 165.

Table 7 Plot C

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	50	0	50
0.1	63	25	63
0.2	75	50	75
0.3	88	75	88

Plot C illustrates a common interference with a uniform effect upon the standard and the substances in the sample. The four data points form a straight line, but the titration increments between the additions is not correct. The straight line between the additions may be extrapolated back through the horizontal axis. The point of intersect of the line with the horizontal axis gives a more accurate estimate of the concentration of the substance in question for the sample. In the example, the first analysis of the sample gave 50 mg/L. The result located graphically (100 mg/L) using the accuracy check should be much closer to the correct result. Other interference effects may also be present, or interferences may not be consistent in all samples. Use of another method not subject to the interference, or elimination of the interference is preferred over extrapolation or use of the percent recovery calculation.

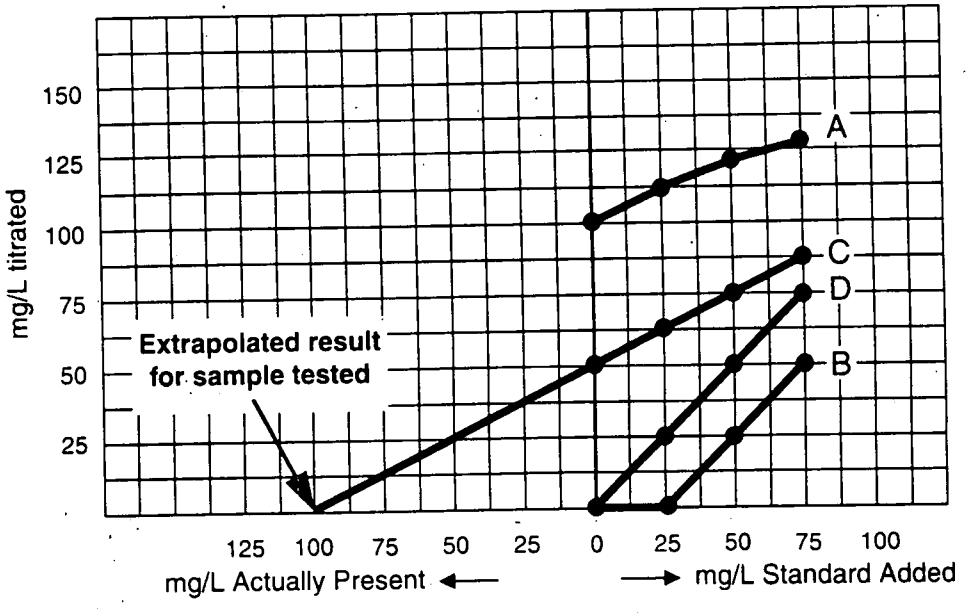
Apparent interferences also may be caused by errors in the method, a defect in the apparatus or standards. Before assuming the interference is chemical in nature, perform Branch B.

Table 8 Plot D

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	25
0.2	50	50	50
0.3	75	75	75

Plot D illustrates correct results but may hide a problem for the analyst. The increments found are uniform and the recovery of the standard was complete. The result of the first analysis was 0 mg/L and the plot graphs back through 0 mg/L. If interfering species are present, the interference may be sufficient to change the sample result but not sufficient to prevent the analyst from finding uniform increments and complete recovery of the additions. This would be an uncommon situation and results are probably correct unless unusual interferences are possible. Refer to the Interferences section in the specific procedure.

Figure 2
Multiple Standard Additions Graph



Branch H

Check operation of the apparatus used in the performance of the test. Verify the correct volumes of sample and standard were used. Check glassware used in the procedure, making sure that it is scrupulously cleaned. Dirty pipets and graduated cylinders are a source of contamination and will not deliver the correct volume. If a defect is found in the apparatus, repeat Branch B after repair or replacement of apparatus. If the apparatus is found to be in good working order, proceed with Branch I.

Branch I

After demonstrating that the procedure, reagents, and apparatus are correct and operating properly, the only possible cause for standard additions not functioning properly in deionized water is the standard used in performing the standard additions. Prepare or obtain a new set of standards and repeat Branch B.

Branch J

If the standard addition gave the correct result, the analyst must then determine if interfering substances are present. If interfering substances are not present, the result of the analysis prior to the standard addition is correct. If interfering substances are present, proceed to Branch C.

One of the greatest aids to the analyst is knowledge of the water sample's composition. An analyst need not know the exact composition of each sample but should be aware of potential interferences in the method of analysis to be used. When performing a particular method, the analyst should know if those interferences are present or not in order to have confidence in the accuracy of the results. Once the interferences are known, the Interference section of each procedure describes how to correct for many common interferences.

If the correct result is obtained with one standard addition when no interfering species are present, the chance of an error in sample results is very small. Possible sources of error not revealed include: sample quality, sample quantity (unless the sample and standard volume used is equal), and inconsistent end point determinations.

Call Hach Technical and Customer Support (1-800-227-4224) for additional help.

GENERAL INFORMATION

At Hach Company, customer service is an important part of every product we make.

With that in mind, we have compiled the following information for your convenience.

REPLACEMENT PARTS AND ACCESSORIES

REPLACEMENT PARTS for Model 16900 Digital Titrator

Description	Unit	Cat. No.
Digital Titrator including delivery tubes, manual, and case	each	16900-01
Delivery Tubes, 180° hook	5/pkg	17205-00
Case	each	46602-00
Digital Titrator Manual	each	16900-08

ORDERING INFORMATION

How to Order

Prices for reagents, equipment and standards may be found in the current Hach *Products For Analysis* catalog. You may also request prices from Customer Service when you order. Prices and shipping conditions may change without notice.

By Phone:

6:00 a.m. to 5:00 p.m. MST
Monday through Friday
800-227-HACH (800-227-4224) (U.S.A. only)
(970) 669-3050

By Mail:

Hach Company World Headquarters
P. O. Box 389
Loveland, Colorado 80539-0389 U.S.A.

By Telex:

160840 (Hach Loveland)

By FAX:

970-669-2932 (Hach Loveland)

Information Required:

Note: *On orders over $500, we require a written or faxed copy of the purchase order or purchase requisition, complete with authorized signature and your terms and conditions.*

- Hach account number (if available)
- Billing address
- Shipping address
- *Your* name and phone number
- Purchase order number
- Catalog number(s)
- Brief description or model number(s)
- Quantity and size(s)

Call or write for free quotations.

echnical and Customer Service

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use and to take your orders. Specialists in analytical methods, they are happy to put their talents to work for you. Call **1-800-227-4224.**

ıternational Customers:

Hach maintains a network of dealers and distributors throughout the world. In Europe, Mediterranean Africa and the Middle East, customers can contact their local distributor or obtain help from:

lach Europe, S.A./N.V.

Chaussée de Namur, 1
B-5150 Floriffoux (Namur), Belgium
Telephone: (32) (81) 44.71.71
FAX: (32) (81) 44.13.00

:anada

Hach Sales & Service Canada Ltd.
1313 Border Street, Unit 34
Winnipeg, Manitoba R3H 0X4
Telephone: (204) 632-5598
Fax: (204) 694-5134

In other areas, obtain assistance from a nearby Hach distributor or:

lach Company World Headquarters

P. O. Box 389
Loveland, Colorado 80539-0389 U.S.A.
Telex: 160840
Telephone: (1) (970) 669-3050
FAX: (1) (970) 669-2932

Information presented on these pages applies only to Hach products manufactured for use within the United States. Exportation of these products renders these terms void.

hipment

Hach products are shipped FOB shipping point. If you do not specify a method of shipment, our staff will determine the best means of transportation consistent with Department of Transportation and postal service regulations. Motor freight shipments will be sent freight collect unless specified otherwise at the time of order. Limited quantities of Class B poisons and "Dangerous When Wet" materials may be shipped by

United Parcel Service without additional charge. This shipment avoids slow and costly motor freight shipments. Although Hach ships your order as quickly as possible, we cannot guarantee delivery dates. Also, it is your responsibility to insure your order during shipment.

Claims and Returns

We take extreme care to fill and pack orders properly. If your freight appears to be damaged when you receive it, do not accept it from the carrier. If you have accepted a delivery and find hidden damages, call a Hach customer service representative immediately. Be sure to keep all containers and packing materials.

AUTHORIZATION MUST BE OBTAINED from Hach when returning items for any reason. Call 800-227-4224; Alaska and Hawaii call 970-669-3050 collect. Sorry, but all "freight collect" shipments of returned merchandise must be refused.

If you need to return items, please follow the procedure below:

1. Within 30 days after receiving the merchandise, contact Hach customer service to get Return Authorization.
2. Hach will send you Return Authorization labels, documentation and instructions.
3. Attach Return Authorization labels and documents to the outside of the shipping cartons and ship to Hach within 15 days. Hach will refuse return shipments without these.

To receive credit, returned shipments must meet the following requirements:

1. Chemicals must be in original, unopened containers. Products that have been used or defaced may not be returned. For kits and portable laboratories, a refurbishing fee will be charged for non-returnable chemicals.
2. Freight charges associated with returned merchandise are the customer's responsibility. Hach will not accept "freight collect" shipments unless you get prior authorization.
3. All returns must be shipped within 15 days after receiving the authorization. Returns not shipped within this time need to be reauthorized.
4. All chemicals authorized for return must be packaged and shipped to comply with U.S. Department of Transportation regulations.

Prices and Terms

Prices are subject to change without notice. All prices are FOB from the shipping point (usually Ames, Iowa). Hach offers instant credit up to $200 on Net 30 Day terms. Larger orders are subject to credit review. Customers may send remittance with orders or we can ship C.O.D. if preferred.

Warranty

Hach warrants its products to be of high quality, to be free of material defects on the date of shipment and to be as specified. Full warranty information is on the back of Hach invoices.

Limits of Usage

Our chemicals and reagents are offered for laboratory and manufacturing use ONLY. They may not be used as drugs, cosmetics or food additives.

MSDS

Hach Material Safety Data Sheets, among the most complete and informative in the industry, provide comprehensive safety data essential for day-to-day operations and safety training.

An MSDS accompanies all Hach chemical products including test kits. For an additional $15.00 per item, we will print MSDSs on your own forms.

Label Information

Labels on Hach chemicals and reagents supply the following information:

- Product Name — Printed in French, German, Italian and Spanish as well as English on all but the smallest-size labels.
- Hach Catalog Number — Makes reordering easy and helps match the appropriate MSDS.
- Storage Information and Lot Numbers — Lot numbers made up of letters and numbers indicate an extended shelf life; a four-digit number indicates items should be rotated and checked with a standard to confirm performance. The lot number is essential if you call for technical assistance or with questions about reagent performance.

Newsletter

- *News & Notes for the Analyst*, Hach's informative newsletter, contains updates on federal regulations, in-depth discussions of chemical reactions, application notes and information about new products. Contact Hach for your free subscription.

HACH COMPANY
WORLD HEADQUARTERS
P.O. Box 389
Loveland, Colorado 80539-0389
Telephone : (970) 669-3050
FAX : (970) 669-2932

HACH COMPANY
P.O. Box 907
Ames, Iowa 50010 USA
Telephone : (515) 232-2533
FAX : (515) 232-1276

HACH EUROPE
Chaussee de Namur, 1
B-5150 Floriffoux (Namur), Belgium
Telephone : (32) (81) 44.71.71
FAX : (32) (81) 44.13.00

FOR TECHNICAL ASSISTANCE, PRICE INFORMATION AND ORDERING:
In the U.S.A. - **Call 800-227-4224 toll-free for more information.**
Outside the U.S.A. - **Contact the HACH office or distributor serving you.**

COLORIMETER

48440-18

DR/820, DR/850, and DR/890

Portable Datalogging Colorimeter Instrument Manual

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dd/dp 6/02/97 1ed
rev. 3, 8/98

CERTIFICATION

Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

The DR/800 Series Colorimeter has been tested and is certified as indicated to the following instrumentation standards:

Immunity:

EN 50082-1 (Generic Immunity Standard) per **89/336/EEC EMC**: Supporting test records by Hach Company, certified compliance by Hach Company.

Required Standard/s include:
EN 61000-4-2 (IEC 1000-4-2) Electro-Static Discharge

EN 61000-4-3 (IEC 1000-4-3) Radiated RF Electro-Magnetic Fields

ENV 50204 "1995" Radiated Electro-Magnetic Field from Digital Telephones

Emissions:

Per **89/336/EEC EMC**: Supporting test records by Intellistor O.A.T.S., certified compliance by Hach Company.

Required European Standard/s include:
EN 55011 (CISPR 11) Emissions, Class B Limits

Additional Emissions Standard/s include:

CANADIAN INTERFERENCE-CAUSING EQUIPMENT REGULATION, IECS-003, Class A:
Supporting test records by Intellistor O.A.T.S., certified compliance by Hach Company.

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

FCC PART 15, Class "A" Limits:

Supporting test records by Intellistor O.A.T.S., certified compliance by Hach Company.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense. The following techniques of reducing the interference problems are applied easily.

1. Remove power from the Colorimeter by removing one of its batteries to verify that it is or is not the source of the interference.
2. Move the Colorimeter away from the device receiving the interference.
3. Reposition the receiving antenna for the device receiving the interference.
4. Try combinations of the above.

SAFETY PRECAUTIONS

Before attempting to unpack, set up or operate this instrument, please read this entire manual. Pay particular attention to all warnings, cautions and notes. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure the protection provided by this equipment is not impaired, this equipment MUST NOT be installed or used in any manner other than that which is specified in this manual.

Use of Hazard Information

If multiple hazards exist, the signal word corresponding to the greatest hazard shall be used.

DANGER
Indicates either a potentially or an imminently hazardous situation which, if not avoided, could result in either death or serious injury

CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury

NOTE
Information that requires special emphasis

Precautionary Labels

Please pay particular attention to labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

The DR/800 Series Colorimeters are Class 1 LED products. A Class 1 LED product has insufficient energy to be considered an eye hazard.

⚠ This symbol, if noted on the instrument, references the Instruction Manual for operational and/or safety information.

⚠ **Section *2.1 Battery Installation***

⚠ **Section *2.4 Sample Cell Insertion***

⚠ ***SECTION 4 CREATING USER-ENTERED PROGRAMS***

TABLE OF CONTENTS

CERTIFICATION i
SAFETY PRECAUTIONS .....
SPECIFICATIONS vi

OPERATION

SECTION 1 GENERAL DESCRIPTION .....
1.1 Instrument Description .....
1.2 Unpacking the Instrument .....
1.2.1 Standard Accessories .....
1.2.2 Optional Accessories .....
1.3 Description of the Keypad .....
1.4 Display Screen in Function and Numeric Modes .....
1.5 Icon and Display Screen .....

SECTION 2 INSTRUMENT SETUP 1
2.1 Battery Installation .....
2.2 Turning the Instrument On 1
2.3 Setting the Date and Time 1
2.3.1 Entering the Correct Date 1
2.3.2 Entering the Correct Time 1
2.4 Sample Cell Insertion 1
2.5 Sample Cell Adapter Installation 1
2.5.1 Using the 16-mm COD/Test 'N Tube Vial Adapter 1
2.5.2 Using the Immunoassay Tube Adapter 1
2.6 Using the Instrument Cap as A Light Shield 1

SECTION 3 INSTRUMENT OPERATION 1
3.1 Menus 1
3.1.1 Setup Menu 1
3.1.2 Recall Menu 1
3.2 Performing an Analysis 1
3.2.1 Colorimeter Setup for Sample Analysis 1
3.2.2 Sample Preparation 1
3.2.3 Zeroing the Colorimeter 2
3.2.4 Measuring the Prepared Sample 2
3.2.5 Alternate Chemical Forms 2
3.2.6 Using the Timer 2
3.2.6.1 Using the Timer in Manual Mode 2
3.2.6.2 Stopping the Timer .....
3.3 Reagent Blank Correction 2
3.4 Adjusting the Standard Curve 2
3.5 Using a Programmed Method 2

SECTION 4 CREATING USER-ENTERED PROGRAMS 27
4.1 User-Entered Programs 27
4.2 Calibration Curves 28
4.3 User-entered Program Information for Bleaching Chemistries 28
4.4 Creating a New User-entered Program 29
4.5 Reviewing and Editing User-Entered Programs 31
4.6 Erasing User-entered Programs 32

SECTION 5 DATA RECALL AND STORAGE 33
5.1 Recalling Data 33
5.2 Erasing All Stored Data 34

SECTION 6 PRINTING AND DATA TRANSFER 35
6.1 Data Transfer Adapter Basics 35
6.1.1 Attaching the Data Transfer Adapter 35
6.2 RS232 Connections 36
6.2.1 Setup and Use of the Printer 36
6.2.2 Connecting to a Personal Computer 38
6.3 Sending Data to a Printer or Computer 38
6.3.1 Sending Currently Displayed Data 39
6.3.2 Sending Recalled Data 39
6.3.3 Sending All Stored Data 39

SECTION 7 MAINTENANCE 41
7.1 Cleaning the Colorimeter 41
7.1.1 Cleaning the Data Transfer Adapter 41
7.1.2 Sample Cells 41
7.2 Replacement Instructions 41
7.2.1 Battery Replacement 41

SECTION 8 TROUBLESHOOTING 43
8.1 Introduction 43
8.1.1 Error Codes 43
8.1.2 Beeper/Error Icon 44
8.1.3 Concentration Out of Range 44
8.1.4 Low Battery 44

APPENDIX A AVAILABLE PARAMETERS AND RANGES 45

GENERAL INFORMATION
REPLACEMENT PARTS 52
HOW TO ORDER 53
REPAIR SERVICE 54
WARRANTY 55

SPECIFICATIONS

Specifications subject to change without notice.

Wavelength Range(s):

- Model DR/890: 420, 520, 560, 610 nm
- Model DR/850: 520, 610 nm
- Model DR/820: 520 nm

Wavelength Accuracy: ±1 nm

Wavelength Selection: Automatic

Photometric Linearity: ±0.002 A (0-1 A)

Photometric Reproducibility: ±0.005 A (0-1 A)

Photometric Accuracy: ±0.005 A @1.0 ABS Nominal

Source Lamp: Light Emitting Diode (LED)

Detector: Silicon Photodiode

Data Readout: 4-digit LCD, 1.5-cm Character Height

Readout Modes: % Transmittance, Absorbance, Concentration

External Outputs: IR (Infrared to RS-232 Serial using the Data Transfer Adapter)

Battery Power: (4) AA alkaline cells

Instrument Dimensions: 23.6 x 8.7 x 4.7 cm (9.3 x 3.4 x 1.9 inches)

Instrument Weight: 470 g (1 lb.)

Photometric Range: 0-2 A

Stray Light: <1.0% at 400 nm

Battery Life: 6 months (typical)

Temperature Range:
Operating Range: 0 to 50 °C (32 to 122 °F)
Storage Range: -40 to 60 °C (- 40 to 140 °F)

Humidity: 90% at 50 °C

Environmental: Designed to meet IP67 Standard; dustproof and waterproof

OPERATION

WARNING

Handling chemical samples, standards, and reagents can be dangerous. Review the necessary Material Safety Data Sheets and become familiar with all safety procedures before handling any chemicals.

ADVERTÊNCIA

A manipulação de amostras, padrões e reagentes químicos pode ser perigosa. Reveja as necessárias Fichas Técnicas de Segurança do Material e familiarizese com os procedimentos de segurança antes de manipular quaisquer substâncias químicas.

ADVERTENCIA

La manipulación de muestras químicas, patrones y reactivos puede ser peligrosa. Antes de manipular cualquier productor químico, conviene leer las Fichas Técnicas de Seguridad y familiarizarse con los procedimientos de seguridad.

ATTENTION

La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les fiches de données de sécurité des produits nécessaires et se familiariser avec toutes les procédures de sécurité avant de manipuler tout produit chimique.

WARNUNG

Da das Arbeiten mit chemikalischen Proben, Standards, Reagenzien und Abfällen mit Gefahren verbunden ist, empfiehlt die Hach Company dem Benutzer dieser Produkte dringend, sich vor der Arbeit mit sicheren Verfahrensweisen und dem richtigen Gebrauch der Chemikalien oder Biogefahrgut vertraut zu machen und alle entsprechenden Materialsicherheitsdatenblätter aufmerksam zu lesen.

1.1 Instrument Description

The Hach DR/800 Series Colorimeter shown in *Figure 1* is a microprocessor-controlled, LED-sourced filter photometer suitable for colorimetric testing in the laboratory or the field. The instrument is precalibrated for common colorimetric measurements and includes convenient calibration capability for user-entered and future Hach methods. Instrument features include:

- Test results are displayed in concentration, absorbance, or percent transmittance.
- Automatic wavelength selection and ranging in the preprogrammed parameters.
- Data storage and recall for datalogging in the field or laboratory.
- Conversion of results to alternate forms for many parameters (i.e., PO_4, P_2O_5, P).
- Reagent Blank Correction and Standard Adjust features may be used to compensate for lot-to-lot variations in reagents.
- Icon prompts displayed during testing.
- A built-in timer to monitor specific reaction times called for in the test procedures. Appropriate times are programmed into the calibration data for specific tests. The timer also can be used manually by the operator independent of the stored methods.
- IR output for RS232 interface capability allows an external printer or computer to interface with the colorimeter.
- Entry of user-entered methods or new Hach methods.
- Error signals for procedural or instrument troubleshooting.

The colorimeter operates on battery power. The instrument holds four AA-size alkaline dry cells (batteries supplied) that power the instrument for at least six (6) months. Optional rechargeable alkaline batteries are also available. The charger and optional rechargeable batteries must be purchased separately.

Figure 1 DR/800 Series Colorimeter Standard Package*

1.2 Unpacking the Instrument

Remove the instrument and accessories from the shipping container and inspect each item for any damage that may have occurred during shipping. Verify that all items listed on the packing slip are included. If any items are missing or damaged, please contact Hach Customer Service, Loveland, Colorado for instructions.

* Carrying Case may be ordered separately.

Hach's toll-free number for customers within the United States is 800-227-4224. For customers outside the United States, contact the Hach office or distributor serving you.

1.2.1 Standard Accessories

- Sample Cells — (2) round, with 10-mL, 20-mL, and 25-mL marks
- COD/TNT Adapter for use with 16-mm vials used in COD and Test 'N Tube methods.
- Batteries — (4) AA alkaline
- Documentation package — includes Instrument Manual and Procedures Manual.

In addition to these standard accessories, several other optional accessories are available from Hach Company (refer to *Replacement Parts and Accessories*).

1.2.2 Optional Accessories

- Immunoassay Tube Adapter
- Rechargeable Alkaline Batteries
- External Alkaline Battery Charger
- Data Transfer Adapter (for RS232 interface)
- HachLink™ Software
- Portable Printer
- Instrument case

1.3 Description of the Keypad

Figure 2 shows the colorimeter's keypad. The description and function of each individual key is given in *Table 1*.

Figure 2 Keypad

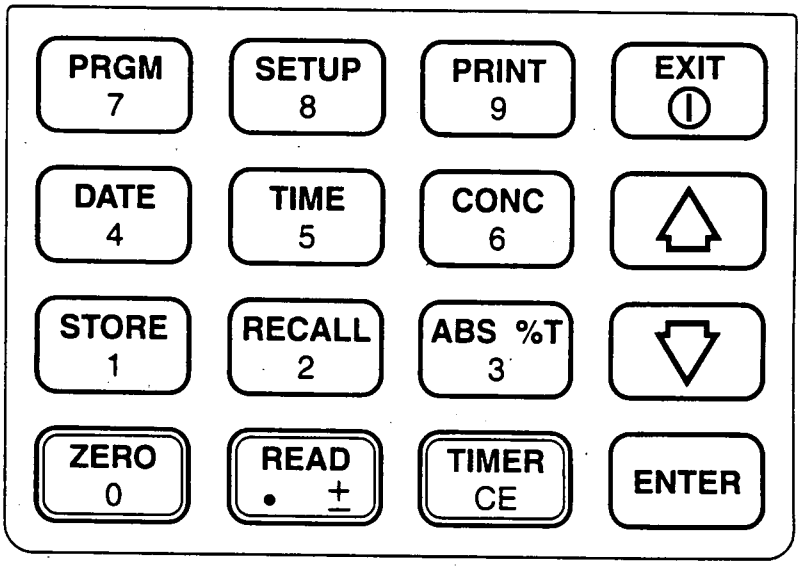


Table 1 Keys and Descriptions

KEY	DESCRIPTION
PRGM 7	Allows the user to select a program. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
SETUP 8	Accesses the SETUP menu (the SETUP icon illuminates in the upper left-hand corner of the display screen). The setup menu provides access to options such as reagent blank, standard adjust, user-entered programs, and instrument configurations. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
PRINT 9	Prints currently displayed data. In the RECALL menu, prints recalled data. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
EXIT	Use this key to turn the instrument on and, when the instrument is on and the EXIT icon is not illuminated, press this key to turn the instrument off. When the EXIT icon is illuminated at the base of the display screen, the **EXIT** key cancels the current entry or selection.

Table 1 Keys and Descriptions (continued)

KEY	DESCRIPTION
DATE 4	Displays the current date. In the RECALL menu, displays the date the recalled sample was stored. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen. Used to set the current date from the SETUP menu.
TIME 5	Displays the current time. In the RECALL menu, displays the time the recalled sample was stored. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen. Used to set the current time from the SETUP menu.
CONC 6	When performing an analysis, this key displays the concentration value of the reading. Used as a toggle key to access alternate chemical forms, if available. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
△	Scrolls up through selected menus or stored data.
STORE 1	When performing an analysis, this key allows the user to store a current reading in one of 99 sample locations. The user can store the reading as numbers 1-99 by pressing **ENTER**. Use the up and down arrow keys to find unused storage numbers or use numeric keys to enter a sample number. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
RECALL 2	Begins the retrieval of stored sample readings (RECALL icon illuminates in the upper-left portion of the screen). Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
ABS %T 3	Toggles between displaying Absorbance and % Transmittance. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
▽	Scrolls down through selected menus or stored data.
ZERO 0	Zeros the instrument on the current sample blank. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen.
READ • ±	When the READ icon is illuminated at the base of the display screen, this key reads and displays the sample concentration. Also used as a numeric key function when the "#" icon is illuminated at the base of the display screen; the first press is a decimal, the second press toggles the value sign.
TIMER CE	If using a Hach-stored program, the **TIMER** key automatically sets the appropriate reaction time. If not in a Hach-stored program, the **TIMER** key allows the user to set a timer. When the "#" icon is illuminated at the base of the display screen, **CE** clears the most recent level of action (deletes the whole entry, not just the last number).
ENTER	Within a menu, selects the displayed menu item. During numeric entry, accepts the displayed value.

1.4 Display Screen in Function and Numeric Modes

The main display operates in two modes: function mode and numeric mode. The user does not select the mode, changeover is automatic depending on the options selected, where the user is in an analysis, and what information the instrument needs from the user.

The main display shows action icons (**ZERO** and **READ**) displayed below the horizontal line. This shows there are two available options to select (zero the instrument, or take a reading) at this point in the analysis.

The numeric mode is signified by the "#" icon illuminated below the horizontal line. In the numeric mode, some function keys act as numeric entry keys (corresponding to the number on the key).

1.5 Icon and Display Screen

Figure 3 shows the icons displayed by the DR/800 Series Colorimeters. *Table 2* provides a brief description of each display element.

Figure 3 Icon and Main Display Screen

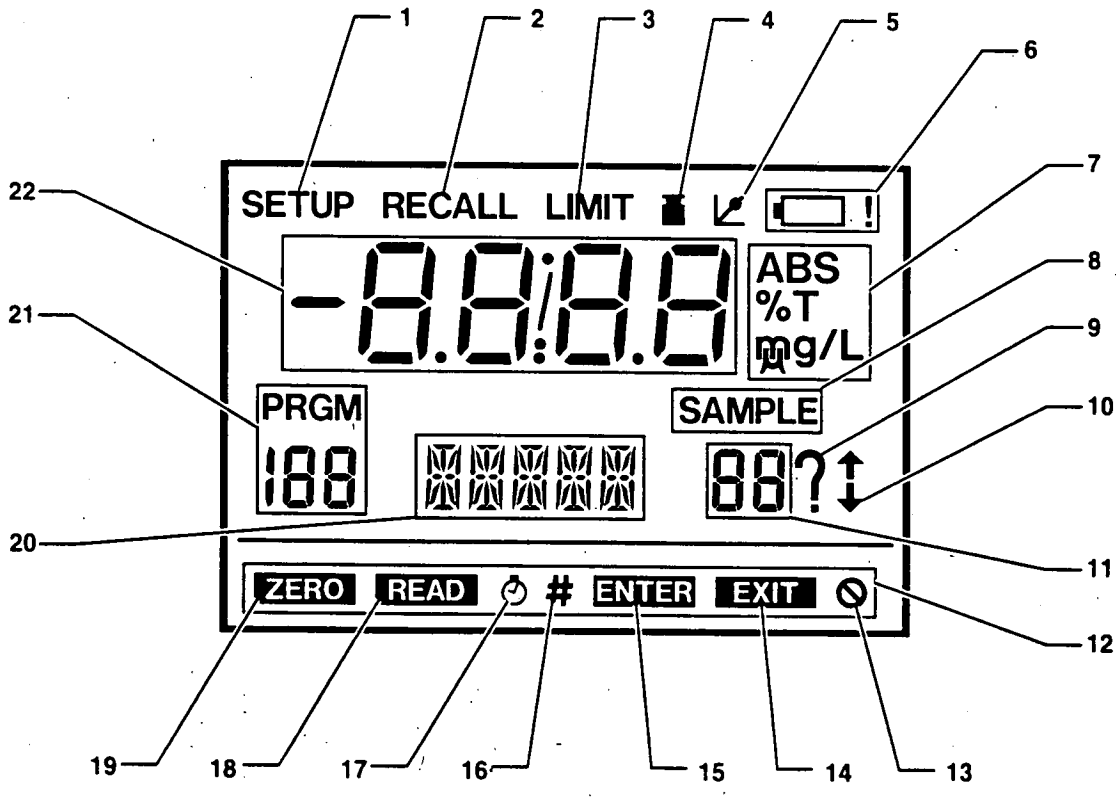


Table 2 Main Display Screen Icons

ITEM NO.	DEFINITION
1	Indicates the user is in the SETUP menu.
2	Indicates the user is in the RECALL menu.
3	The sample concentration exceeds the limits of the selected program.
4	Sample cell icon. Indicates a reagent blank adjustment is in use for the current program.
5	Standard adjust icon. Indicates a standard adjust is in use for the current program.
6	Indicates a low battery condition - replace the batteries as soon as possible.
7	These three icons follow the sample reading and represent either absorbance, percent transmittance, milligrams per liter, micrograms per liter, or grams per liter.
8	Illuminates whenever the numbers in the main display (22) or the sample display (11) refer to a sample number.
9	Indicates the instrument is waiting for information from the user.
10	Depending on the arrow(s) illuminated, these icons indicate the available scroll direction (using the **ARROW** keys) for accessing options.
11	In the RECALL menu or when storing data, these digits show the selected sample number.
12	Most icons displayed in this area are action icons. Action icons tell the user what actions are acceptable options during an analysis.
13	Indicates an invalid key press was made. This icon flashes briefly accompanied by a short beep.
14	Exit action icon - (when illuminated) tells the user that pressing the **EXIT** key to exit the current level of action is an acceptable option.
15	Enter action icon - (when illuminated) tells the user that pressing the **ENTER** key to confirm an action is an acceptable option.
16	Numeric entry action icon - (when illuminated) tells the user the numeric key pad is active.
17	Timer action icon - (when illuminated) tells the user that the instrument is presently running a timer. This icon will flash while the timer is counting.
18	Read action icon - (when illuminated) tells the user that pressing the **READ** key to read the sample cell is an acceptable option.
19	Zero action icon - (when illuminated) tells the user that pressing the **ZERO** key to zero the instrument on a sample cell is an acceptable option.
20	Depending on the currently active menu, the series of alphabetical letters displayed here gives information on a current reading, a stored reading, indicates the options available within a menu, or prompts the user for the next action.
21	Shows the active program number, (either a user-entered (101-110) or Hach-stored program (1-100). The program number is displayed immediately below the PRGM icon.
22	Depending on the currently active menu, the numbers displayed here represent either the sample reading, the clock timer, or the numeric characters entered by the user.

2.1 ⚠ Battery Installation

Power is supplied by four AA-sized alkaline batteries. Typically, a set of batteries provides approximately six months of operation. The colorimeter lamp is an LED and is on only long enough for the measurement sequence to take place (approximately 2 seconds).

The instrument will automatically shut off if no keystrokes are made for 15 minutes when in normal mode and four hours when in user-entry mode.

Figure 4 provides an exploded view of the battery installation. When replacing discharged batteries, always replace the complete set of four.

Hach recommends using alkaline batteries in this instrument. **Do not use rechargeable Nickel Cadmium (NiCad) batteries.** If rechargeable batteries are desired, rechargeable alkaline batteries are available from Hach.

The battery compartment is accessible from the underside of the instrument. Make sure the sample cell compartment is empty. Lay the instrument upside down on a padded surface, and install batteries as follows:

Note: *For performance reasons, never remove the battery cover from this product except when servicing the batteries.*

1. Disconnect the Data Transfer Adapter (if connected) from the instrument.
2. Loosen the two battery compartment screws and remove the battery compartment door as shown in *Figure 4*.
3. Install four AA alkaline batteries in the battery holder as shown in *Figure 4*. Match the polarities of the batteries with the polarity markings in the battery compartment.
4. Replace the battery compartment cover, tighten the screws, and return the instrument to the upright position.

DANGER ⚠
Use of nickel-cadmium batteries under a fault condition creates a potential fire hazard.

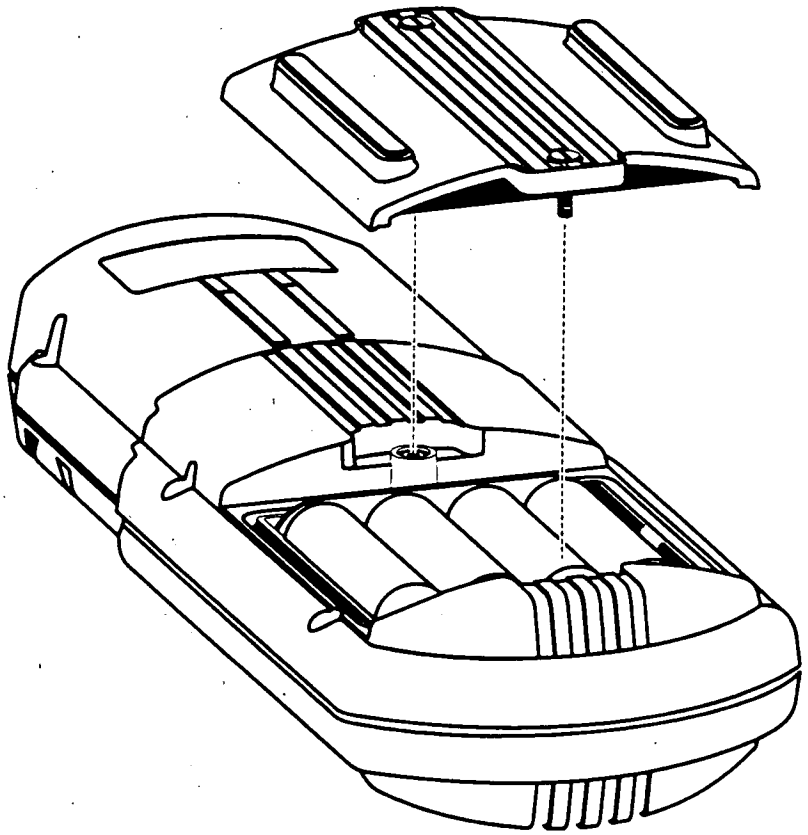
PELIGRO
La utilización de pilas de níquel-cadmio en condiciones de falla crea el riesgo de incendio.

PERIGRO
O uso de baterias de níquel-cádmio em condição de falha cria a possibilidade de incêndio.

DANGER
L'utilisation de batteries nickel-cadmium dans des conditions inappropriées crée un risque d'incendie.

GEFAHR
Unter einer Störungsbedingung stellt die Verwendung von Nickel-Kadmium-Batterien eine Feuergefahr dar.

Figure 4 Battery Installation



2.2 Turning the Instrument On

Once batteries are installed, turn the instrument on using the EXIT/I/O key (located on the top row, far-right column of the instrument keypad).

Press the key once to power-on the instrument. The display will show the software version number, then will default to the last used program number. The instrument is now ready for operation.

2.3 Setting the Date and Time

Setting the instrument's date and time allows sample readings to be stored and recalled with the proper date and time. Check the currently entered date or time by pressing the respective **DATE** or **TIME** key.

To set the date and time, continue with Section *2.3.1* or *2.3.2* below.

2.3.1 Entering the Correct Date

Check the current date by pressing the **DATE** key. If the date is incorrect, follow the procedure below to change it.

Enter the correct year, then the correct month and day as follows:

1. Press the **I/O** key to turn the instrument on.
2. Access the **SETUP** menu by pressing the **SETUP** key on the keypad. (The down **ARROW** icon on the right side of the display is shown.)
3. Press the down **ARROW** key until **DATE** is displayed.
4. Press the **ENTER** key to select the date option.
5. Four horizontal lines (showing available spaces for numeric entry) and **YEAR ?** will appear on the display. Enter the digits corresponding to the correct year using the numeric keypad. For instance, if the year is 1997, press **1 9 9 7** then the **ENTER** key.

   If an incorrect number is entered, press the **CE** key and re-enter the information.

Next, the instrument prompts for the month and day.

6. Enter the correct month and day using the numeric keypad. The month must be entered first, followed by the day. If an incorrect number is entered, press the **CE** key and re-enter the information.

Note: *When entering a one digit month or day, always press the* **ZERO** *key before the digit. For example: If the month and day to be entered is March 4, press* **0 3 0 4** *on the numeric keypad, then press the* **ENTER** *key to accept.*

7. Press the **ENTER** key to accept the new information. Press the **EXIT** key to return to the main menu

2.3.2 Entering the Correct Time

1. Press the **I/O** key to turn the instrument on.
2. Access the **SETUP** menu by pressing the **SETUP** key on the keypad. (The down **ARROW** icon on the right side of the display is shown.)

3. Press the down **ARROW** key until **TIME** is displayed.

4. Press the **ENTER** key to select the time option.

5. Enter the time in 24-hour (military) notation using the numeric keypad then press the **ENTER** key to accept the entry. For example, 9:00 a.m. is entered as **0 9 0 0 ENTER** and 2:00 p.m. is entered as **1 4 0 0 ENTER**. If an incorrect number is entered, press the **CE** key and re-enter the information.

6. The display returns to the setup menu. Press the **EXIT** key to return to the main menu.

2.4 ⚠ Sample Cell Insertion

⚠ *DANGER*
This instrument is not intended for use with flammable samples or those containing hydrocarbons.

PELIGRO
Este instrumento no está destinado para uso con muestras inflamables o que contengan hidrocarburos.

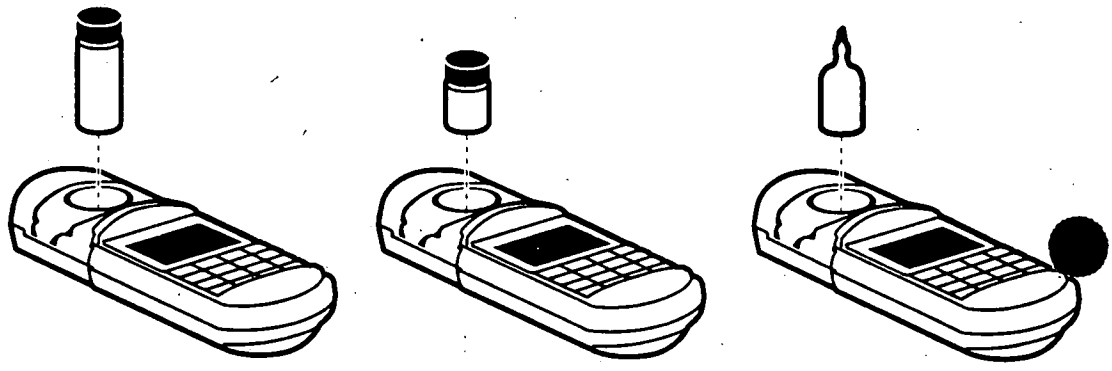
PERIGO
Este instrumento não é feito com o fim de ser empregado com amostras inflamáveis ou aquelas que contêm hidrocarbonetos.

DANGER
Cet instrument n'est pas conçu pour une utilisation avec des échantillons inflammables ou des échantillons contenant des hydrocarbures.

GEFAHR
Dieses Gerät darf nicht für Tests mit brennbaren Proben oder Proben, die Kohlenwasserstoffe enthalten, benutzt werden.

Wipe the sample cell with a lint-free cloth or tissue and insert the cell into the sample cell compartment with the diamond-shaped marker toward the keypad.

Figure 5 Placing Samples in the Sample Cell Compartment



2.5 Sample Cell Adapter Installation

When installing an adapter into the sample cell compartment, insert the adapter into the cell compartment and rotate until it drops into the alignment slots. Finish installation by gently pushing down on the adapter until it snaps into position.

Place the appropriate vial or sample cell into the adapter - the vial or sample cell should fit well into the adapter. If it does not, double-check that the correct sample container (vial or sample cell) is being used and that the adapter is installed correctly. For a list of available adapters, refer to *Replacement Parts and Accessories.*

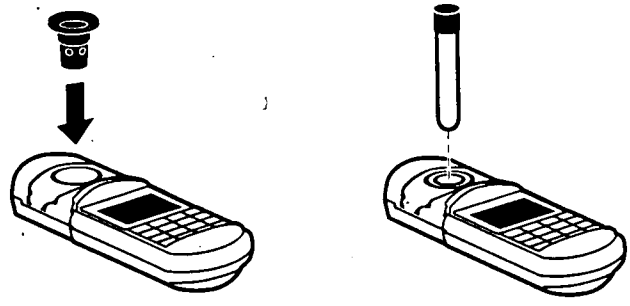
2.5.1 Using the 16-mm COD/Test 'N Tube Vial Adapter

The methods for chemical oxygen demand (COD) and Test 'N Tube (TNT) determinations in the colorimeter procedures manual use 16-mm vials as the sample cell for the colorimetric measurement. This adapter also holds a standard 16-mm test tube.

Place the COD/TNT Adapter in the instrument's sample cell compartment as instructed in Section *2.5*, above. Place the vial into the COD/TNT Adapter (see *Figure 6*).

Always place the instrument cap over the adapter when measuring in bright sunlight (see *Figure 8*).

Figure 6 Installing the COD/TNT Adapter



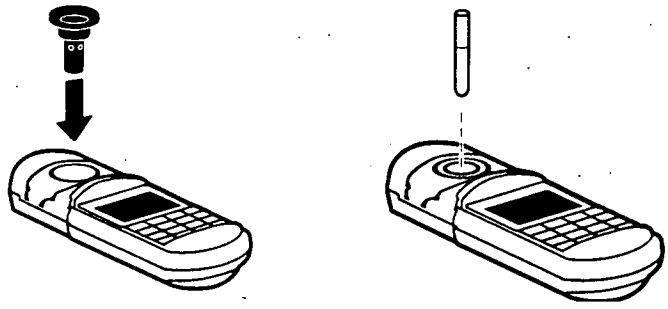
2.5.2 Using the Immunoassay Tube Adapter

Immunoassay methods develop and read the color in special antibody coated tubes. The instrument can read immunoassay results with the aid of the adapter.

Place the Immunoassay Tube Adapter in the instrument's sample cell compartment as instructed in section *2.5*, above. Place the tube into the adapter after it is properly installed in the cell compartment (see *Figure 7*).

Always place the instrument cap over the adapter when measuring in bright sunlight (see *Figure 8*).

Figure 7 Installing the Immunoassay Tube Adapter

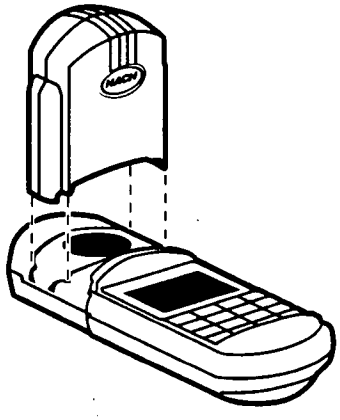


2.6 Using the Instrument Cap as A Light Shield

The colorimeter cap is removable (by sliding it away from the keypad) to expose the sample cell compartment. The instrument cap also functio[illegible] a light shield. Samples may be analyzed without the light shield in place but using the light shield provides a good seal against stray light and contributes to more accurate results. Use of the light shield is especially important when performing an analysis in bright light or direct sunlight.

To use the instrument cover as a light shield during measurements, place the cap over the sample cell, into the grooved marks on the instrument. See *Figure 8*.

Figure 8 Installing the Light Shield



3.1 Menus

The instrument has two important menus which allow access to different options. The menus are:

- Setup Menu
- Recall Menu

Once the user has selected the desired menu, the arrow icons illuminate on the main display screen. The arrows indicate that additional options are available in this menu. Press the up or down **ARROW** key (whichever arrow is illuminated) to scroll until the desired option is displayed. A press of the **ENTER** key at this time selects the displayed option.

When choosing options from menus, the up or down **ARROW** keys, **ENTER**, and **EXIT** keys help navigate between menus and within menu options. Use the **ENTER** key to select a menu option. Press **ENTER** again to accept a new setting. Pressing the **EXIT** key leaves a menu or leaves the displayed item unchanged.

3.1.1 Setup Menu

Enter the **Setup Menu** from the **Main Menu** by pressing the **SETUP** key.

Refer to the arrow icons on the main display for an indication of which key (up **ARROW** or down **ARROW**) to press on the keypad - the direction of the illuminated icon on the main display indicates the available scrolling direction. The up and down **ARROW** (scroll) keys move from one menu option to the next.

Example: when the down arrow icon is illuminated on the display screen, the user only has the option to press the down **ARROW** key to move from one option to the next. Once the user scrolls down, the down arrow icon changes to a dual-direction arrow icon (up and down arrows) until the user reaches the last menu option available in that menu.

The following instrument operating features are available in the **Setup** menu

- **BLANK** - Used to compensate for color contributed by the reagents in a reagent blank. Readjust for each new lot of reagents. Press the **ENTER** key to activate this option. The default setting is off. Chemistries which zero on a reagent blank do not have this option available.

- **STD** - Standard Adjust option allows for entry of the value of the prepared standard. Press the **ENTER** key to activate this option. The default setting is off.

Note: The BLANK and/or STD options may or may not be available, depending on the selected Hach program; the BLANK and STD options are always available for user-entered programs.

- **PRINT (ALL)** - Prints all stored data to a printer or downloads it to a personal computer. The information printed includes: sample concentration reading, date of sample, time of sample, units, sample number, program number, Absorbance, and %T. Refer to Section *6* for detailed printing information and to *Figure 11* for an example of a printout. Press the **ENTER** key to activate this option.

- **USER** - Allows access to the User-Entered Program Menu. Press the **ENTER** key to activate this option. See *CREATING USER-ENTERED PROGRAMS* on page *27* for more information.

- **DATE** - Allows the user to set the date. Press the **ENTER** key to activate this option. See Section *2.3.1* for more information.

- **TIME** - Allows the user to set the time. Press the **ENTER** key to activate this option. See Section *2.3.2* for more information.

- **ERASE (ALL)** - This clears all the data previously stored in memory. Press the **ENTER** key to activate this option.

3.1.2 Recall Menu

The recall menu allows access to stored data. Complete information and instructions for the use of this menu is presented in *SECTION 5 DATA RECALL AND STORAGE.*

3.2 Performing an Analysis

The procedures manual provides illustrated, step-by-step procedures for performing all the factory-entered methods. This instrument manual has supplemental information on how the instrument performs the necessary functions, and how to use the special operating features. Once you are familiar with the instrument, the instructions in the procedure manual should be sufficient to analyze your samples.

Colorimetric testing with preprogrammed calibrations can be divided into four general phases:

1. Colorimeter setup
2. Sample preparation
3. Zeroing the instrument
4. Measuring the prepared sample

The following sections describe each phase in detail.

3.2.1 Colorimeter Setup for Sample Analysis

The colorimeter setup using a Hach program begins by selecting the desired program number. Programs numbers can be found in the individual procedure. (See the DR/800 Series Procedures manual supplied with your instrument.) Prompting icons will appear to indicate which keys are acceptable for the user to select. After turning the instrument on, the main display shows information from the last program used before the instrument was turned off.

If a different program is desired, press the **PRGM** key and enter the desired program number with the numeric keypad. The instrument will recall that program.

If the number selected is not valid, an error signal sounds and the display momentarily flashes an error icon. The display returns to the prompt for the program number. Re-enter the correct program number. Only select chemistries are available on the DR/820 and DR/850. See *APPENDIX A AVAILABLE PARAMETERS AND RANGES* on page *45*.

When the program number has been successfully entered, the display immediately prompts the user to zero the instrument by illuminating the **ZERO** action icon.

3.2.2 Sample Preparation

For colorimetric tests, sample preparation is next. The zero solution (or blank) and sample(s) are usually prepared at this time. Generally, sample preparation consists of adding the contents of a premeasured reagent pillow to a small volume of sample. Follow the instructions in the procedure specific to your analysis.

It is important to observe the waiting period specified in the test procedure to ensure the color from the reaction of the reagent(s) with the target analyte develops fully. Many procedures also give a maximum time limit after which the color may begin to fade.

The instrument has method-specific timers for color development times pre-programmed into the software. The user is notified when the time has elapsed by a series of short beeps.

3.2.3 Zeroing the Colorimeter

The instrument must be zeroed for each test or series of tests to establish a zero reference for the measurement. This is done by placing a solution recognized as the blank solution in the cell holder, covering the sample with the instrument cap, and pressing the **ZERO** key. The next prompt will display zeros and illuminate the **READ** action icon. The instrument is now ready to take the first sample reading.

Note: *Once the zero reference point has been established, several samples be measured consecutively by placing each of them into the cell holder and pressing the* **READ** *key. The instrument can be re-zeroed at any time by placing the zero solution (blank) into the instrument and pressing the* **ZERO** *key.*

3.2.4 Measuring the Prepared Sample

When ready to take the reading, place the prepared sample in the sample compartment. For best results orient the sample cell consistently for each measurement; see *Figure 5* on page *14*. Place the instrument cap (light shield) over the sample cell and press the **READ** key. After a brief pause, the results will be displayed.

Toggle between absorbance or percent transmittance values by successive presses of the **ABS %T** key. Press the **CONC** key to restore the concentration display. Successive presses of the **CONC** key toggles between alternate forms, if any. See Appendix A for currently available chemistries and their alternate forms.

3.2.5 Alternate Chemical Forms

Many Hach programs provide alternate chemical forms for the measured parameter. Press the **CONC** key to scroll through these alternate forms after the measurement is displayed. Each press of the **CONC** key takes the user to the next alternate chemical form. For example: In Program #1, mg/L Al may also be displayed as mg/L Al_2O_3. If alternate forms are not available, the instrument returns to its original form and reading.

3.2.6 Using the Timer

Many Hach test methods use one or more timers which are pre-programmed into the DR/800 Series Colorimeters. When the procedure instructs you to, press the **TIMER** key to display a timer interval. Press **ENTER** to start the timer count-down. Several beeps will sound at the end of a timer interval. If the method requires additional timers, the instrument will automatically display the next timer when the first timer elapses. Press **ENTER** to start the next timer.

To zero the instrument on the blank while the timer is running, press the **EXIT** key. The timer icon will continue to flash, indicating the timer is running. Press **ZERO**, or perform other available functions within the method (such as blank correction) while the timer is running. To return to the timer display, press the **TIMER** key.

3.2.6.1 Using the Timer in Manual Mode

The manual timer function allows the operator to use the timer independently from the method timer. Make sure the instrument is not in numeric entry mode and activate the timer with a press of the **TIMER** key. If using a pre-programmed timer, press the **TIMER** key again.

The "**#**" action icon is illuminated, to indicate that the numeric keypad is active. Enter the desired time using the numeric keypad. For example, to enter 2 minutes, press **2 0 0**, then **ENTER**. To enter 12 minutes, press **1 2 0 0**, then **ENTER**. The display will momentarily show the entered time, then the timer countdown will begin. The display will show the remaining time. At the end of the elapsed time, the instrument sounds five beeps.

3.2.6.2 Stopping the Timer

Stop the timer at any point in the countdown by pressing the **ENTER** key. If a pre-programmed timer was in use, the full timer period will be displayed. Press the **ENTER** key again to resume count down. If a manual timer was in use, the display for entering a new length of time will be shown, see Section *3.2.6.1 Using the Timer in Manual Mode*. Press **EXIT** to leave the timer mode.

3.3 Reagent Blank Correction

The Reagent Blank Correction can be used with some of the factory-entered methods. It subtracts the color absorbed when running the test with deionized water instead of sample. The blank value is subtracted from every result to correct for any background color due to reagents.

When using the Reagent Blank Correction feature, the blank correction should be entered before the Standard Adjust feature is used.

To enter a programmed correction for the reagent blank:

1. Run the test using deionized water with each new lot of reagents.
2. Press **READ** to obtain the blank value; record the value for use in step *4*.
3. Press **SETUP**, scroll to **BLANK** and press **ENTER**. The display will show **BLANK?**.
4. Enter the blank value obtained in step *2*.
5. Press **ENTER** to accept the value as the blank to be subtracted from each reading.
6. The display will show 0.00 mg/L (resolution and units vary with the method) and the sample cell icon will be displayed, indicating that the reagent blank feature is enabled and the blank value will be subtracted from each reading. Repeat the reagent blank adjust for each new lot of reagents.

Note: *After entering a reagent blank adjust, the display may flash "limit" when zeroing if the sample used for zeroing has a lower absorbance value than the reagent blank.*

To disable the Reagent Blank adjust feature, press **SETUP**, scroll to **BLANK** and press **ENTER** twice. The concentration readings will be displayed without subtracting the blank. The sample cell icon will no longer appear in the display.

Do not attempt to use the Reagent Blank Adjust feature if the procedure uses a reagent blank for zeroing.

3.4 Adjusting the Standard Curve

The DR/890 Colorimeter has over 90 Hach Programs permanently installed in memory (other models have fewer programs). A program usually includes a preprogrammed calibration curve. Each curve is the result of an extensive calibration performed under ideal conditions and is normally adequate for most testing. Deviations from the curve can occur from using compromised testing reagents, defective sample cells, incorrect test procedure, incorrect technique, or other correctable causes. Interfering substances or other causes may be beyond the analyst's control.

In some situations, using the preprogrammed curve may not be convenient:

- Running tests where frequent calibration curve checks are required.
- Testing samples which give a consistent test interference.

Consider the following before adjusting the calibration curve:

1. Will future test results be improved by adjusting the curve?
2. Are interfering substances consistent in all the samples that you will test?

Any precision and test range information provided with the procedure may not apply to an adjusted curve calibration.

You can adjust many of the calibration curves by following the steps found in the test procedures. Working carefully is important. After the adjustment, it is wise to run standard solutions of several concentrations to make sure the adjusted curve is satisfactory. Perform standard additions on typical samples to help determine if the adjusted curve is acceptable.

Think of the standard adjust measurement as a two-step process. First, the instrument measures the sample using the preprogrammed calibration. Second, it multiplies this measurement by an adjustment factor. The factor is the same for all concentrations. The instrument will remember the factor indefinitely and will display the standard adjustment icon when it is used.

Adjust the calibration curve using the reading obtained with a Hach Standard Solution or carefully prepared standard made from a concentrated Hach Standard Solution. It is important to adjust the curve in the correct concentration range. For most purposes, Hach recommends adjusting the curve using a standard concentration that is 70 to 85% of the maximum concentration range of the test.

For example, the Hach preprogrammed method for fluoride has a range of 0-2.0 mg/L F. To adjust the calibration curve, use a standard with a concentration between 1.4-1.6 mg/L. Hach provides a 1.60 mg/L Fluoride Standard Solution (80% of the full range). This is a convenient standard to use for adjusting the calibration curve.

If the range of all your samples is known to be below a concentration that is less than 50% of the full range (50% of 2.0 is 1.0 mg/L), then adjust the standard curve with a standard that is within that range.

For example, if all the samples contain 0.6-0.9 mg/L F, you may use a 1.00 mg/L fluoride standard to adjust the curve. You may use the 1.00 mg/L standard because it is closer to the sample range you are working with.

If you are using a Reagent Blank Correction, the blank correction should be entered before the standard curve is adjusted.

To adjust the standard curve:

1. Prepare the standard.
2. Use the standard as the sample in the procedure.
3. When the reading for the standard is obtained, press **SETUP**.
4. Use the **ARROW** keys to scroll to the "**STD**" setup option.
5. Press **ENTER** to activate the standard adjust option.
6. Enter the concentration of the standard used.
7. Press **ENTER**. The standard adjust icon will be displayed, indicating that the curve has been adjusted with the standard.

Note: *If the attempted correction is outside the allowable adjustment limit, the instrument will beep and flash the error icon and the operation will not be allowed.*

To eliminate the standard curve adjustment:

1. Press the **PRGM** key.
2. Enter the stored-program number and press **ENTER**.
3. Press the **SETUP** key
4. Press an **ARROW** key to display **STD**.

Note: *On will be displayed if an adjustment is in use.*

5. Press **ENTER** twice.

3.5 Using a Programmed Method

Hach programmed and user-entered program options are available on this instrument. The Procedures Manual supplied at the time of purchase contains all currently available Hach-programmed methods. Up to ten user-programmed methods may be entered into the instrument. See *CREATING USER-ENTERED PROGRAMS* on page *27* for instructions for this function.

Table 3 shows the components of typical factory programmed test method.

Table 3

Step	Action/Keystroke	Display
1. Turn power on.	Press the **EXIT/I/O** key.	The instrument defaults to and displays the initial screen of the last program used. EXAMPLE: If program 20 was the last program in use, the instrument will automatically recall program 20.
2. Select the Program number to be used.	Press the **PGRM** key, then enter the program number and press the **ENTER** key.	After the **PGRM** key is pressed, a blinking cursor appears with a question mark. Enter the desired program number. Press **ENTER** to confirm this action and recall the desired program number.
3. As needed, set, then start the **TIMER**.	Press the **TIMER** key. In a Hach-stored program, the timer automatically defaults to the appropriate reaction time. Press **ENTER** to start the timer.	The entered or programmed reaction time will display and count down to zero.
4. ZERO the instrument using the sample blank.	Insert blank and press **ZERO.**	After the **ZERO** key is pressed, the instrument zeros on the sample cell.
5. Obtain reading in concentration, absorbance, or % transmittance.	Place the prepared sample into the cell holder. Press **READ.**	The instrument reads the sample and displays the results.

SECTION 4 CREATING USER-ENTERED PROGRAMS

⚠ *DANGER*
This instrument is not intended for use with flammable samples or those containing hydrocarbons.

PELIGRO
Este instrumento no está destinado para uso con muestras inflamables o que contengan hidrocarburos.

PERIGO
Este instrumento não é feito com o fim de ser empregado com amostras inflamáveis ou aquelas que contêm hidrocarbonetos.

DANGER
Cet instrument n'est pas conçu pour une utilisation avec des échantillons inflammables ou des échantillons contenant des hydrocarbures.

GEFAHR
Dieses Gerät darf nicht für Tests mit brennbaren Proben oder Proben, die Kohlenwasserstoffe enthalten, benutzt werden.

The DR/800 Series Colorimeters can store the calibration information needed to read prepared samples from up to ten different user-entered programs. To create a new, user-entered program, you will need a blank and prepared standards or the correct absorbance readings for each standard. The prepared standards are made with standard solutions of the parameter (i.e. analyte). Up to twelve concentrations of standards, including a zero concentration standard, may be used.

The absorbances of the prepared standards must be different from one another. If the colorimeter detects a duplicate, it will beep and ignore the latest reading.

Using a previously entered method's program number erases all the previously entered information stored under that program number.

While creating a user-entered program, the colorimeter remains on for four hours following any keypress. If more than four hours pass between keypresses, the instrument will power down. All data which was entered, but not yet stored, will be deleted. The user-entered program must be re-entered from the beginning.

4.1 User-Entered Programs

The instrument allows storage of up to ten user-entered programs (101-110) and up to 113 Hach programs.
A minimum of two data points are required for the instrument to recognize and accept a user-entered program.

- Program numbers 101 through 110 are reserved for storing user-entered programs.

- The maximum number of data points that can be entered for a method is 12. After the twelfth standard (1 through 12) is accepted, the instrument stores the method and will not accept any more data, but will allow the user to review the data already entered.

Before entering a calibration, determine the optimum wavelength, timing sequences (if any), and the workable range of the method.

4.2 Calibration Curves

Calibration curves may have positive or negative slopes, but they must be based on absorbance (% transmittance not allowed) and must pass through the origin that represents zero concentration.

It is important that the standards adequately describe the curve over the range of interest. Because this is largely dependent on the shape of the curve, it may be necessary to prepare a preliminary curve using extra data points to help select the appropriate standards.

If the curve is linear, only two concentration data points are needed. For example, standards with a zero absorbance and a standard with 1.000 absorbance are appropriate. If the curve is nonlinear, additional data points are needed to achieve good accuracy. Up to 12 data points can be entered for a single calibration curve.

4.3 User-entered Program Information for Bleaching Chemistries

Although the majority of colorimetric test procedures produce a higher absorbance (i.e. deeper color) as the concentration of the parameter being measured increases, some tests do the opposite. These bleaching chemistries (fluoride is one example) produce a lighter color at increasing concentrations. The zero concentration standard is usually produced by combining deionized water with the reagents. Commonly this solution is used to zero the instrument as in Step 13 of *Section 4.4 Creating a New User-entered Program.*

Once the zero is entered, the prepared standards must be read from lightest to darkest. In the case of bleaching chemistries, the absorbance values reported by the colorimeter may be negative.

Even when your test produces a lower absorbance (lighter color) with increasing concentration, the prepared standards must be read by the colorimeter in the order of increasing absorbance (i.e., from colorless or the palest color, to the deepest color). The instrument will not accept standards read out of order.

4.4 Creating a New User-entered Program

Use the step-by-step instructions below to enter a new user-entered program into instrument memory. Terminate at any point (before the program is stored) by pressing the **EXIT** key until the display is blank. The colorimeter will not retain any of the entered data.

1. Press the **I/O** key to turn on the instrument.

2. Press the **SETUP** key. The display will show **SETUP** in the upper-left and the down-arrow icon in the lower-right. Available action functions are also shown.

3. Press the down **ARROW** key until **USER** is displayed.

Note: *Press the up* **ARROW** *key if the display goes past* ***USER***.

4. Press the **ENTER** key. Four horizontal lines (numeric entry display) will be displayed.

5. Select a program number from 101 through 105 by pressing the corresponding digit key. The number will appear in the display.

Note: *Press* **CE** *to correct errors.*

6. Press **ENTER**. A wavelength and **nm** will be displayed.

   - If the wavelength is correct as displayed, skip to Step 7.
   - Some instrument models can use different wavelengths. If a different wavelength is preferred, proceed as follows:

   a) Press **ENTER**. A flashing question mark will be displayed in the lower-right corner.

   b) Press either **ARROW** key until the preferred wavelength is displayed.

   c) Press **ENTER** to accept the displayed wavelength. The down-arrow icon will be displayed.

7. Press the down **ARROW** key to move to the **RES** (resolution) option. One to four zeros, a decimal point if needed, and the units of concentration may be modified here.

   - If the displayed resolution and units are correct, skip to step 8.
   - If the displayed resolution or units are incorrect for your test, proceed with the following:

a) Press **ENTER**. A flashing question mark will be displayed.

b) Press either **ARROW** key until the preferred resolution and concentration units are displayed. The available options are:

0.000	0.00	0.0	0
0.000 µg/L	0.00 µg/L	0.0 µg/L	0 µg/L
0.000 mg/L	0.00 mg/L	0.0 mg/L	0 mg/L
0.000 g/L	0.00 g/L	0.0 g/L	0 g/L

c) Press **ENTER**. The question mark will disappear.

8. Press the down **ARROW** key to scroll to **STD**. **STD** and the number of the standard (i.e., 1 is shown for the first standard, 2 for the second, etc.) will be shown on the lower portion of the display.

9. Press **ENTER**. Four horizontal lines (denoting numeric entry) will be displayed.

10. Enter the standard's concentration, using the numeric entry keys (the # icon will be illuminated on the display).

Note: *Press the* **CE** *key to correct errors.*

11. Press the **ENTER** key. The concentration will be displayed.

Note: *A beep means that the concentration is a duplicate of a previous standard or the concentration is too high for the selected resolution. Repeat step 10 with a different concentration and continue.*

12. Press the down **ARROW** key. **ABS** will be displayed followed by the number of the standard.

13. The colorimeter requires one zero be entered in this procedure; the ZERO action icon will appear in the lower portion of the display. Place a blank into the cell holder and press the **ZERO** key. Four horizontal lines will appear, then disappear, across the display. The READ action icon will appear in the lower portion of the display.

Note: *If necessary, the colorimeter can be re-zeroed. The most recently entered zero will be used for subsequent readings.*

14. Prepare the standards using the same reagents and procedure used to test samples.

15. Place the prepared standard into the cell holder.

16. Press the **READ** key. An absorbance value will be displayed.

Note: Or, press the **ENTER** *key to input an absorbance value or change the value read by the instrument. Use the numeric keys to enter the value then press the* **ENTER** *key.*

Note: A beep indicates that the absorbance is a duplicate of a previously entered standard or that it falls between two previous standards. Repeat steps 14 through 16 with the correct standard, or press the up **ARROW** *key and repeat steps 8 through 16 with a correct, prepared standard and blank.*

17. Press the down **ARROW** key to advance to the next standard.

18. Repeat steps 8 through 17 for all remaining standards.

19. Press the **EXIT** key once. **STORE ?** will be displayed.

20. Press the **ENTER** key to store the new method in the instrument's memory.

4.5 Reviewing and Editing User-Entered Programs

Note: When a user-entered program is edited and stored, all stored data associated with that program is erased.

All method information previously stored by the operator can be reviewed and changed to add, delete, or modify data points. At any point during the editing function, the operator can terminate the procedure and exit by pressing the **EXIT** key. No changes to the program will occur.

Because the standards must be read in the order of increasing absorbancy, data points may not be inserted into the middle of an existing user-entered program.

To review and edit previously stored user-entered programs:

1. Press the **I/O** key to turn the instrument on.
2. Press the **SETUP** key.
3. Scroll to the **USER** option and press **ENTER**.
4. Enter the program number of the method to review or edit and press the **ENTER** key.
5. Scroll through the calibration information using the **ARROW** keys. To avoid making changes, press the **EXIT** key.
6. To edit the data shown on the display, press **ENTER**. Make necessary changes, then press the **ENTER** key to return to reviewing the data.
7. Press **EXIT** once. **STORE?** will be displayed.
8. Press **ENTER** to store the program.

4.6 Erasing User-entered Programs

Note: When a user-entered program is erased, all stored data associated with that program is also erased.

User-entered programs are automatically deleted when another user-entered program is entered and stored in the previously entered method's storage number (101-105). They also may be erased from the instrument memory as follows:

1. Press the **I/O** key to turn the instrument on.
2. Press the **SETUP** key.
3. Scroll to the **USER** option and press **ENTER**.
4. Enter the program number of the method to be erased and then press **ENTER**.
5. Scroll to the concentration data for STD 1 using the down **ARROW** key. Press **ENTER**.
6. Press **CE**. Press **ENTER**.
7. Press the **EXIT** key. **ERASE?** will be displayed.
8. Press the **ENTER** key to erase the method or the **EXIT** key to retain it in memory.

To store sample data, press **STORE** after the sample measurement is displayed. Data must be stored if you wish to recall it later for review, downloading or printing. The following information is stored for each sample:

- instrument model
- instrument serial number
- chemical form
- concentration
- units
- absorbance
- %T
- date
- time
- sample number
- program number

After the **STORE** key is pressed, a flashing question mark icon is shown in the lower-right portion of the display. In the center of the display, the next available storage number will appear. If this storage location is acceptable, press **ENTER** to accept it.

To select an empty storage number (between 1 and 99), use the **ARROW** keys to scroll to the desired number or enter the desired number with the numeric keys. Press **ENTER** to accept. The instrument will store the data, then revert back to the measurement display.

5.1 Recalling Data

To recall data stored in the colorimeter, press the **RECALL** key.

Use the **ARROW** keys to scroll through the stored data. Only data numbers containing stored sample reading data (of the available storage numbers 1-99) are displayed in the RECALL menu. For example, if the user has stored data into storage numbers 6, 10 and 15, those are the only accessible numbers in the Recall option. Available storage numbers are not shown as a Recall option because no data has been stored for recall purposes.

When a number of sample readings have been stored and a specific reading must be recalled, proceed as follows:

1. Press the **I/O** key to turn the colorimeter on.
2. Press the **RECALL** key to access the RECALL Menu.

Note: A beep indicates that no data is presently stored.

3. Press the number key(s) or either **ARROW** key on the keypad to scroll to the desired sample number.

4. Press the **ENTER** key. The stored reading will be displayed.

Note: A beep indicates that no data is stored as that sample number.

5. While the stored reading is displayed, press the **DATE** key or the **TIME** key to display the date or time the reading was stored. Press the **CONC** key to display the concentration data.

6. If other stored data is desired, press either **ARROW** key until the data is displayed.

7. Press **EXIT** to terminate data recall.

5.2 Erasing All Stored Data

Stored data can be erased and the memory of the instrument cleared using the procedure that follows.

1. Press the **I/O** key to turn the colorimeter on.

2. Press the **SETUP** key to enter the SETUP menu.

3. Scroll using the down **ARROW** key until ERASE and ALL appears on the display.

4. Press the **ENTER** key to confirm this selection with the instrument.

A flashing question mark icon will appear in the lower-right portion of the screen as an additional step to avoid erasing all data if the choice was made erroneously.

5. Confirm this action by pressing the **ENTER** key or, if this is not the desired action, press the **EXIT** key.

After the **ENTER** key is pressed, the instrument automatically erases all stored data and returns to the last used program.

SECTION 6 PRINTING AND DATA TRANSFER

6.1 Data Transfer Adapter Basics

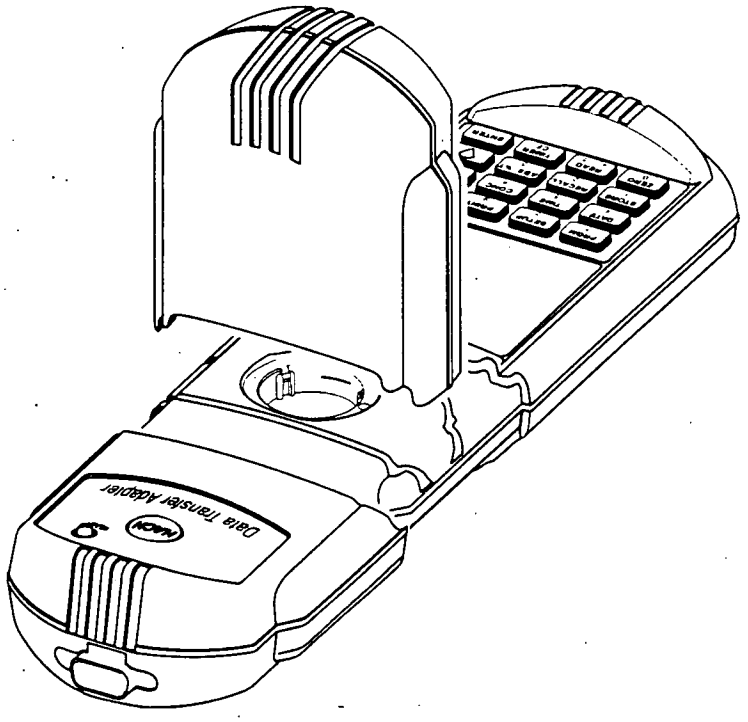
The optional Data Transfer Adapter (DTA) utilizes infra-red technology to receive data from the DR/800 Series Colorimeter and then transfer the signal into RS232 format. The DTA then sends the RS232 signal to a printer or personal computer.

The sleeve design makes the adapter compact, easy to use, and robust. Samples may be tested while the adapter is in place and the information may be immediately printed or downloaded to a computer. Data stored in the instrument memory may also be printed or downloaded at any time.

6.1.1 Attaching the Data Transfer Adapter

The Data Transfer Adapter is designed to fit on the instrument in the same way the instrument cap does. To install the DTA, simply remove the instrument cap, then slide the DTA onto the colorimeter body until it snaps into place. The DTA design allows the instrument cap to be used as a light shield. See *Figure 9 Installing the Data Transfer Adapter.*

Figure 9 Installing the Data Transfer Adapter



6.2 RS232 Connections

The RS232 receptacle on the Data Transfer Adapter connects with a 9-pin Sub-D connector (see *Figure 10 RS232 Connection*). A suitable RS232 cable is listed under Optional Accessories in *REPLACEMENT PARTS* on page *52*.

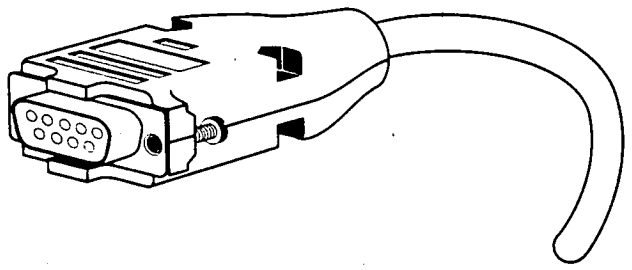
The RS232 interface output is an eight-bit data word plus one stop bit and no parity with a baud rate of 1200. It can communicate with either a serial printer or a serial communication port on a computer.

Press the **PRINT** key to send data to the printer or computer. See Section *6.3 Sending Data to a Printer or Computer* for instructions.

With the use of a serial-to-parallel converter, the data string transmitted from the colorimeter prints on any compatible parallel printer of the type normally used with IBM compatible applications.

All RS232 connections are made using the serial I/O port on the DTA. This port uses an industry standard 9-pin connector. See *Figure 10 RS232 Connection*.

Figure 10 RS232 Connection



Note: *For optimum performance and ESD protection, use a five-conductor shielded cable. Use a metal shell for the printer or CRT terminal connector, and connect the shield of the cable to the metal shell and to the sleeve (signal ground, of the RS232 plug.*

6.2.1 Setup and Use of the Printer

Follow the manufacturer's instructions when configuring the printer for compatibility with the colorimeter.

Pressing **PRINT** manually starts the printing, and pressing the **EXIT** key stops the printing (refer to Section *6.3 Sending Data to a Printer or Computer*).

Connect the DTA to a printer using the printer interface cable listed in *REPLACEMENT PARTS* on page *52*. The cable provides a direct link between the instrument and the 9-pin connector used for the serial port on most serial printers.

Table 4 and *Table 5* show the proper pin connections for 9-pin computer cables and for 25-pin printer cables. Use of cables that do not match the pin information given may cause undesirable operation.

Table 4 Standard 9-pin to 9-pin Computer Cable

DR/800 Series 9-pin Connector Socket		Computer 9-pin D Connector, plug	
Pin	**Signal Name**	**Pin**	**Signal Name**
2	RXD	3	TXD
3	TXD	2	RXD
4	DTR	no connection	—
5	GND	5	GND
6	DSR	no connection	—
7	RTS	8	CTS
8	CTS	7	RTS

Table 5 Standard 9-pin to 25-pin Printer Cable

DR/800 Series 9-pin Connector Socket		Computer 9-pin D Connector, plug	
Pin	**Signal Name**	**Pin**	**Signal Name**
2	RXD	no connection	—
3	TXD	3	RXD
4	DTR	no connection	—
5	GND	7	GND
6	DSR	20	DTR
7	RTS	no connection	—
8	CTS	20	DTR

To print, the communication parameters (baud rate, data bits and parity) of the instrument and the printer must match.

6.2.2 Connecting to a Personal Computer

Connect the colorimeter to a personal computer (PC) with the computer interface cable (Cat. No. 48129-00) listed under *REPLACEMENT PARTS* on page 52. The cable provides a direct link between the colorimeter and the 9-pin D connector used for the serial port on most personal computers. If your computer has a 25-pin D connector, use a 9-pin to 25-pin adapter (available at most computer supply stores).

Use a communications software, such as HachLink™ Software (Cat. No. 49665-00) to collect data from the instrument. HachLink is a Windows-based application that allows a personal computer to capture data from several Hach instruments, including the DR/800 Series Colorimeters.

The captured data can be stored in a text file as a spread-sheet compatible format or as free-format text. Data captured in the spreadsheet format is easily transferred into most spreadsheet programs (i.e., Excel®, Microsoft Works®, Lotus 123®) for graphing and reporting.

To install and run HachLink™ Software, the computer and software must meet the following minimum requirements:

- IBM PC/AT or compatible with a 386SX processor (16 MHz or better)
- 4 megabytes of RAM
- Hard disk drive with 2 megabytes or more of free space
- 3-1/2 inch, 1.44 megabyte floppy disk drive
- VGA graphics with 640 x 480 or higher resolution, 16 or more colors
- Mouse or other pointing device
- A 9-pin serial port (or 25-pin serial port with 9-pin adapter)
- Windows 3.1 or later
- DOS 3.3 or later

To transfer data, the communication parameters (baud rate, data bits and parity) of the instrument and the computer must match. Once the communication link is established, press **PRINT** to send data to the computer.

6.3 Sending Data to a Printer or Computer

A permanent record of test results may be obtained using the DTA RS232 serial output to drive a printer or by transferring the data to a computer for storage. Data displayed on the instrument screen may be sent to an accessory printer or computer by attaching the DTA to the instrument and pressing the **PRINT** key. The data can be data recalled from memory or the current sample reading. Only the information shown on the display will be printed.

6.3.1 Sending Currently Displayed Data

To transfer currently displayed data:

1. Remove the instrument cap and slide the DTA onto the instrument until snug.
2. Make sure the DTA is properly connected to the computer or printer. See *Section 6.2 RS232 Connections.*
3. Press the **PRINT** key. Four dashes and **PRINT** are displayed while the data is being transmitted to the DTA.

6.3.2 Sending Recalled Data

To transfer recalled data:

1. Remove the instrument cap and slide the DTA onto the instrument until snug.
2. Make sure the DTA is properly connected to the computer or printer. (See *Section 6.2 RS232 Connections.*)
3. Recall the data to be transferred (see *Section 5.1 Recalling Data* on page *33*).
4. When sample data is displayed, press the **PRINT** key. Four horizontal lines and **PRINT** are displayed while the data is transmitted to the DTA.

6.3.3 Sending All Stored Data

All data stored in memory may be sent to a printer or computer via the **SETUP** menu option as follows:

1. Remove the instrument cap and slide the DTA onto the instrument until snug.
2. Make sure the DTA is properly connected to the computer or printer. (See *Section 6.2 RS232 Connections.*)
3. Press the **SETUP** key.
4. Scroll, using the down **ARROW** key, to the **PRINT** option.
5. Press the **ENTER** key when the word **ALL** is displayed above **PRINT**. All stored data is now sent to the DTA. After the data has been successfully sent, the instrument defaults to the last used program.

Transferred data will include the following information:

- instrument model number
- instrument serial number
- instrument software version
- date
- time
- program number
- sample number
- concentration
- units
- chemical form
- Overrange errors (limit)
- absorbance
- %T

Figure 11 Printed Data Format

```
DR/890      970990000319   P1.2
01/01/97   00:02   Program  52
0.000  ABS  100.1  %T


DR/890      970990000319   P1.2
02/01/97   19:19   Program  56
0.451  ABS  35.40  %T


DR/890      970990000319   P1.2
02/02/97   01:14   Program  25
0 520 ug/L DEHA
0.000  ABS  99.89  %T
```

7.1 Cleaning the Colorimeter

Use a damp cloth to wipe the outside of the colorimeter enclosure. Wipe up spills promptly. Use cotton swabs to clean and dry the sample compartment if any spillage occurs.

Keep the colorimeter and sample cells clean at all times. Use a lens tissue or a soft, lint-free cloth (that will not leave an oil film) to wipe out the sample cell.

7.1.1 Cleaning the Data Transfer Adapter

Little cleaning is required of this adapter. Clean the outside and inside with a barely damp cloth. Wipe up spills promptly.

7.1.2 Sample Cells

Clean sample cells with detergent, rinse several times with tap water, and then rinse thoroughly with deionized water. Some cells may require acid washing or other special cleaning procedures. Refer to the Procedures Manual for additional information. Rinse sample cells used with organic solvents (chloroform, benzene, toluene, etc.) with acetone before the detergent wash, and again as a final rinse before drying.

7.2 Replacement Instructions

To prevent static electricity damage to the instrument, always turn the instrument off before removing the batteries.

7.2.1 Battery Replacement

When the **LOW BATTERY** icon appears in the display the batteries must be replaced or recharged as soon as possible to ensure proper instrument performance. Turn the instrument off before removing the battery compartment door.

The correct date and time may need to be reentered after battery replacement. See *Section 2.3 Setting the Date and Time*.

See *Section 2.1 Battery Installation* for complete installation instructions.

8.1 Introduction

Correcting problem conditions with the DR/800 Series Colorimeters in the field is limited to responding to the error messages presented in the display. Other problems must be handled by a Hach technician at a service center. Refer to *REPAIR SERVICE*. **Do not** attempt to service anything other than the battery; there are no other field-serviceable parts. Opening the instrument case will void the warranty.

8.1.1 Error Codes

This feature identifies the problem area or areas when an error indication occurs during instrument operation. When an error occurs, **ERROR** displays on the screen, followed by a number which refers to a diagnostic error code. Refer to *Table 6* below to determine the error cause and possible corrective actions. Turn the instrument off, then on, to restore the instrument to operation.

Table 6 Error Codes

ERROR Code Number	Error Code Type	Corrective Action
1	Unconfigured instrument	Contact Hach Instrument Service Department
2	Could not read program data	Contact Hach Instrument Service Department
3	Could not write program data	Contact Hach Instrument Service Department
4	Measurement battery error	Replace instrument batteries
5	Measurement A/D error	Contact Hach Instrument Service Department
6	Measurement offset error	Check to be sure instrument light shield (cap) is correctly installed
7	Measurement low light error	Check for light path blockage Zero is out of instrument range; dilute to within range Contact Hach Instrument Service Department
8	Measurement over-range error	Make sure instrument cap is properly installed Contact Hach Instrument Service Department

8.1.2 Beeper/Error Icon

When a key is pressed that calls for the instrument to perform a function that is not available at that time, the beeper is activated once and the error icon appears on the display. Each time the unacceptable command is entered, one beep sounds.

If an unavailable program number is entered, the beeper also sounds. Program numbers must range from 101 to 105 (user programs) and 1 to 100 (Hach programs). Entering a number other than these results in the beeper sound and the error icon briefly illuminates. After this beep sounds, re-enter the proper number.

8.1.3 Concentration Out of Range

An out-of-range condition is indicated by the illuminated **LIMIT** icon. It means the sample concentration exceeds the range of the programmed calibration. Make sure the test procedure is followed correctly, dilute the sample (for over range samples) and rerun the test. Each Hach test has upper concentration value that defines the program range. Measurements beyond that range are unreliable.

8.1.4 Low Battery

The instrument continuously monitors battery voltage. If the battery voltage falls to a level which indicates less than ten percent battery life remains, the instrument automatically warns the operator by displaying the **LOW BATTERY** icon. Replace the batteries as soon as possible for most reliable instrument performance.

Table 7 DR/820 Chemistries

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Aluminum, Aluminon	Al	Al_2O_3	0 - 0.800	1
Bromine	Br_2	—	0 - 4.50	5
Bromine, AV	Br_2	—	0 - 4.50	6
Chlorine, free, HR	Cl_2	—	0 - 5.00	8
Chlorine, total, HR	Cl_2	—	0 - 5.00	8
Chlorine, free	Cl_2	—	0 - 2.00	9
Chlorine, total	Cl_2	—	0 - 2.00	9
Chlorine, free, AV	Cl_2	—	0 - 2.00	11
Chlorine, total, AV	Cl_2	—	0 - 2.00	11
Chlorine, free, Test 'N Tube	Cl_2	—	0.200	10
Chlorine, total, Test 'N Tube	Cl_2	—	0.200	10
COD, Manganese III	COD	—	20 - 1000	18
Cyanuric acid	CYACD	—	0 - 55	24
Hardness, calcium	$CaCO_3$	Ca	0 - 4.00	29
Hardness, magnesium	$CaCO_3$	Mg, $MgCO_3$	0 - 4.00	30
Iron, Ferrous	Fe	—	0 - 3.00	33
Iron, Ferrous, AV	Fe	—	0 - 3.00	33
Iron, total, FerroVer	Fe	—	0 - 3.00	33
Iron, total, FerroVer, AV	Fe	—	0 - 3.00	33
Manganese, HR	Mn	MnO_4, $KMnO_4$	0 - 20.0	41
Nitrate, HR, AV	NO_3-N	NO_3	0 - 30.0	50
Nitrate, HR	NO_3-N	NO_3	0 - 30.0	51
Nitrate, LR	NO_3-N	NO_3	0 - 0.50	55
Nitrite, LR	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	60
Nitrite, LR, AV	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	62
Nitrite, TNT	NO_2-N	NO_2, $NaNO_2$	0 - 0.500	63
Oxygen, dissolved, HR, AV	O_2	—	0 - 15.0	70
pH	pH	—	6.5 - 8.5 pH	75
Phosphorous, amino acid	PO_4	P, P_2O_5	0 - 30.0	85
Sulfate	SO_4	—	0 - 70	91
Sulfate, AV	SO_4	—	0 - 70	92
Turbidity	FAU	—	0 - 1000 FAU	95
Volatile Acids	HOAc	—	0 - 2800	96

Table 8 DR/850 Chemistries

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Aluminum, Aluminon	Al	Al_2O_3	0 - 0.800	1
Bromine	Br_2	—	0 - 4.50	5
Bromine, AV	Br_2	—	0 - 4.50	6
Chlorine, free, HR	Cl_2	—	0 - 5.00	8
Chlorine, total, HR	Cl_2	—	0 - 5.00	8
Chlorine, free	Cl_2	—	0 - 2.00	9
Chlorine, total	Cl_2	—	0 - 2.00	9
Chlorine, free, AV	Cl_2	—	0 - 2.00	11
Chlorine, total, AV	Cl_2	—	0 - 2.00	11
Chlorine, free, Test 'N Tube	Cl_2	—	0 - 2.00	10
Chlorine, total, Test 'N Tube	Cl_2	—	0 - 2.00	10
COD, HR, HR+	COD	—	0 - 1500, 0-15,000	17
COD, Manganese III	COD	—	20 - 1000	18
Cyanide	CN	—	0 - 0.240	23
Cyanuric acid	CYACD	—	0 - 55	24
Detergents	LAS	—	0 - 0.30	26
Fluoride, SPADNS	F	—	0 - 2.00	27
Fluoride, SPADNS, AV	F	—	0 - 2.0	28
Hardness, calcium	$CaCO_3$	Ca	0 - 4.00	29
Hardness, magnesium	$CaCO_3$	Mg, $MgCO_3$	0 - 4.00	30
Iron, Ferrous	Fe	—	0 - 3.00	33
Iron, Ferrous, AV	Fe	—	0 - 3.00	33
Iron, total, FerroVer	Fe	—	0 - 3.00	33
Iron, total, FerroVer, AV	Fe	—	0 - 3.00	33
Iron, total, FerroMo	Fe	—	0 - 1.80	38
Iron, total, TPTZ	Fe	—	0 - 1.80	39
Iron, total, TPTZ, AV	Fe	—	0 - 1.80	39
Manganese, HR	Mn	MnO_4, $KMnO_4$	0 - 20.0	41
Molybdenum, ternary complex	Mo^6	MoO_4	0 - 3.00	47
Nitrogen, monochloramine and free ammonia, Salicylate	N	Cl_2, NH_3	0 - 0.50	49
Nitrogen, monochloramine and free ammonia, Salicylate, AV	N	Cl_2, NH_3	0 - 0.50	49
Nitrate, HR, AV'	NO_3-N	NO_3	0 - 30.0	50
Nitrate, HR	NO_3-N	NO_3	0 - 30.0	51

Table 8 DR/850 Chemistries (continued)

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Nitrate, LR	NO_3-N	NO_3	0 - 0.50	55
Nitrite, LR	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	60
Nitrite, LR, AV	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	62
Nitrite, TNT	NO_2-N	NO_2, $NaNO_2$	0 - 0.500	63
Nitrogen, Ammonia, Salicylate	NH_3-N	NH_3 , NH_4	0 - 0.50	64
Nitrogen, Ammonia, LR, TNT	NH_3-N	NH_3	0 - 2.50	66
Nitrogen, Ammonia, HR, TNT	NH_3-N	NH_3	0 - 50	67
Nitrogen, Total Inorganic, TNT	N	NH_3	0 - 25.0	68
Oxygen, dissolved, HR, AV	O_2	—	0 - 15.0	70
Oxygen, dissolved, LR, AV	O_2	—	0 - 1000 µg/L	71
Ozone, LR, AV	O_3	—	0 - 0. 25	72
Ozone, MR, AV	O_3	—	0 - 1.50	73
Ozone, HR, AV	O_3	—	0 - 0.75	74
pH	pH	—	6.5 - 8.5 pH	75
Phosphonates	PO_4	—	0-125	80
Phosphorous, PhosVer 3	PO_4	P, P_2O_5	0 - 2.50	79
Phosphorous, PhosVer 3, AV	PO_4	P, P_2O_5	0 - 2.50	79
Phosphorous, total, PhosVer 3	PO_4	P, P_2O_5	0 - 2.5	79
Phosphorous, acid hydrolyzable, PhosVer 3	PO_4	P, P_2O_5	0 - 2.5	79
Phosphorous, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 5.0	82
Phosphorous, total, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 3.50	82
Phosphorous, acid hydrolyzable, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 5.00	82
Phosphorous, amino acid	PO4	P, P_2O_5	0 - 30	85
Silica, LR	SiO2	—	0 - 1.60	90
Sulfate	SO_4	—	0 - 70	91
Sulfate, AV	SO_4	—	0 - 70	92
Sulfide	S	—	0 - 0.70	93
Suspended Solids	SuSld	—	0 - 750	94
Tannin and Lignin	tanic	—	0 - 9.0	98
Toxicity	Toxic	—	0 - 100% Inhibition	61
Turbidity	FAU	—	0 - 1000 FAU	95
Volatile Acids	HOAc	—	0 - 2800	96
Zinc	Zn	—	0 - 3.00	97

Table 9 DR/890 Chemistries

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Aluminum, Aluminon	Al	Al_2O_3	0 - 0.800	1
Boron	B	H_3BO_3	0 - 1.60	4
Bromine	Br_2	—	0 - 4.50	5
Bromine, AV	Br_2	—	0 - 4.50	6
Chlorine Dioxide, MR	ClO_2	—	0 - 50	7
Chlorine, free, HR	Cl_2	—	0 - 5.00	8
Chlorine, total, HR	Cl_2	—	0 - 5.00	8
Chlorine, free	Cl_2	—	0 - 2.00	9
Chlorine, total	Cl_2	—	0 - 2.00	9
Chlorine, free, AV	Cl_2	—	0 - 2.00	11
Chlorine, total, AV	Cl_2	—	0 - 2.00	11
Chlorine, free, Test 'N Tube	Cl_2	—	0 - 2.00	10
Chlorine, total, Test 'N Tube	Cl_2	—	0 - 2.00	10
Chromium, Hexavalent	Cr^6	CrO_4, Cr_2O_7	0 - 0.60	13
Chromium, Hexavalent, AV	Cr^6	CrO_4, Cr_2O_7	0 - 0.60	14
Chromium, total	Cr	—	0 - 0.60	15
COD, LR	COD	—	0 - 150	16
COD, HR, HR+	COD	—	0 - 1500, 0 - 15000	17
COD, Manganese III	COD	—	20 - 1000	18
Color	Pt Co	—	0 - 500 APHA color	19
Copper, Bichinchoninate	Cu	—	0 - 5.00	20
Copper, Bichinchoninate, AV	Cu	—	0 - 5.00	21
Copper, porphyrin	Cu	—	0 - 210.0 µg/L	22
Cyanide	CN	—	0 - 0.240	23
Cyanuric acid	CYACD	—	0 - 55	24
DEHA	DEHA	—	0 - 500 µg/L	25
Detergents	LAS	—	0 - 0.30	26
Fluoride, SPADNS	F	—	0 - 2.00	27
Fluoride, SPADNS, AV	F	—	0 - 2.00	28
Hardness, calcium	$CaCO_3$	Ca	0 - 4.00	29
Hardness, magnesium	$CaCO_3$	Mg, $MgCO_3$	0 - 4.00	3[illegible]
Hydrazine	N_2H_4	—	0 - 500 µg/L	3[illegible]
Hydrazine, AV	N_sH_4	—	0 - 500 µg/L	32

Table 9 DR/890 Chemistries (continued)

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Immunoassay, PCB	—	—	threshold	42
Immunoassay, TPH	—	—	threshhold	42
Immunoassay, TPH in water	—	—	threshhold	42
Iron, Ferrous	Fe	—	0 - 3.00	33
Iron, Ferrous, AV	Fe	—	0 - 3.00	33
Iron, total, FerroVer	Fe	—	0 - 3.00	33
Iron, total, FerroVer, AV	Fe	—	0 - 3.00	33
Iron, total, Ferrozine	Fe	—	0 - 1.300	37
Iron, total, FerroMo	Fe	—	0 - 1.80	38
Iron, total, TPTZ	Fe	—	0 - 1.80	39
Iron, total, TPTZ, AV	Fe	—	0 - 1.80	39
Manganese, HR	Mn	MnO_4, $KMnO_4$	0 - 20.0	41
Manganese, LR	Mn	MnO_4, $KMnO_4$	0 - 0.700	43
Molybdenum, Molybdate, HR	Mo^6	MoO_4	0 - 40.0	44
Molybdenum, Molybdate, HR, AV	Mo^6	MoO_4,	0 - 40.0	44
Molybdenum, ternary complex	Mo^6	MoO_4	0 - 3.00	47
Nickel, PAN	Ni	—	0 - 1.000	48
Nitrogen, monochloramine and free ammonia, Salicylate	N	Cl_2, NH_3	0 - 0.50	49
Nitrogen, monochloramine and free ammonia, Salicylate, AV	N	Cl_2, NH_3	0 - 0.50	49
Nitrate, HR, AV	NO_3-N	NO_3	0 - 30.0	50
Nitrate, HR	NO_3-N	NO_3	0 - 30.0	51
Nitrate, Cd reduction, MR, AV	NO_3-N	NO_3	0 - 5.0	53
Nitrate, Cd reduction, MR	NO_3-N	NO_3	0 - 5.0	54
Nitrate, LR	NO_3-N	NO_3	0 - 0.50	55
Nitrate, TNT, chromotropic acid finish	NO_3-N	NO_3	0 - 30.0	57
Nitrogen, TN, TNT, chromotropic acid	N	NO_3, NH_3	0 - 25	58
Nitrite, HR	NO_2	NO_2-N, $NaNO_2$	0 - 150	59
Nitrite, LR	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	60
Nitrite, LR, AV	NO_2-N	NO_2, $NaNO_2$	0 - 0.350	62
Nitrite, TNT	NO_2-N	NO_2, $NaNO_2$	0 - 0.500	63
Nitrogen, Ammonia, Salicylate	NH_3-N	NH_3 , NH_4	0 - 0.50	64
Nitrogen, TKN with Nessler finish	TKN	—	0 - 150	65
Nitrogen, Ammonia, LR, TNT	NH_3-N	NH_3	0 - 2.50	66

Table 9 DR/890 Chemistries (continued)

PARAMETER	Primary Form	Alternate Forms	Test Range of Primary Form (mg/L or as noted)	Program number
Nitrogen, Ammonia, HR, TNT	NH_3-N	NH_3	0 - 50	67
Nitrogen, Total Inorganic TNT	N	NH_3	0 - 25.0	68
Oxygen, dissolved, HR, AV	O_2	—	0 - 15.0	70
Oxygen, dissolved, LR, AV	O_2	—	0 - 1000 µg/L	71
Ozone, LR, AV	O_3	—	0 - 0.25	72
Ozone, MR, AV	O_3	—	0 - 0.75	73
Ozone, HR, AV	O_3	—	0 - 1.50	74
pH	pH	—	6.5 - 8.5 pH	75
Phosphonates	PO_4	—	0 - 125	80
Phosphorous, Molybdovanadate	PO_4	P, P_2O_5	0 - 45.0	77
Phosphorous, Molybdovanadate, AV	PO_4	P, P_2O_5	0 - 45.0	78
Phosphorous, PhosVer 3	PO_4	P, P_2O_5	0 - 2.50	79
Phosphorous, PhosVer 3, AV	PO_4	P, P_2O_5	0 - 2.50	79
Phosphorous, total, PhosVer 3	PO_4	P, P_2O_5	0 - 2.5	79
Phosphorous, acid hydrolyzable, PhosVer 3	PO_4	P, P_2O_5	0 - 2.5	79
Phosphorous, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 5.0	82
Phosphorous, total, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 3.50	82
Phosphorous, acid hydrolyzable, PhosVer 3, TNT	PO_4	P, P_2O_5	0 - 5.00	82
Phosphorous, amino acid	PO_4	P, P_2O_5	0 - 30.0	85
Silica, UHR	SiO_2	—	0 - 200	88
Silica, HR	SiO_2	—	0 - 75.0	89
Silica, LR	SiO_2	—	0 - 1.60	90
Sulfate	SO_4	—	0 - 70	91
Sulfate, AV	SO_4	—	0 - 70	92
Sulfide	S	—	0 - 0.70	93
Suspended Solids	SuSld	—	0 - 750	94
Triazole, Benzotriazole	BENZO	TOLY	0 - 16.0	3
Triazole, Tolytriazole	TOLY	BENZO	0 - 16.0	3
Tannin and Lignin	Tanic	—	0 - 9.0	98
Toxicity	Toxic	—	0 - 100% Inhibition	6[illegible]
Turbidity	FAU	—	0 - 1000 FAU	95
Volatile Acids	HOAc	—	0 - 2800	96
Zinc	Zn	—	0 - 3.00	97

GENERAL INFORMATION

At Hach Company, customer service is an important part of every product we make.

With that in mind, we have compiled the following information for your convenience.

REQUIRED APPARATUS

Description	Unit	Cat. N
Adapter, Assembly, COD	each	48464-(
Batteries, Alkaline AA	pkg/4	19380-(
Battery Cover Assembly	each	48455-(
Battery Holder for 4 Alkaline AA cells	each	48434-(
Manual Set, DR/890, includes Instrument & Procedure Manual & Binder	each	48470-[illegible]
Manual Set, DR/850, includes Instrument & Procedure Manual & Binder	each	48450-[illegible]
Manual Set, DR/820, includes Instrument & Procedure Manual & Binder	each	48440-[illegible]
Sample Cell, 25 x 95 mm 10-20-25 mL	pkg/6	24019-(

OPTIONAL ACCESSORIES

Adapter, Immunoassay	each	48[illegible]
Adapter, Data Transfer, RS232, includes 48129-00 cable	each	48[illegible]
Batteries, Rechargeable, NiCad, for PN60 Printer	each	26688-(
Batteries, Rechargeable, Alkaline AA, for DR/800 Series Colorimeter	pkg/4	49427-(
Battery Charger, Alkaline AA 115 VAC UL Approved	each	49428-(
Cap, Sample Cell, for 25 x 95 mL cell	pkg/12	24018-1
Carrying Case, DR/800 Series Colorimeter	each	49425-(
Carrying Case, Portable Laboratory	each	49430-(
Computer Interface Cable, 6 ft., for use with the DTA	each	48129-(
Foot, Rubber, DR/800 Series Colorimeter	each	49424-(
HachLink Software	each	49665-(
Instrument Cap	each	49431-(
Power Cord for PN60 Printer, European Plug	each	46836-(
Printer, 115/230V, Citizen PN60*	each	26687-(
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Printer Ink Cartridge, for PN60 Printer, Black	pkg/2	26690-(

* Requires Data Transfer Adapter

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Hach Sales & Service Canada Ltd.
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Winnipeg, Manitoba R3H 0X4
Telephone: (204) 632-5598
FAX: (204) 694-5134

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- Hach Account number
- Billing Address
- Your Name and phone number
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- Brief description or model number
- Quantity

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Telephone: (970) 669-3050
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Chaussée de Namur, 1
B-5150 Floriffoux (Namur), Belgium
Telephone: (32)(81) 44.71.71
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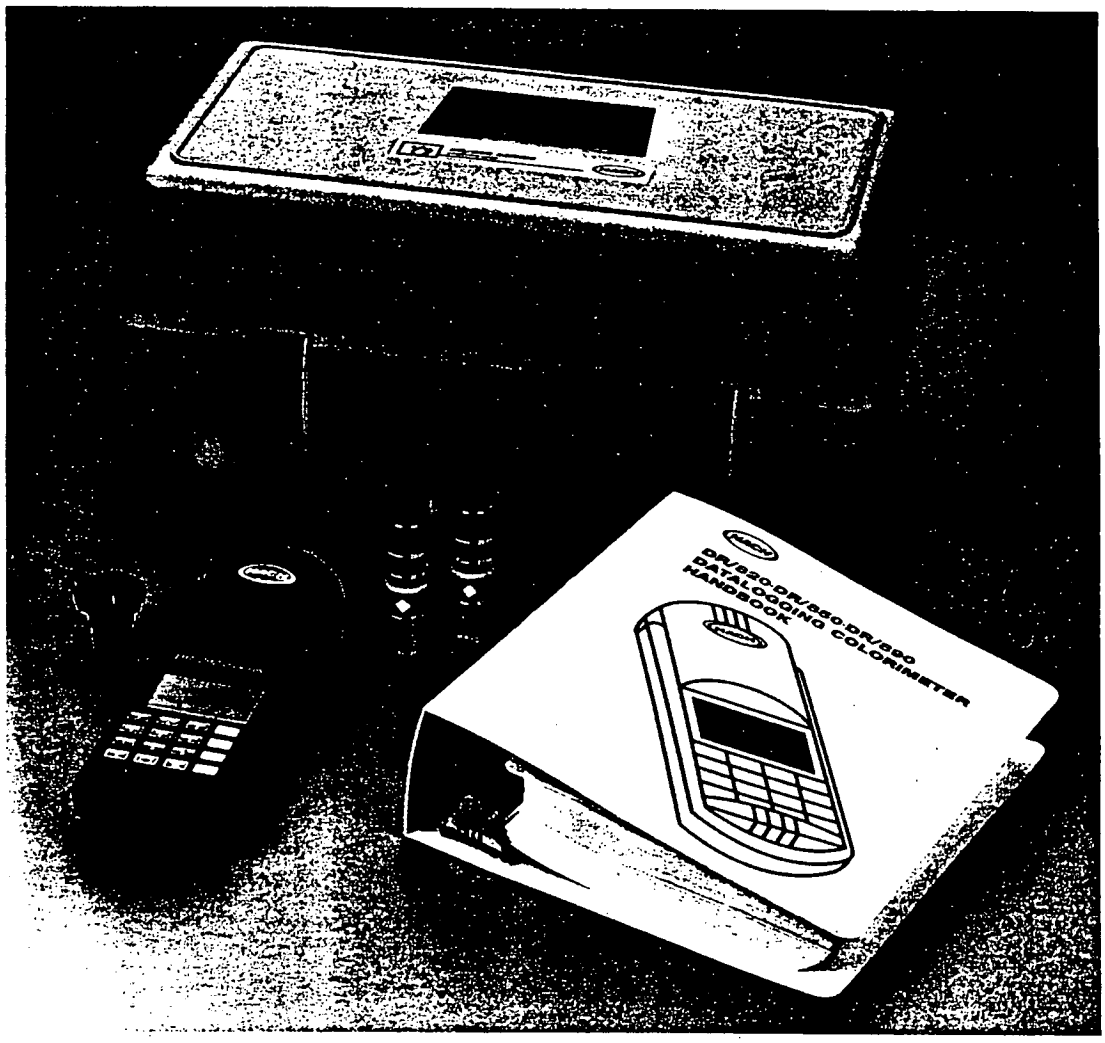

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Note: Strikethrough sections are not used on this job and have been removed from the Operations Manual.

TABLE OF CONTENTS

INTRODUCTION 1
Sample Procedure Explained 3

SECTION 1 CHEMICAL ANALYSIS INFORMATION 7
Abbreviations 7
Converting Chemical Species 7
Hardness Conversion 8
Dissolved Oxygen 10
Sample Collection, Preservation and Storage 12
Collecting Water Samples 15
Acid Washing Bottles 16
Correcting for Volume Additions 16
Boiling Aids 17
Sample Filtration 17
Temperature Considerations 19
Sample Dilution Techniques 19
Using Pipets and Graduated Cylinders 20
Using the TenSette Pipet 22
Mixing Water Samples 23
Using Sample Cells 25
Orientation of Sample Cells 25
Care of Hach Sample Cells 25
Cleaning Sample Cells 25
Using the COD/TNT Adapter 25
Volume Measurement Accuracy 25
Using AccuVac Ampuls 26
Using Reagent Powder Pillows 27
Using PermaChem Pillows 27
Reagent and Standard Stability 28
Interferences 28
pH Interference 29
Accuracy and Precision 30
Standard Additions 30
Method Performance 37
Estimated Detection Limit 37
Precision 40
Estimating Precision 40
Reagent Blank Correction 41

TABLE OF CONTENTS, continued

Standard Adjust (Adjusting the Standard Curve) 41
Preparing a User-Entered Calibration Curve 43
%T Versus Concentration Calibration 43
Absorbance Versus Concentration Calibration 45
USEPA Approved and Accepted Definitions 45

SECTION 2 SAMPLE PRETREATMENT 47
Digestion 47
EPA Mild Digestion with Hot Plate for Metals Analysis Only 47
EPA Vigorous Digestion with Hot Plate for Metals Analysis Only 48
General Digesdahl Digestion (Not USEPA accepted) 49
Distillation 50

SECTION 3 WASTE MANAGEMENT AND SAFETY 51
Waste Management ..... [illegible]
Waste Minimization ..... [illegible]
Regulatory Overview 51
Hazardous Waste Definition 52
Characteristic Hazardous Waste Codes 53
How to Determine if Waste is Hazardous 53
Examples of Hazardous Waste 54
Hazardous Waste Disposal 54
Management of Specific Wastes 55
Special Considerations for Cyanide-Containing Materials 55
Resources 56
Material Safety Data Sheets 57
How to Obtain A MSDS 57
Sections of the MSDS 58
Safety 60
Material Safety Data Sheet 60
Reading Labels Carefully 60
Protective Equipment 61
First Aid Equipment and Supplies 61
General Safety Rules 62
OSHA Chemical Hygiene Plan 62

TABLE OF CONTENTS, continued

SECTION 4 PROCEDURES 63

~~ALUMINUM, Aluminon Method ..... 65~~

~~BROMINE, DPD Method ..... 71~~

~~CHLORINE, FREE, High Range, DPD Method ..... 79~~

~~CHLORINE, TOTAL, High Range, DPD Method ..... 85~~

~~CHLORINE, FREE, DPD Method ..... 91~~

~~CHLORINE, TOTAL, DPD Method ..... 99~~

~~CHLORINE, FREE, DPD Test 'N Tube™ Method ..... 107~~

~~CHLORINE, TOTAL, DPD Test 'N Tube™ Method ..... 113~~

~~CYANIDE, Pyridine-Pyrazalone Method ..... 119~~

~~CYANURIC ACID, Turbidimetric Method ..... 129~~

~~FLUORIDE, SPADNS Method ..... 133~~

~~HARDNESS, Calcium and Magnesium, Calmagite Colorimetric Method ..... 141~~

IRON, FERROUS, 1,10 Phenanthroline Method 147

~~IRON, TOTAL, FerroVer Method ..... 153~~

~~IRON, TOTAL, FerroMo™ Method ..... 161~~

~~IRON, TOTAL, TPTZ Method ..... 165~~

~~MANGANESE, High Range, Periodate Oxidation Method ..... 173~~

~~MOLYBDENUM, MOLYBDATE, Low Range, Ternary Complex Method ..... 177~~

~~NITRATE, High Range, Cadmium Reduction Method ..... 183~~

NITRATE, LR, Cadmium Reduction Method 191

NITRITE, Low Range, Diazotization Method 197

~~NITRITE, Test 'N Tube™, Diazotization Method ..... 203~~

~~NITROGEN, AMMONIA, Salicylate Method ..... 207~~

~~NITROGEN, AMMONIA, Low Range Test 'N Tube, Salicylate Method ..... 213~~

~~NITROGEN, AMMONIA, High Range, Test 'N Tube, Salicylate Method ..... 219~~

~~NITROGEN, MONOCHLORAMINE AND FREE AMMONIA, Salicylate Method ..... 225~~

~~NITROGEN, Total Inorganic, Test 'N Tube™, Titanium Trichloride Reduction Method ..... 233~~

~~OXYGEN DEMAND, CHEMICAL, Manganese III Digestion Method ..... 239~~

~~OXYGEN DEMAND, CHEMICAL, Reactor Digestion Method ..... 249~~

~~Colorimetric Determination, 0 to 1,500 and 0 to 15,000 mg/L COD ..... 251~~

~~OXYGEN, DISSOLVED, High Range, HRDO Method ..... 257~~

TABLE OF CONTENTS, continued

~~OXYGEN, DISSOLVED, Low Range, Indigo Carmine Method ..... 261~~

~~OZONE, Indigo Method ..... 265~~

~~pH, Colorimetric pH Determination Using Phenol Red ..... 269~~

~~PHOSPHONATES, Persulfate UV Oxidation Method ..... 273~~

~~PHOSPHORUS, REACTIVE, (Also called Orthophosphate) PhosVer 3 (Ascorbic Acid) Method ..... 279~~

~~PHOSPHORUS, TOTAL, (Also called Organic and Acid Hydrolyzable) Acid Persulfate Digestion Method ..... 287~~

~~PHOSPHORUS, ACID HYDROLYZABLE, Hydrolysis to Orthophosphate Method ..... 291~~

~~PHOSPHORUS, REACTIVE, PhosVer 3 Method, Test 'N Tube Procedure ..... 295~~

~~PHOSPHORUS, TOTAL, PhosVer 3 with Acid Persulfate Digestion ..... 301~~

~~PHOSPHORUS, ACID HYDROLYZABLE, PhosVer 3 with Acid Hydrolysis ..... 307~~

~~PHOSPHORUS, REACTIVE, Amino Acid Method ..... [illegible]~~

~~SILICA, Low Range, Heteropoly Blue Method ..... 319~~

~~SULFATE, SulfaVer 4 Method ..... 325~~

SULFIDE, Methylene Blue Method 333

~~SURFACTANTS, ANIONIC, (Also called: Detergents) Crystal Violet Method ..... 337~~

~~SUSPENDED SOLIDS, Photometric Method ..... 341~~

~~TANNIN AND LIGNIN, Tyrosine Method ..... 345~~

~~TOXTRAK™ TOXICITY TEST, Colorimetric Method ..... 349~~

~~TURBIDITY, Absorptometric Method ..... 355~~

~~VOLATILE ACIDS, Esterification Method ..... 359~~

~~ZINC, Zincon Method ..... 365~~

SECTION 5 ORDERING INFORMATION 371

HOW TO ORDER 373

ADDITIONAL INFORMATION 375

INTRODUCTION

This manual is divided into five sections:

Section 1 Chemical Analysis Information

This section applies to all the procedures. It provides background information and reference/review material for the technician or chemist. Commonly used techniques are explained in detail.

Section 2 Sample Pretreatment

This section provides a brief overview of sample pretreatment and two USEPA digestions. A brief discussion of the Hach Digesdahl Digestion Apparatus and the Hach Distillation Apparatus is included.

Section 3 Waste Management and Safety

Section 3 includes information on waste management, regulations, waste disposal and resources on waste management. The Safety portion covers reading an MSDS and general safety guidelines.

Section 4 Procedures

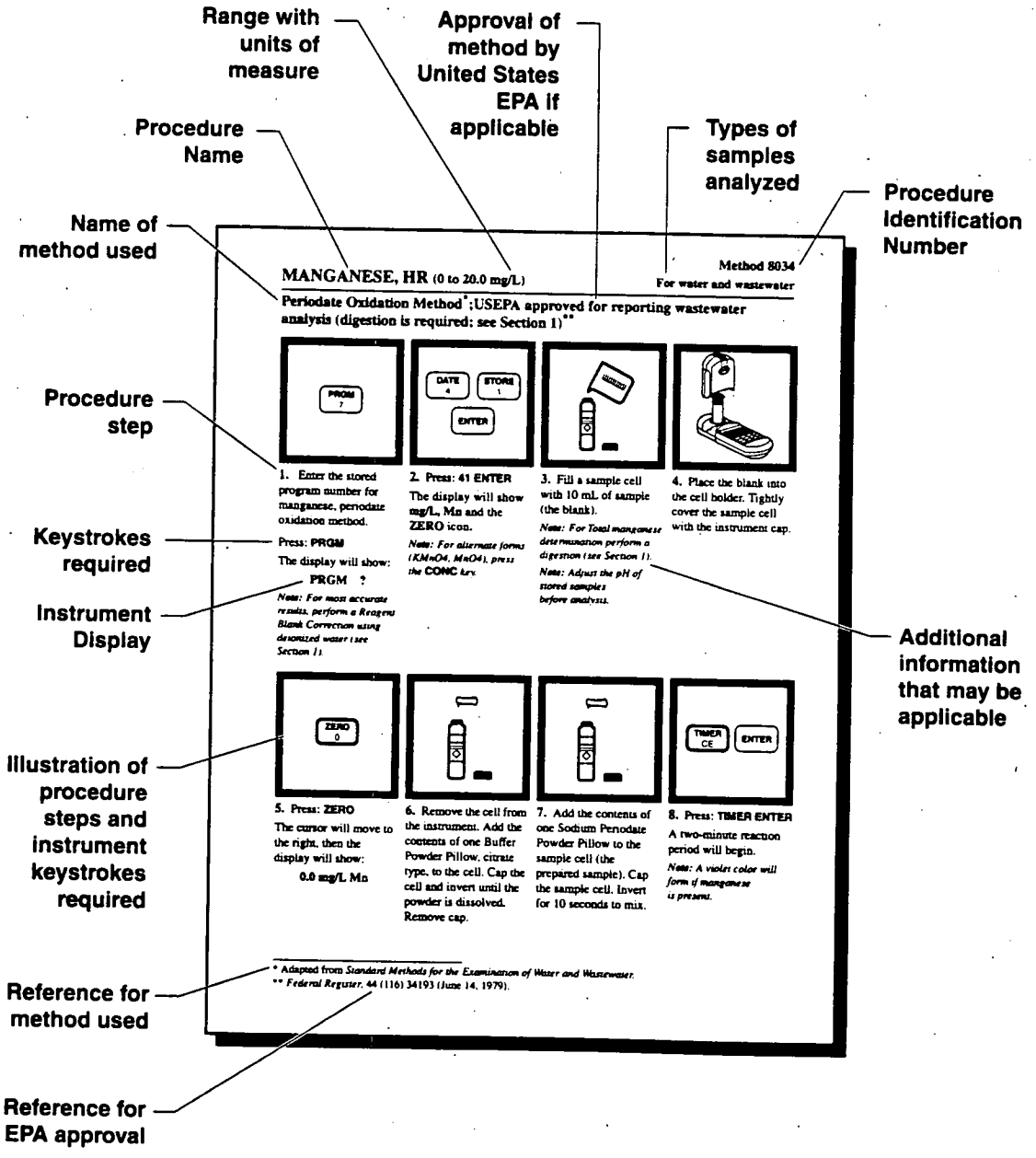
Section 4 contains step-by-step illustrated instructions for measuring parameters. The steps also include helpful notes. Each procedure contains information on sample collection, storage and preservation, accuracy checks, possible interferences, summary of method and a list of the reagents and apparatus necessary to run the test.

Section 5 Ordering Information

This section provides information needed for ordering, shipping, return of items and Hach trademarks.

Before attempting the analysis procedures the analyst should read the instrument manual to learn about the colorimeter's features and operation.

Sample Procedure Explained

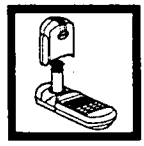


Sample Procedure Explained, continued

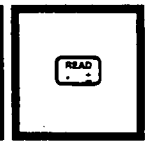
Specific sampling and storage information for this test

Confirm accuracy with these steps (in addition, may also be used to troubleshoot a test, improve technique, check reagents and to assure cleanliness of glassware)

MANGANESE, HR, continued



9. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.



10. Press: **READ**

The cursor will move to the right, then the result in mg/L manganese will be displayed.

Note: Standard Adjust may be performed using a prepared standard (see Section 1).

Sampling and Storage

Collect samples in acid-washed plastic bottles. Manganese may be lost by adsorption to glass container walls. Adjust the pH to less than 2 with nitric acid (about 2 mL per liter). Preserved samples may be stored up to six months at room temperature. Adjust the pH to 4 to 5 with 5.0 N sodium hydroxide before analysis. Do not exceed pH 5, as manganese may be lost as a precipitate. Correct the test result for volume additions: see *Correction for Volume Additions* in *Section 1* for more information. If only dissolved Mn is to be determined, filter before acid addition.

Accuracy Check

Standard Additions Method

a) Snap the neck off a Manganese Voluette Ampule Standard Solution, 250 mg/L Mn.

b) Use the TenSette Pipet to add 0.1, 0.2 and 0.3 mL of standard, respectively, to the three 25-mL water samples. Swirl to mix.

c) Transfer only 10 mL of each solution to the 10-mL sample cells.

d) Analyze each standard addition sample as described in the procedure. The manganese concentration should increase 1.0 mg/L for each 0.1 mL of standard added.

e) If these increases do not occur, see *Standard Additions* in *Section 1* for troubleshooting information.

Sample Procedure Explained, continued

Expected repeatability and estimated detection limit of the procedure

Levels of common sample substances or conditions that will cause inaccurate results

Concise explanation of method

MANGANESE, HR, continued

Standard Solution Method
Prepare a 5.0 mg/L manganese standard solution by pipetting (use a TenSette or CLass A volumetric pipet) 5.00 mL of Manganese Standard Solution, 1000 mg/L Mn, into a 1000-mL volumetric flask. Dilute to the mark with deionized water. Or, prepare this standard by diluting 1.00 mL of a High Range Manganese Standard Voluette Ampule, 250 mg/L, to 50 mL. Prepare these solutions daily. Use these solutions as the sample in the procedure.

Method Performance

Precision
In a single laboratory, using a standard solution of 10.00 mg/L Mn and two representative lots of reagent with the instrument, a single operator obtained a standard deviation of ±0.18 mg/L Mn.

Estimated Detection Limit
The estimated detection limit for program 41 is 0.12 mg/L Mn. For more information on the estimated detection limit, see *Section 1*.

Interferences

The following may interfere when present in concentrations exceeding those listed below:

Calcium	700 mg/L
Chloride	70,000 mg/L
Iron	5 mg/L
Magnesium	100,000 mg/L

Highly buffered samples or extreme sample pH may exceed the buffering capacity of the reagents and require sample pretreatment; see *pH Interferences* in *Section 1*.

Summary of Method
Manganese in the sample is oxidized to the purple permanganate state by sodium periodate, after buffering the sample with citrate. The purple color is directly proportional to the manganese concentration.

Sample Procedure Explained, continued

Lists all reagents and standards required for the procedure

Items needed to perform the procedure

Supplemental reagents and apparatus mentioned in notes or after the procedure

Use this phone number to obtain technical assistance

Amount of reagents and apparatus needed to perform the procedure

MANGANESE, HR, continued

REQUIRED REAGENTS

	Cat. No.
High Range Manganese Reagent Set (100 tests) 10 mL	24300-00

Description	Quantity Required Per Test	Unit	Cat. No.
Buffer Powder Pillows, citrate type for manganese	1 pillow	100/pkg	21076-69
Sodium Periodate Powder Pillows for manganese	1 pillow	100/pkg	21077-69

REQUIRED APPARATUS

Sample Cell, 10-20-25 mL, w/cap	2	6/pkg	24019-06

OPTIONAL REAGENTS

Hydrochloric Acid, 6 N	500 mL	884-49
Manganese Standard Solution, 1000 mg/L Mn	100 mL	12791-42
Manganese Standard Solution, Voluette ampule, High Range, 250 mg/L Mn, 10 mL	16/pkg	14258-10
Nitric Acid, ACS	500 mL	152-49
Nitric Acid Solution 1:1	500 mL	2540-49
Sodium Hydroxide Solution, 5.0 N	100 mL MDB	2450-32
Water, deionized	4 L	272-56

OPTIONAL APPARATUS

Ampule Breaker Kit	each	21968-00
Clippers, for opening powder pillows	each	968-00
Flask, erlenmeyer, 250 mL	each	505-46
Flask, volumetric, Class A, 50 mL	each	14574-41
Flask, volumetric, Class A, 500 mL	each	26366-49
Flask, volumetric, Class A, 100 mL	each	14574-42
Flask, volumetric, Class A, 1000 mL	each	14574-53
pH Indicator Paper, 1 to 11 pH	5 rolls/pkg	391-33
pH Meter, EC10, portable	each	50050-00
Pipet, serological, 1 mL	each	532-35
Pipet, serological, 5 mL	each	532-37
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet, TenSette, 1.0 to 10.0 mL	each	19700-10
Pipet Tips, for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet Tips, for 19700-10 TenSette Pipet	50/pkg	21997-96
Pipet, volumetric, Class A, 5.00 mL	each	14515-37
Pipet, volumetric, Class A, 1.00 mL	each	14515-35
Pipet Filler, safety bulb	each	14651-00

For Technical Assistance, Price and Ordering

In the U.S.A.—Call 800-227-4224

Outside the U.S.A.—Contact the Hach office or distributor serving you.

SECTION 1 CHEMICAL ANALYSIS INFORMATION

Abbreviations

The following abbreviations are used throughout the text of the procedure section:

Abbrev-iation	Definition	Abbrev-iation	Definition
°C	degree(s) Celsius (Centigrade)	MDL	Method detection limit
°F	degree(s) Fahrenheit	MDB	marked dropping bottle
ACS	American Chemical Society reagent grade purity	mg/L	milligrams per liter (ppm)
APHA Standard Methods	*Standard Methods for the Examination of Water and Wastewater.*[1]	µg/L	micrograms per liter (ppb)
AV	AccuVac	mL	(milliliter)-approximately the same as a cubic centimeter (cc) or 1/1000 of a liter. Also known as a "cc".
conc	concentrated	MR	medium range
CFR	Code of Federal Regulations	NIPDWR	National Interim Primary Drinking Water Regulations
DB	dropping bottle	NPDES	National Pollutant Discharge Elimination System
EDL	Estimated detection limit	PCB	Poly chlorinated biphenyl
FAU	Formazin Attenuation Units. Turbidity unit of measure based on a Formazin stock suspension.	SCDB	self-contained dropping bottle
g	grams	TNT	Test 'N Tube™
gr/gal	grains per gallon (1 gr/gal = 17.12 mg/L)	TPH	Total petroleum hydrocarbons
HR	high range	TPTZ	(2,4,6-Tri-(2-Pyridyl)-1,3,5-Triazine)
L	Liter. Volume equal to one cubic decimeter (dm^3)	ULR	Ultra low range
LR	low range	USEPA	United States Environmental Protection Agency

[1] Published jointly by the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF). Order from Hach requesting Cat. No. 22708-00 or from the Publication Office of the American Public Health Association. This book is the standard reference work for water analysis. Many procedures contained in this manual are based on *Standard Methods.*

Converting Chemical Species

Species conversion factors for many commonly used substances are pre-programmed into the instrument (see *Table 1*). Conversions are method specific and are viewable after taking the reading by pressing **CONC.**

Table 1 Conversion Factors

To Convert From...	To...	Multiply By...
mg/L Al	mg/L Al_2O_3	1.8895
mg/L B	mg/L H_3BO_3	5.7

Table 1 Conversion Factors

To Convert From...	To...	Multiply By...
mg/L Ca-$CaCO_3$	mg/L Ca	0.4004
mg/L $CaCO_3$	mg/L Ca	0.4004
mg/L $CaCO_3$	mg/L Mg	0.2428
µg/L Carbohydrazide	µg/L Hydroquinone	1.92
µg/L Carbohydrazide	µg/L ISA	2.69
µg/L Carbohydrazide	µg/L MEKO	3.15
mg/L Cr^{6+}	mg/L CrO_4^{2-}	2.231
mg/L Cr^{6+}	mg/L Na_2CrO_4	3.115
mg/L Mg-$CaCO_3$	mg/L Mg	0.2428
mg/L Mn	mg/L $KMnO_4$	2.876
mg/L Mn	mg/L MnO_4^-	2.165
mg/L Mo^{6+}	mg/L MoO_4^{2-}	1.667
mg/L Mo^{6+}	mg/L Na_2MoO_4	2.146
mg/L N	mg/L NH_3	1.216
mg/L N	mg/L NO_3^-	4.427
mg/L Na_2CrO_4	mg/L Cr^{6+}	0.321
mg/L Na_2CrO_4	mg/L CrO_4^{2-}	0.72
mg/L NH_2Cl-N	mg/L Cl_2	5.0623
mg/L NH_2Cl-N	mg/L NH_2Cl	3.6750
mg/L NH_3-N	mg/L NH_3	1.216
mg/L NH_3-N	mg/L NH_4^+	1.288
mg/L NO_2^-	mg/L $NaNO_2$	1.5
mg/L NO_2^-	mg/L NO_2^--N	0.3045
mg/L NO_2^--N	mg/L $NaNO_2$	4.926
µg/L NO_2^--N	µg/L $NaNO_2$	4.926
mg/L NO_2^--N	mg/L NO_2^-	3.284
µg/L NO_2^--N	µg/L NO_2^-	3.284
mg/L NO_3^--N	mg/L NO_3^-	4.427
mg/L PO_4^{3-}	mg/L P	0.3261
µg/L PO_4^{3-}	µg/L P	0.3261
mg/L PO_4^{3-}	mg/L P_2O_5	0.7473
µg/L PO_4^{3-}	µg/L P_2O_5	0.7473
mg/L SiO_2	mg/L Si	0.4674
µg/L SiO_2	µg/L Si	0.4674

Hardness Conversion

Table 2 lists the factors for converting one unit of measure for hardness to another unit of measure. For example, to convert mg/L $CaCO_3$ to German parts/100.000 CaO, multiply the value in mg/L x 0.056.

Table 2 Hardness Conversion Factors

Units of Measure	mg/L $CaCO_3$	British gr/gal (Imperial) $CaCO_3$	American gr/gal (US) $CaCO_3$	French parts/ 100,000 $CaCO_3$	German Parts/ 100,000 CaO	meq/L[1]	g/L CaO	lbs./cu ft $CaCO_3$
mg/L $CaCO_3$	1.0	0.07	0.058	0.1	0.056	0.02	5.6×10^{-4}	6.23×10^{-5}
English gr/gal $CaCO_3$	14.3	1.0	0.83	1.43	0.83	0.286	8.0×10^{-3}	8.9×10^{-4}
US gr/gal $CaCO_3$	17.1	1.2	1.0	1.72	0.96	0.343	9.66×10^{-3}	1.07×10^{-3}
Fr. p/ 100,000 $CaCO_3$	10.0	0.7	0.58	1.0	0.56	0.2	5.6×10^{-3}	6.23×10^{-4}
Ger. p/ 100,000 CaO	17.9	1.25	1.04	1.79	1.0	0.358	1×10^{-2}	1.12×10^{-3}
meq/L	50.0	3.5	2.9	5.0	2.8	1.0	2.8×10^{-2}	3.11×10^{-2}
g/L CaO	1790.0	125.0	104.2	179.0	100.0	35.8	1.0	0.112
lbs./cu ft $CaCO_3$	16,100.0	1,123.0	935.0	1,610.0	900.0	321.0	9.0	1.0

[1] 'epm/L, or 'mval/L'
Note: 1 meq/L = 1N/1000

Dissolved Oxygen

Table 3 lists the mg/L dissolved oxygen in water at saturation for various temperatures and atmospheric pressures. The table was formulated in a laboratory using pure water. The values given are only approximations for estimating the oxygen content of a particular body of surface water.

Table 3 Dissolved Oxygen Saturation In Water

		Pressure in Millimeters and Inches Hg							
		mm							
		775	760	750	725	700	675	650	625
Temp		inches							
°F	°C	30.51	29.92	29.53	28.45	27.56	26.57	25.59	24.61
32.0	0	14.9	14.6	14.4	13.9	13.5	12.9	12.5	12.0
33.8	1	14.5	14.2	14.1	13.6	13.1	12.6	12.2	11.7
35.6	2	14.1	13.9	13.7	13.2	12.9	12.3	11.8	11.4
37.4	3	13.8	13.5	13.3	12.9	12.4	12.0	11.5	11.1
39.2	4	13.4	13.2	13.0	12.5	12.1	11.7	11.2	10.8
41.0	5	13.1	12.8	12.6	12.2	11.8	11.4	10.9	10.5
42.8	6	12.7	12.5	12.3	11.9	11.5	11.1	10.7	10.3
44.6	7	12.4	12.2	12.0	11.6	11.2	10.8	10.4	10.0
46.4	8	12.1	11.9	11.7	11.3	10.9	10.5	10.1	9.8
48.2	9	11.8	11.6	11.5	11.1	10.7	10.3	9.9	9.5
50.0	10	11.6	11.3	11.2	10.8	10.4	10.1	9.7	9.3
51.8	11	11.3	11.1	10.9	10.6	10.2	9.8	9.5	9.1
53.6	12	11.1	10.8	10.7	10.3	10.0	9.6	9.2	8.9
55.4	13	10.8	10.6	10.5	10.1	9.8	9.4	9.1	8.7
57.2	14	10.6	10.4	10.2	9.9	9.5	9.2	8.9	8.5
59.0	15	10.4	10.2	10.0	9.7	9.3	9.0	8.7	8.3
60.8	16	10.1	9.9	9.8	9.5	9.1	8.8	8.5	8.1
62.6	17	9.9	9.7	9.6	9.3	9.0	8.6	8.3	8.0
64.4	18	9.7	9.5	9.4	9.1	8.8	8.4	8.1	7.8
66.2	19	9.5	9.3	9.2	8.9	8.6	8.3	8.0	7.6
68.0	20	9.3	9.2	9.1	8.7	8.4	8.1	7.8	7.5
69.8	21	9.2	9.0	8.9	8.6	8.3	8.0	7.7	7.4
71.6	22	9.0	8.8	8.7	8.4	8.1	7.8	7.5	7.2
73.4	23	8.8	8.7	8.5	8.2	8.0	7.7	7.4	7.1

Table 3 Dissolved Oxygen Saturation In Water (continued)

		Pressure in Millimeters and Inches Hg							
		mm							
		775	760	750	725	700	675	650	625
Temp		inches							
°F	°C	30.51	29.92	29.53	28.45	27.56	26.57	25.59	24.61
75.2	24	8.7	8.5	8.4	8.1	7.8	7.5	7.2	7.0
77.0	25	8.5	8.4	8.3	8.0	7.7	7.4	7.1	6.8
78.8	26	8.4	8.2	8.1	7.8	7.6	7.3	7.0	6.7
80.6	27	8.2	8.1	8.0	7.7	7.4	7.1	6.9	6.6
82.4	28	8.1	7.9	7.8	7.6	7.3	7.0	6.7	6.5
84.2	29	7.9	7.8	7.7	7.4	7.2	6.9	6.6	6.4
86.0	30	7.8	7.7	7.6	7.3	7.0	6.8	6.5	6.2
87.8	31	7.7	7.5	7.4	7.2	6.9	6.7	6.4	6.1
89.6	32	7.6	7.4	7.3	7.0	6.8	6.6	6.3	6.0
91.4	33	7.4	7.3	7.2	6.9	6.7	6.4	6.2	5.9
93.2	34	7.3	7.2	7.1	6.8	6.6	6.3	6.1	5.8
95.0	35	7.2	7.1	7.0	6.7	6.5	6.2	6.0	5.7
96.8	36	7.1	7.0	6.9	6.6	6.4	6.1	5.9	5.6
98.6	37	7.0	6.8	6.7	6.5	6.3	6.0	5.8	5.6
100.4	38	6.9	6.7	6.6	6.4	6.2	5.9	5.7	5.5
102.2	39	6.8	6.6	6.5	6.3	6.1	5.8	5.6	5.4
104.0	40	6.7	6.5	6.4	6.2	6.0	5.7	5.5	5.3
105.8	41	6.6	6.4	6.3	6.1	5.9	5.6	5.4	5.2
107.6	42	6.5	6.3	6.2	6.0	5.8	5.6	5.3	5.1
109.4	43	6.4	6.2	6.1	5.9	5.7	5.5	5.2	5.0
111.2	44	6.3	6.1	6.0	5.8	5.6	5.4	5.2	4.9
113.0	45	6.2	6.0	5.9	5.7	5.5	5.3	5.1	4.8
114.8	46	6.1	5.9	5.9	5.6	5.4	5.2	5.4	4.8
116.6	47	6.0	5.9	5.8	5.6	5.3	5.1	4.8	4.7
118.4	48	5.9	5.8	5.7	5.5	5.3	5.0	4.8	4.6
120.2	49	5.8	5.7	5.6	5.4	5.2	5.0	4.7	4.5
122.0	50	5.7	5.6	5.5	5.3	5.1	4.9	4.7	4.4

Sample Collection, Preservation and Storage

Correct sampling and storage are critical for accurate testing. For greatest accuracy, thoroughly clean sampling devices and containers to prevent carryover from previous samples. Preserve the sample properly; each procedure has information about sample preservation.

- The least expensive containers are polypropylene or polyethylene.
- The best and most expensive containers are quartz or PTFE (polytetrafluoroethylene, Teflon).
- Avoid soft glass containers for metals in the microgram-per-liter range.
- Store samples for silver determination in light-absorbing containers, such as amber bottles.

Avoid contaminating the sample with metals from containers, deionized water or membrane filters. Thoroughly clean sample containers as described under Acid Washing Bottles.

Preservation slows the chemical and biological changes that continue after collection. These processes may change the amount of a chemical species available for analysis. Normally, analyze the samples as soon as possible after collection, especially when the analyte concentration is expected to be low. This also reduces the chance for error and minimizes labor.

Preservation methods include pH control, chemical addition, refrigeration and freezing. *Table 4* gives the recommended preservation for various substances. It also includes suggested types of containers and the maximum recommended holding times for properly preserved samples.

Preserve aluminum, cadmium, chromium, cobalt, copper, iron, lead, nickel, potassium, silver and zinc samples for at least 24 hours by adding one Nitric Acid Solution Pillow 1:1 (Cat. No. 2540-98) per liter of sample. Check the pH with pH indicator paper or a pH meter to assure the pH is 2 or less. Add additional pillows if necessary. Adjust the sample pH prior to analysis by adding an equal number of Sodium Carbonate Anhydrous Powder Pillows (Cat. No. 179-98). Or raise the pH to 4.5 with Sodium Hydroxide Standard Solution, 1 N or 5 N. Correct for the added volume of the preservatives; see *Correcting For Volume Additions*.

Table 4 Required Containers, Preservation Techniques and Holding Times[1]

Parameter No./Name	Container[2]	Preservation[3,4]	Maximum Holding Time[5]
Table 1A - Bacterial Tests			
1-4. Coliform, fecal and total	P,G	Cool, 4°C, 0.008%, $Na_2S_2O_3$[6]	6 hours
5. Fecal streptococci	P,G	Cool, 4°C, 0.008%, $Na_2S_2O_3$	6 hours

Table 4 Required Containers, Preservation Techniques and Holding Times[1] (continued)

Parameter No./Name	Container[2]	Preservation[3,4]	Maximum Holding Time[5]
Table 1B - Inorganic Tests			
1. Acidity	P, G	Cool, 4°C	14 days
2. Alkalinity	P, G	Cool, 4°C	14 days
4. Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
9. Biochemical oxygen demand (BOD)	P, G	Cool, 4°C	48 hours
10. Boron	P, PFTE or quartz	HNO_3 to pH<2	6 months
11. Bromide	P, G	None required	28 days
14. Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
15. Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
16. Chloride	P, G	None required	28 days
17. Chlorine, total residual	P, G	None required	Analyze immediately
21. Color	P, G	Cool, 4°C	48 hours
23-24. Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH>12, 0.6 g ascorbic acid[6]	14 days[7]
25. Fluoride	P	None required	28 days
27. Hardness	P, G	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months
28. Hydrogen ion (pH)	P, G	None required	Analyze immediately
31, 43. Kjeldahl and organic nitrogen	P, G	Cool 4°C, H_2SO_4 to pH<2	28 days
Metals[8]			
18. Chromium VI	P, G	Cool, 4°C	24 hours
35. Mercury 3, 5-8, 12, 13, 19, 20, 22, 26, 29, 30, 32-34, 36, 37, 45, 47, 51, 52, 58-60, 62, 63, 70-72, 74, 75.[9] Metals, except boron, chromium VI and mercury	P, G	HNO_3 to pH<2	6 months
38. Nitrate	P, G	Cool, 4°C	48 hours
39. Nitrate-nitrite	P, G	Cool 4°C, H_2SO_4 to pH<2	28 days
40. Nitrite	P, G	Cool, 4°C	48 hours
41. Oil and grease	G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
42. Organic Carbon	P, G	Cool, 4°C, HCl or H_2SO4 or H_3PO_4 to pH<2	28 days
44. Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
46. Oxygen, dissolved probe	G Bottle and top	None required	Analyze immediately
47. Winkler	G Bottle and top	Fix on site and store in dark	8 hours
48. Phenols	G only	Cool 4°C, H_2SO_4 to pH<2	28 days

Table 4 Required Containers, Preservation Techniques and Holding Times[1] (continued)

Parameter No./Name	Container[2]	Preservation[3,4]	Maximum Holding Time[5]
49. Phosphorus, elemental	G	Cool, 4°C	48 hours
50. Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
53. Residue, total	P, G	Cool, 4°C	7 days
54. Residue, filterable	P, G	Cool, 4°C	7 days
55. Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
56. Residue, Settleable	P, G	Cool, 4°C	48 hours
57. Residue, volatile	P, G	Cool, 4°C	7 days
61. Silica	P, PFTE or quartz	Cool, 4°C	28 days
64. Specific conductance	P, G	Cool, 4°C	28 days
65. Sulfate	P, G	Cool, 4°C	28 days
66. Sulfide	P, G	Cool 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
67. Sulfite	P, G	none required	Analyze immediately
68. Surfactants	P, G	Cool, 4°C	48 hours
69. Temperature	P, G	None required	Analyze immediately
73. Turbidity	P, G	Cool, 4°C	48 hours

1 This table was taken from Table II published in the Federal Register, July 1, 1995, 40 CFR, Part 136.3, pages 643-645. Organic tests are not included.

2 Polyethylene (P) or glass (G).

3 Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

4 When any sample is to be shipped by common carrier or sent through United States Mails, it must comply with the Department of Transportation Hazardous Material Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5 Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permitee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administer under §136.3(e). Some samples may not be stable for the maximum time period given in the table. A permitee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See §136.3(e) for details. The term "analyze immediately" usually means within 15 minutes or less after sample collection.

6 Should only be used in the presence of residual chlorine.

[7] Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to p' 12.

[8] Samples should be filtered immediately on-site before adding preservative for dissolved metals.

[9] Numbers refer to parameter numbers in 40 CFR Part 136.3, Table 1B.

Collecting Water Samples

Obtain the best sample by careful collection. In general, collect samples near the center of the vessel or duct and below the surface. Use only clean containers (bottles, beakers). Rinse the container several times first with the water to be sampled.

Take samples as close as possible to the source of the supply. This lessens the influences of the distribution system on the sample. Let the water run long enough to flush the system. Fill sample containers slowly with a gentle stream to avoid turbulence and air bubbles. Collect water samples from wells after the pump has run long enough to deliver water representative of the ground water feeding the well.

It is hard to obtain a truly representative sample when collecting surface water samples. Obtain best results by testing several samples. Use samples taken at different times from several locations and depths. The results can be used to establish patterns for that particular body of water.

Generally, as little time as possible should elapse between collecting the sample and analyzing it.

Depending on the test, special precautions in handling the sample may be necessary. This prevents natural interferences such as organic growth or loss or gain of dissolved gases. Each procedure describes sample preservatives and storage techniques for samples that are held for testing.

Acid Washing Bottles

If a procedure suggests acid-washing, use the following instructions:

a) Clean the glassware or plasticware with laboratory detergent (phosphate-free detergent is recommended).

b) Rinse well with tap water.

c) Rinse with a 1:1 Hydrochloric Acid Solution or 1:1 Nitric Acid Solution.

d) Rinse well with deionized water at least four times. Up to 12-15 rinses may be necessary if chromium is being determined.

e) Air dry.

Use chromic acid or chromium-free substitutes to remove organic deposits from glass containers. Rinse containers thoroughly with water to remove traces of chromium.

Wash glassware for phosphate determinations with phosphate-free detergents and acid-wash with 1:1 HCl. Thoroughly rinse the glassware with deionized water. For ammonia and Kjeldahl nitrogen, rinse with ammonia-free water.

Correcting for Volume Additions

If you use a large volume of preservative, correct for the volume of preservative added. This accounts for dilution due to the acid added to preserve the sample and the base used to adjust the pH to the range of the procedure. This correction is made as follows:

1. Determine the volume of initial sample, the volume of acid and base added, and the total or final volume of the sample.

2. Divide the total volume by the initial volume of sample.

3. Multiply the test result by this factor.

Example:

A one-liter sample was preserved with 2 mL of nitric acid. It was neutralized with 5 mL of 5 N sodium hydroxide. The result of the analysis procedure was 10.00 mg/L. What is the volume correction factor and correct result?

1. Total Volume = 1000 mL + 2 mL + 5 mL = 1007 mL

2. $\frac{1007}{1000} = 1.007$ = volume correction factor

3. 10.0 mg/L × 1.007 = 10.07 mg/L = correct result

Hach 1:1 Nitric Acid Pillows contain 2.5 mL of acid: correct for this volume. The addition of a Sodium Carbonate Power Pillow (neutralizes the 1:1 Nitric Acid Solution Pillow) does not need to be corrected for.

Boiling Aids

Boiling is necessary in some procedures. Using a boiling aid such as boiling chips (Cat. No. 14835-31) helps reduce bumping. Bumping is caused by the sudden, almost explosive conversion of water to steam as it is heated. Avoid bumping; it may cause injury or sample loss.

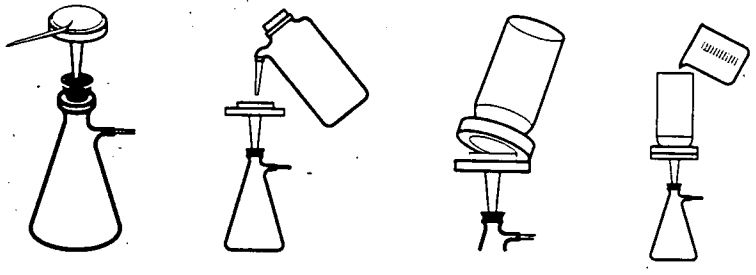
Make sure the boiling aids will not contaminate the sample. Do not use boiling aids (except glass beads) more than once. Loosely covering the sample during boiling will prevent splashing, reduce the chances of contamination and minimize sample loss.

Sample Filtration

Filtering separates particles from the aqueous sample. Filtration uses a medium, usually filter paper, to retain particles but pass solution. This is especially helpful when sample turbidity interferes with analysis. Two general methods of filtration are gravity and vacuum. Gravity filtration uses gravity to pull the sample though the filter paper. Vacuum filtration uses suction and gravity to move the sample through the filter. An aspirator or vacuum pump creates the suction. Vacuum filtration is faster than gravity filtration. Vacuum filter (see *Figure 1*) as follows:

1. Using tweezers, place a filter paper into the filter holder.
2. Place the filter holder assembly in the filtering flask. Wet the filter with deionized water to ensure adhesion to the holder. Empty the flask before filtering the sample.
3. Position the funnel housing on the filter holder assembly.
4. While applying a vacuum to the filtering flask, transfer the sample to the filtering apparatus.
5. Slowly release the vacuum from the filtering flask and transfer the solution from the filter flask to another container.

Figure 1 Vacuum Filtration



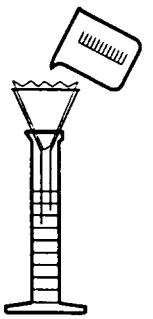
REQUIRED APPARATUS FOR VACUUM FILTRATION

Description	Unit	Cat. No.
Filter Discs, glass 47 mm, 1.5 µm	100/pkg	2530-00
Filter Holder, membrane	each	13529-00
Flask, filter, 500 mL	each	546-49
Pump, vacuum, hand operated	each	14283-00
OR		
Pump, vacuum, portable, 115 V	each	14697-00
Pump, vacuum, portable, 230 V	each	14697-02

Several procedures in this manual use gravity filtration. The only labware required is filter paper, a conical funnel and a receiving vessel. This labware is included under Optional Apparatus at the end of a procedure. Gravity filtration is better for retaining fine particles. For faster filtering, add solution until the filter paper cone is three-fourths filled. Never fill the cone completely. Gravity filter (see *Figure 2*) as follows:

1. Place a filter paper into the funnel.
2. Wet the filter with deionized water to ensure adhesion to the funnel. Allow all the deionized water to drain.
3. Place the funnel into an erlenmeyer flask or graduated cylinder.
4. Pour the sample into the funnel.

Figure 2 Gravity Filtration



REQUIRED APPARATUS FOR GRAVITY FILTRATION

Description	Unit	Cat No.
Cylinder, graduated, 100 mL	each	508-42
Funnel, poly, 65 mm	each	1083-67
Filter Paper, 12.5 cm	each	1894-57
Flask, erlenmeyer, 125 mL	each	505-43

Testing for metals requires acid and heat to pretreat the sample. Since these conditions destroy filter paper, vacuum filtration with glass fiber filter discs is recommended. Also, glass filter discs, unlike paper, do not retain colored species.

Temperature Considerations

For best results, perform most tests in this manual with sample temperatures between 20 °C (68 °F) and 25 °C (77 °F). If a test requires closer temperature control, notes in the procedure will indicate this.

Sample Dilution Techniques

Ten and 25 mL are the volumes used for most colorimetric tests. However, in some tests, the color developed in the sample may be too intense to be measured. Unexpected colors may develop in other tests. In both cases, dilute the sample to determine if interfering substances are present.

To dilute the sample easily, pipet the chosen sample portion into a clean graduated cylinder (or volumetric flask for more accurate work). Fill the cylinder (or flask) to the desired volume with deionized water. Mix well. Use the diluted sample when running the test.

To help with dilutions, *Table 5* shows the amount of sample used, the amount of deionized water used to bring the volume up to 25 mL and the multiplication factor.

The concentration of the sample is equal to the diluted sample reading multiplied by the multiplication factor.

More accurate dilutions can be done with a pipet and a 100-mL volumetric flask (see *Table 6* for more information). Pipet the sample and dilute to volume with deionized water. Swirl to mix.

Table 5 Sample Dilution Volumes

Sample Volume (mL)	mL Deionized Water Used to Bring the Volume to 25 mL	Multiplication Factor
25.0	0.0	1
12.5	12.5	2
10.0[1]	15.0	2.5
5.0[1]	20.0	5
2.5[1]	22.5	10
1.0[1]	24.0	25
0.250[1]	24.75	100

[1] For sample sizes of 10 mL or less, use a pipet to measure the sample into the graduated cylinder or volumetric flask.

Table 6 Multiplication Factors for Diluting to 100 mL

Sample Volume (mL)	Multiplication Factor
1	100
2	50
5	20
10	10
25	4
50	2

Sample Dilution and Interfering Substances

Sample dilution may influence the level at which a substance may interfere. The effect of the interferences decreases as the dilution increases. In other words, higher levels of an interfering substance can be present in the original sample if it is diluted before analysis.

An Example:

Copper does not interfere at or below 100 mg/L for a 25.00 mL sample in a procedure. If the sample volume is diluted with an equal volume of water, what is the level at which copper will not interfere?

$$\frac{\text{Total volume}}{\text{Sample volume}} = \text{Dilution factor}$$

$$\frac{25}{12.5} = 2$$

$$\text{Interference Level} \times \text{Dilution Factor} = \text{Interference level in sample}$$

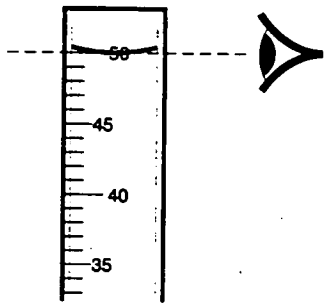
$$100 \times 2 = 200$$

The level at which copper will not interfere in the undiluted sample is at or below 200 mg/L.

Using Pipets and Graduated Cylinders

When small sample quantities are used, the accuracy of measurements is important. *Figure 3* illustrates the proper way of reading the sample level or the meniscus formed when the liquid wets the cylinder or pipet walls.

Figure 3 Reading the Meniscus



Rinse the pipet or cylinder two or three times with the sample to be tested before filling. Use a pipet filler or pipet bulb to draw the sample into the pipet. Never pipet chemical reagent solutions or samples by mouth. When filling a pipet, keep the tip of the pipet below the surface of the sample as the sample is drawn into the pipet.

Serological pipets have marks that indicate the volume of liquid delivered by the pipet. The marks may extend to the tip of the pipet or may be only on the straight portion of the tube. If the marks are only on the straight part of the tube, fill serological pipets to the zero mark and discharge the sample by draining the sample until the meniscus is level with the desired mark. If the serological pipet has marks extended to the tip of the pipet, fill the pipet to the desired volume and drain all the sample from the pipet. Then blow the sample out of the pipet tip for accurate measurements.

Volumetric (transfer) pipets have a bulb in the middle and a single ring above the bulb to indicate the volume of liquid when it is filled to the mark. To discharge a volumetric pipet, hold the pipet vertical until only a small amount of liquid remains (about ¾ inch), then hold the pipet at a slight angle against the container wall to drain. Do not attempt to discharge the solution remaining in the tip of the pipet after draining. Volumetric pipets are designed to retain a small amount of sample in the pipet tip.

If sample drops stay on the walls of the pipet, the pipet is dirty and is not delivering the correct amount of sample. Wash the pipet thoroughly with a laboratory detergent or cleaning solution and rinse several times with deionized water.

Using the TenSette Pipet

For best results use a new tip each time you pipet. After several uses, the pipet tip may retain some liquid, causing inaccurate delivery. Each pipet is supplied with 50 tips; order Hach replacement tips for best results.

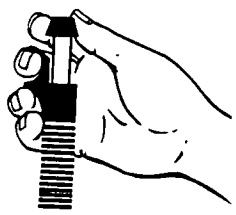
Always use careful, even hand movements for best reproducibility. If the pipet does not operate smoothly, disassemble and coat the piston and retainer with high-quality stopcock grease. Also coat the metering turret lightly with grease. Refer to the TenSette Pipet manual.

For best pipetting accuracy, the solution and the room temperature should be between 20-25 °C.

Never lay the pipet down with the liquid in the tip. Solution could leak into the pipet and cause corrosion.

Operating the TenSette Pipet

1. Attach a clean tip by holding the pipet body in one hand and gently pressing the large end of the pipet tip onto the tapered end of the pipet. Be sure a good seal is obtained.

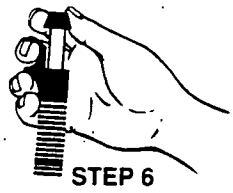


2. Turn the turret cap to align the desired volume with the mark on the pipet body.

3. Using a smooth motion, press down on the turret cap until it reaches the stop. Immerse the tip about 5 mm (¼ inch) below the solution surface to avoid drawing air into the pipet. Do not insert the tip any deeper or the delivery volume may be affected.

4. While maintaining a constant pressure, allow the turret to return slowly to the extended position. A rapid return may affect the delivery volume.

5. With the turret up, take the tip out of the solution and move it to the receiving vessel. Do not press on the turret cap while moving the pipet.



6. Use the thumb and forefinger to twist the turret cap to the next higher volume position to ensure quantitative transfer of the sample. The "F" position provides full blowout.

7. With the tip in contact with the side of the receiving vessel, slowly and smoothly press down on the turret cap until it reaches the stop and the solution is completely discharged.

Mixing Water Samples

The following two methods may be helpful in tests that require mixing sample with chemicals (usually indicated by "invert to mix" instructions).

1. When mixing sample in a round sample cell or mixing cylinder, invert the cell or cylinder; see *Figure 4*. Hold the cell in a vertical position with the cap on top. Invert the cell so the cap is on the bottom. Return the cell to the original position. Do the same with the mixing cylinder.

2. Swirling is recommended when mixing samples in a graduated cylinder or a titration flask. Grip the cylinder (or flask) firmly with the tips of three fingers; see *Figure 5*. Hold the cylinder at a 45-degree angle and twist the wrist. This should move the cylinder in an approximately 12-inch circle, creating enough rotation to complete the mixing in a few turns.

These mixing procedures are the most gentle. Both methods are simple but take a bit of practice to obtain the best results.

Figure 4 Inverting a Sample Cell

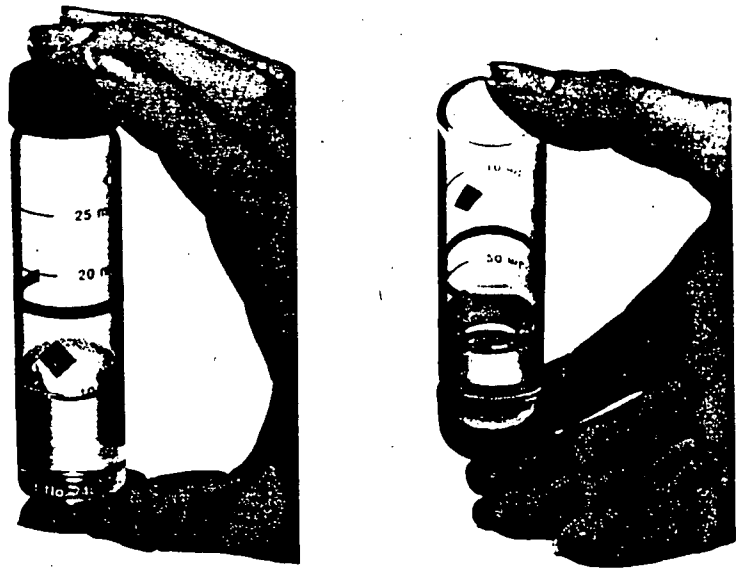
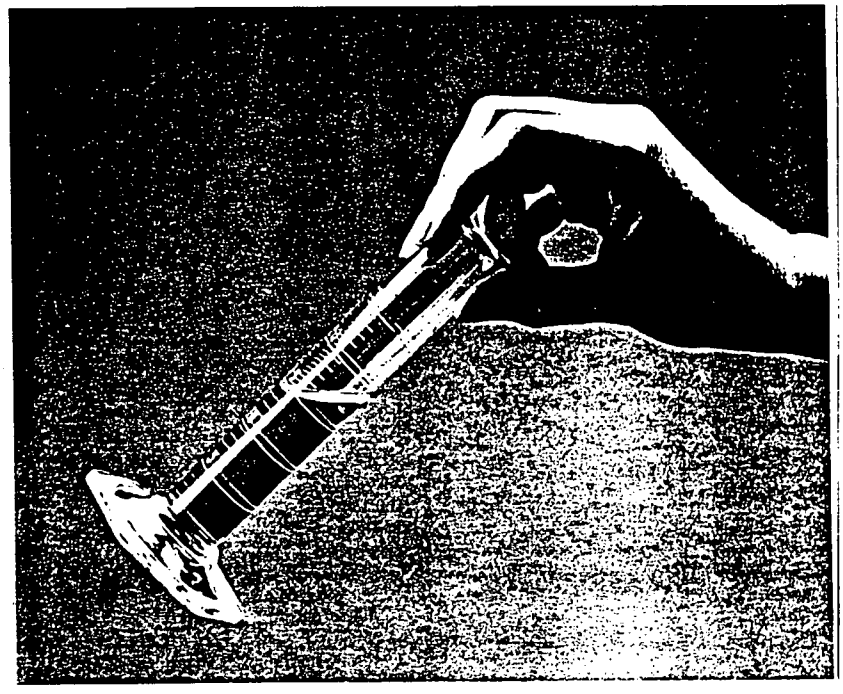


Figure 5 Swirling a Graduated Cylinder



Using Sample Cells

Orientation of Sample Cells

Two round sample cells are shipped with the DR/820, DR/850 and DR/890. They are marked with 10-, 20- and 25-mL fill lines which may be used to measure the sample volume unless the procedure instructs you to use other glassware to measure the sample volume.

To minimize variability of measurements using a particular cell, always place the cell into the cell holder with the same orientation. The cells are placed in the instrument with the fill marks facing the user.

In addition to proper orientation, the sides of the cells should be free of smudges, fingerprints, etc. to ensure accurate readings. Wipe the sides of the cells with a moist cloth followed by a dry soft cloth to clean the surface before taking measurements.

Care of Hach Sample Cells

Store sample cells in their boxes when not in use to protect them from scratching and breaking. It is good laboratory practice to empty and clean sample cells after analyses are complete--avoid leaving colored solutions in the cells for extended periods of time. Finish the cleaning procedure with a few rinses of deionized water and allow to dry. Individual procedures often recommend specific cleaning methods.

Cleaning Sample Cells

Most laboratory detergents can be used at recommended concentrations. Neutral detergents such as Neutracon are safer if regular cleaning is required, as in the case of protein residues.

If using a detergent, you can speed cleaning by increasing the temperature or using an ultrasonic bath.

Rinsing is more efficient when using deionized water.

Using the COD/TNT Adapter

Use care when seating a vial into the COD/ TNT adapter (for COD vials and Test 'N Tubes). Place the vial into the adapter and press straight down on the top of the vial until it seats solidly. Do not move the vial from side to side; this can cause errors.

Volume Measurement Accuracy

The sample cells supplied with the instrument have fill marks to indicate 10, 20 or 25 mL. The fill marks are intended to measure the volume to be analyzed. Do not use these fill marks to perform sample dilutions.

If a sample must be diluted, use a pipet, graduated mixing cylinder and/or a volumetric flask for accurate measurement. When diluting, accuracy is important because a slight mistake in measuring a small sample will cause

a substantial error in the result. For instance, a 0.1-mL mistake in the dilution of a 1.0-mL final volume produces a 10% error in the test result.

Volumes for standard additions can be measured using the 25-mL mark, but it is not recommended for the 10-mL mark due to a potentially excessive relative error. An error of 0.5 mL in 25 mL is only 2%, while 0.5 mL error in 10 mL is 5%.

For 10 mL standard additions, follow this procedure:

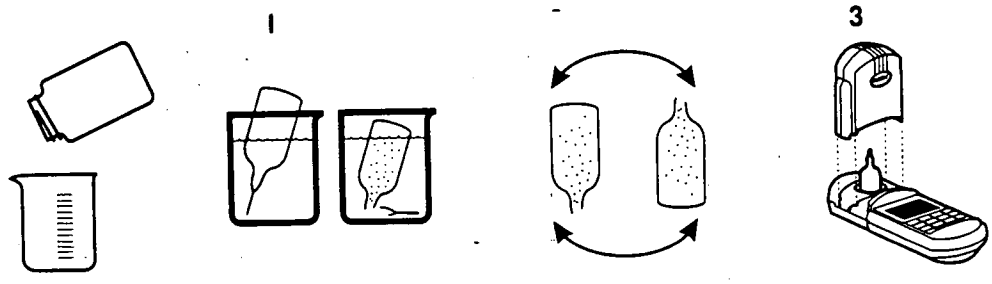
1. Transfer 10.0 mL of sample into a clean, dry sample cell (the unspiked sample).
2. Add the standard (spike) to a 25 mL portion of sample in a 25-mL mixing cylinder. Stopper and mix thoroughly.
3. Transfer 10 mL to another sample cell (use fill mark) for analysis.

Using AccuVac Ampuls

AccuVac ampuls contain pre-measured powder or liquid in optical-quality glass ampuls.

1. Collect the sample in a beaker or other open container.
2. Place the ampul tip well below the sample surface and break the tip off (see *Figure 6*) against the beaker wall. The break must be far enough below the surface to prevent air from being drawn in as the level of the sample lowers (the AccuVac Breaker may be used instead of breaking the ampul against the beaker side).
3. Invert the ampul several times to dissolve the reagent. Do not place your finger over the broken end; the liquid will stay in the ampul when inverted. Wipe the ampul with a towel to remove fingerprints, etc.
4. Insert the ampul into the instrument and read the results directly.

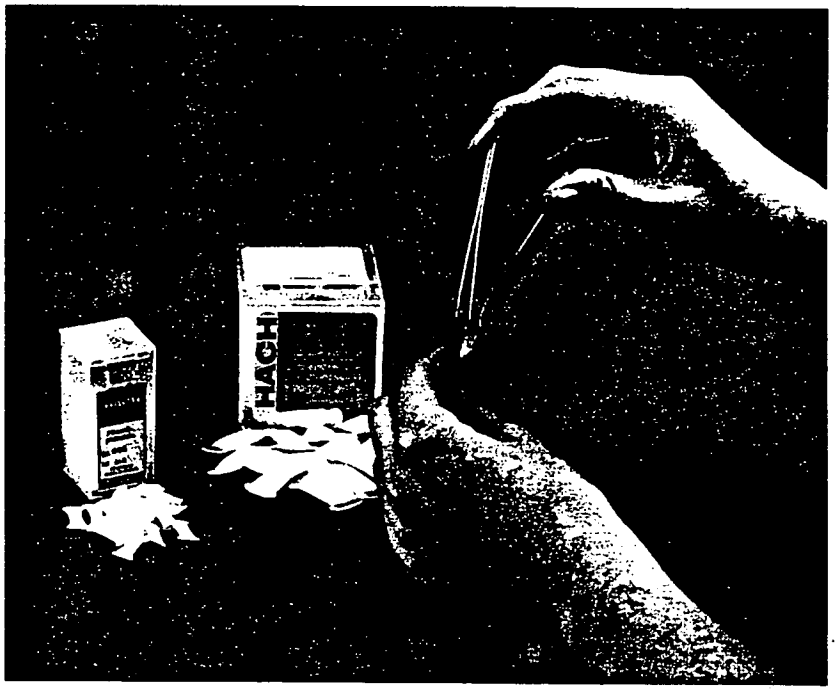
Figure 6 Using AccuVac Ampuls



Using Reagent Powder Pillows

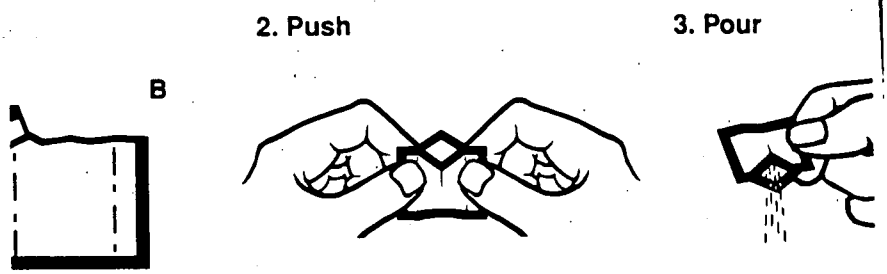
Hach uses dry powdered reagents when possible. This minimizes leakage and deterioration problems. Some powders are packaged in individual, pre-measured, polyethylene "powder pillows" or foil pillows called PermaChem® pillows. Each pillow contains enough reagent for one test. Open the poly powder pillows with nail clippers or scissors; see *Figure 7*.

Figure 7 Opening Powder Pillows



Using PermaChem Pillows

1. Tap the pillow on a hard surface to collect the powdered reagent in the bottom.
2. Tear (or cut) across the top of the pillow, from B to A, holding the pillow away from your face.
3. Using two hands, push both sides toward each other to form a spout.
4. Pour the pillow contents into the sample cell and continue the procedure according to the instructions. Tap the pillow to remove any powder from the corners.



Reagent and Standard Stability

Hach always strives to make stable formulations and package them to provide maximum protection. Most chemicals and prepared reagents do not deteriorate after manufacture. However, the way they are stored and the packaging can affect how long the reagents are stable. Light, bacterial action, and absorption of moisture and gases from the atmosphere can affect shelf life. Some chemicals may react with the storage container or they may react with other chemicals.

Chemicals supplied with the colorimeter have an indefinite shelf life when stored under average room conditions, unless the packaging says something different. Product labels state any special storage conditions required. Otherwise, store reagents in a cool, dry, dark place for maximum life. It is always good practice to date chemicals when you receive them. Use older supplies first. If in doubt about the reagent shelf life, run a standard to check its effectiveness.

Interferences

Substances in the sample may interfere with a measurement. Hach mentions common interferences in the test procedures. The reagent formulations eliminate many interferences. You can remove others with sample pretreatments described in the procedure.

If you get an unusual answer, a color that you don't expect, or you notice an unusual odor or turbidity, the result may be wrong. Repeat the test on a sample diluted with deionized water; see *Sample Dilution Techniques*. Compare the result (corrected for the dilution) with the result of the original test. If these two are not close, the original result may be wrong and you should make an additional dilution to check the second test (first dilution). Repeat this process until you get the same corrected result twice in a row.

More information about interferences and methods to overcome them is contained in *Standard Additions* of this manual and the *General Introduction* section of APHA Standard Methods. Hach urges the analyst to obtain this book and refer to it when problems are encountered.

One of the greatest aids is knowing what is in the sample. You don't need to know exactly what is in each sample, but be aware of substances that are likely to interfere in the analysis method you use. When using a method, it may be helpful to determine if those interferences are present.

pH Interference

Many of the procedures in this manual only work within a certain pH range. Hach reagents contain buffers to adjust the pH of the typical sample to the correct pH range. However, the reagent buffer may not be strong enough for some samples. This occurs most often with highly buffered samples or samples with extreme sample pH.

The *Sampling and Storage* section of each procedure usually gives the proper pH range for the sample.

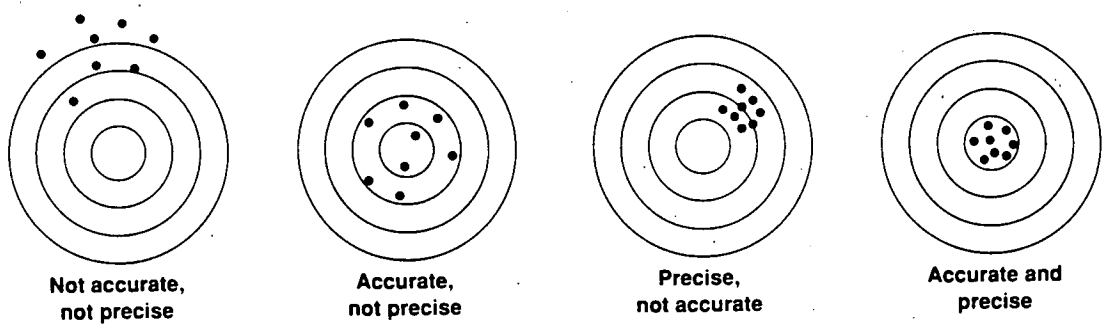
Adjust the sample to the proper pH range before testing. If this information is not given, follow these steps:

1. Measure the pH of your analyzed sample with a pH meter. For measuring Ag^+, K^+ or Cl^-, use pH paper.
2. Prepare a sample using deionized water. Add all reagents called for in the procedure. Timer sequences, etc., may be ignored. Mix well.
3. Measure the pH of the reagent blank with a pH meter.
4. Compare the pH values of your analyzed sample with the reagent blank.
5. If there is little difference in the values of your analyzed sample and the reagent blank, then pH interference is not the problem. Follow the *Accuracy Check* given in the procedure to help identify the problem.
6. If there is a large difference between the value of your analyzed sample and the reagent blank, adjust the sample pH to the value of the reagent blank. Adjust the sample pH to this same pH for all future samples from the same source before analysis. Use the appropriate acid, usually nitric acid, to lower the pH (do not use nitric acid for nitrate or nitrogen testing). Use the appropriate base, usually sodium hydroxide, to raise the pH. Adjust the final result for any dilution caused by adding acid or base; see *Correcting for Volume Additions*.
7. Analyze the sample as before.
8. Some purchased standards may be very acidic and will not work directly with Hach procedures. Adjust the pH of these standards as described above. Adjust the final concentration of the standard for the dilution. The Hach standard solutions suggested in the procedures are formulated so that no pH adjustment is necessary.

Accuracy and Precision

Accuracy is the nearness of a test result to the true value. Precision is how closely repeated measurements agree with each other. Although good precision suggests good accuracy, precise results can be inaccurate (see *Figure 8*). The following paragraphs describe how to improve accuracy and precision of analyses by using Standard Additions.

Figure 8 Precision and Accuracy Illustrated



Standard Additions

Standard Additions is a common technique for checking test results. Other names are "spiking" and "known additions." The standard additions technique can test for interferences, bad reagents, faulty instruments, and incorrect procedures.

Perform Standard Additions by following the Standard Additions Method section in the procedure under *Accuracy Check*. Follow the detailed instructions given.

If you get about 100% recovery for each addition, everything is working right and your results are correct.

If you don't get about 100% recovery for each addition, a problem exists. You can tell if you have an interference. Repeat the Standard Additions using deionized water as your sample. If you get about 100% recovery for each addition, you have an interference. If you didn't get good recoveries with the deionized water, the following checklist may help to find the problem quickly:

1. Check to see that you are following the procedure exactly:

   a) Are you using the proper reagents in the proper order? Are you using 10-mL reagents with a 10-mL sample or 25-mL reagents with a 25-mL sample?

   b) Are you waiting the necessary time for color to develop?

c) Are you using the correct glassware?

d) Is the glassware clean?

e) Does the test need a specific sample temperature?

f) Is the sample's pH in the correct range?

Hach's written procedure should help you to answer these questions.

2. Check your reagents. Repeat the Standard Additions using new, fresh reagents. If your results are good, the original reagents were bad.

3. If nothing else is wrong, the standard is almost certainly bad. Repeat the Standard Additions with a new standard.

If the check list does not determine the problem, use the decision tree (*Figure 9*) and explanation of each branch, below, to identify the problem.

Branch A

Suppose a single standard addition to the sample did not give the correct concentration increase. A possible cause could be interferences. Other causes include defective reagents, incorrect technique, a defective instrument/apparatus or defective standard used for the standard addition.

If interferences are known or assumed to be absent, proceed to Branch B. If interferences are known to be present, proceed to Branch C.

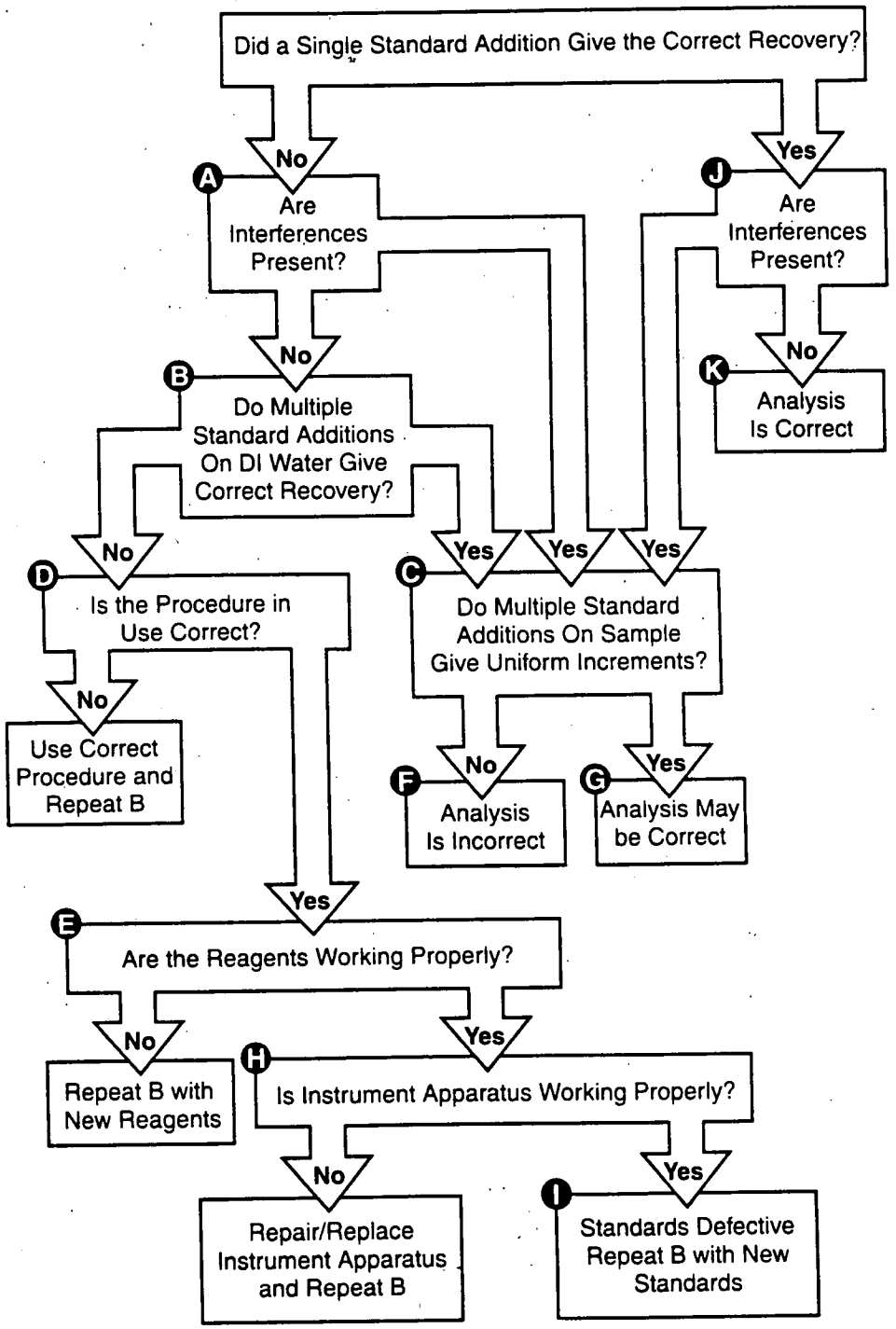
Branch B

Perform multiple standard additions on a sample of deionized water as in the following example using iron as the analyte of interest:

1. Pour 25 mL of deionized water into a 25-mL sample cell.
2. Add 0.1 mL of a 50-mg/L iron standard solution to a second 25 mL sample of deionized water.
3. Add 0.2 mL of the same standard to a third 25 mL sample of deionized water.
4. Add 0.3 mL of the same standard to a fourth 25 mL sample of deionized water. Analyze all these samples for iron.
5. Tabulate the data as shown below:

mL of Standard Added	mg/L of Standard Added	mg/L of Iron Found
0	0	0
0.1	0.2	0.2
0.2	0.4	0.4
0.3	0.6	0.6

Figure 9 Standard Additions Decision Tree



The data show several points:

- The chemicals, instrument, procedure/technique and standards are working correctly because the iron added to the water sample was completely recovered in the same uniform steps that match the standard addition increments.
- Because iron added to the deionized water was recovered, but iron added to an actual sample was not recovered (Branch A), the sample contains an interference which prevents the test reagents from working properly.
- An iron analysis previously done on the actual sample using this method gave an inaccurate result.

If the results of multiple standard additions give the correct increment for each addition, proceed to Branch C.

If the results of multiple standard additions do not give the correct increment for each addition, go to Branch D.

Branch C

If interfering substances are present, the analysis may be incorrect. However, with multiple standard additions, it may be possible to arrive at an approximate result if the increases are uniform.

Suppose the sample result for iron was 1.0 mg/L. Because interferences may be present, a standard addition of 0.1 mL of a 50 mg/L iron standard to a 25 mL sample is made. The expected increase in the iron concentration is 0.2 mg/L, but the actual increase is 0.1 mg/L. Then 0.2 and 0.3 mL of the same standard are added to two more 25 mL samples and analyzed for iron.

If there is a uniform increase in concentration between each addition (i.e., 0.1 mg/L difference between each addition), use Branch G. If the increase in concentration is not uniform (i.e., 0.1, 0.08, 0.05), go to Branch F.

Branch D

Carefully check the instructions for the test. Make sure to use the correct reagents in the correct order. Be sure the glassware in use is what is required. Be sure time for color development and the sample temperature are as specified. If the procedure technique was incorrect, repeat Branch B. If the procedure was correctly followed, proceed to Branch E.

Branch E

Check the reagent performance. This may be done by obtaining a fresh lot of reagent or by using a known standard solution to run the test. Make sure the color development time given in the procedure is equal to the

time required for the reagent in question. If the reagent(s) is defective, repeat Branch B with new reagents. If the reagents are good, proceed with Branch H.

Branch F

Examples of non-uniform increments between standard additions are shown below.

Example A

mL of Standard Added	mg/L Standard Added	mg/L Found
0	0	1.0
0.1	0.2	1.10
0.2	0.4	1.18
0.3	0.6	1.23

Example B

mL of Standard Added	mg/L Standard Added	mg/L Found
0	0	0
0.1	0.2	0
0.2	0.4	0.2
0.3	0.6	0.4

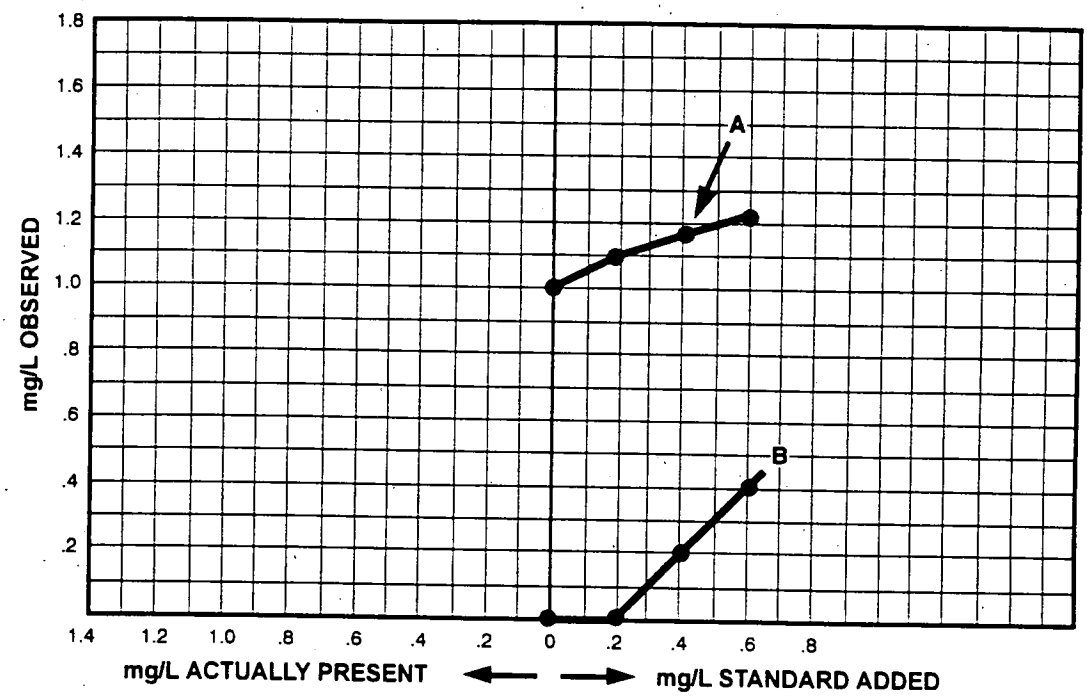
These examples show the effect of interferences on the standard addition. Data plotted on the graph in *Figure 10* for samples A and B show that the four data points do not lie on a straight line.

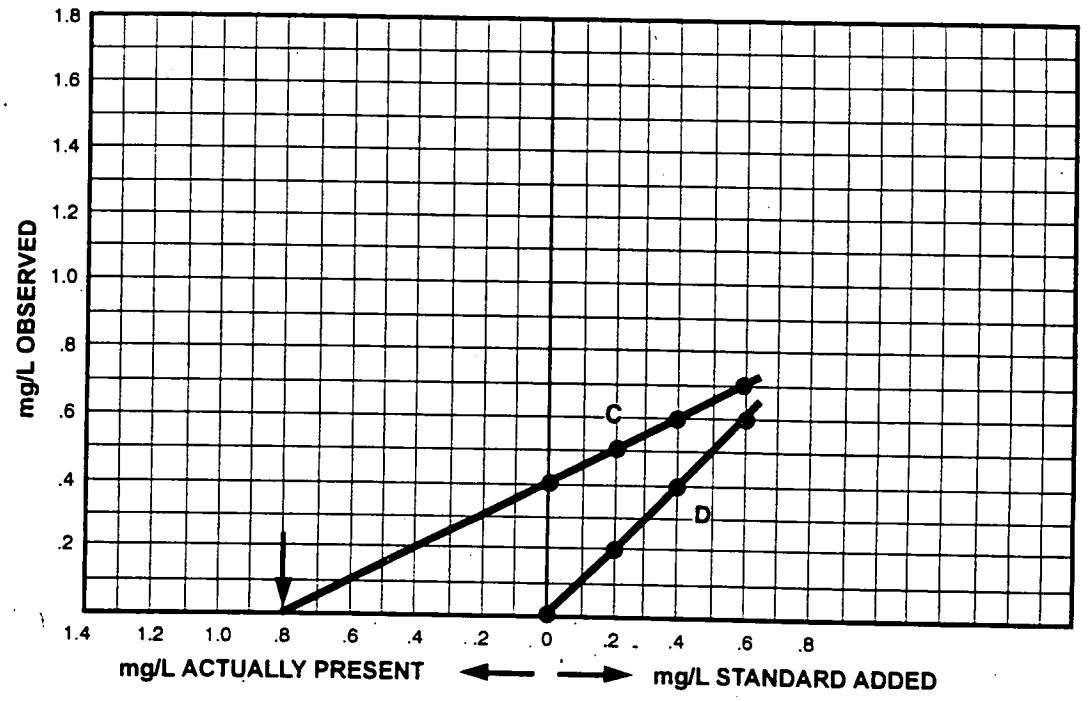
The plot for sample A illustrates an interference that becomes progressively worse as the concentration of the standard increases. This type of interference is uncommon and may be caused by an error or malfunction of the procedure, reagents or instrument. It is recommended Branch B be performed to verify the supposed interference.

The plot for sample B shows a common chemical interference which becomes less or even zero as the concentration of standard increases. The graph shows the first addition was consumed by the interference and the remaining additions gave the correct increment of 0.2 mg/L.

The apparent interference in Example B could be the result of an error made in the standard addition. Repeat the analysis to see if an error was made during standard addition. If not, the method is not appropriate for the sample matrix. When these two types of interferences occur, try to analyze the sample with a method which uses a different type of chemistry.

Figure 10 Multiple Standard Additions Graph





Branch G

Examples of uniform increments between standard additions are given below.

Example C

mL of Standard Added	mg/L Standard Added	mg/L Found
0	0	0.4
0.1	0.2	0.5
0.2	0.4	0.6
0.3	0.6	0.7

The plot for sample C illustrates a common interference with a uniform effect on the standard and the substances in the sample. The four data points form a straight line which may be extended back through the horizontal axis. The point where the line meets the axis can be used to determine the concentration of the substance you are measuring.

In this example, the first analysis gave 0.4 mg/L. After extrapolating the line to the horizontal axis, the graph shows the result should be much closer to the correct result: 0.8 mg/L.

Apparent interferences may also be caused by a defect in the instrument or standards. Before assuming the interference is chemical, check Branch B.

Example D

mL of Standard Added	mg/L Standard Added	mg/L Found
0	0	0
0.1	0.2	0.2
0.2	0.4	0.4
0.3	0.6	0.6

The plot for sample D illustrates a problem for the analyst. The increments are uniform and the recovery of the standard was complete. The result of the first analysis was 0 mg/L and the line extrapolates back through 0 mg/L. If interferences are known to be present, the interferences may be present in an amount equal to the substance in question, preventing the analyst from finding the substance. This would be an uncommon situation.

Branch H

Check operation of the instrument and/or apparatus used to perform the test. Check glassware used in the procedure and make sure it is extremely clean. Dirty pipets and graduated cylinders can cause contamination and will not deliver the correct volume. Check delivery of pipets by using deionized water and a balance; 0.2 mL = 0.2 grams.

If a defect is found in the instrument and/or apparatus, repeat Branch B after repair or replacement. If the instrument and apparatus are working, proceed with Branch I.

Branch I

After determining the procedure, reagents, instrument and/or apparatus are correct and working properly, you may conclude the only possible cause for standard additions not functioning correctly in deionized water is the standard used for performing standard additions. Obtain a new standard and repeat Branch B.

Branch J

If the standard additions gives the correct result, the analyst must then determine if an interfering substance(s) is present. If interfering substances are present, proceed to Branch C. If they are not present, the analysis is correct.

If you still cannot identify the problem, extra help is available. Please call our Technical Support Group at 800-227-4224 (U.S.A.) or 970-669-3050. A representative will be happy to help you.

Method Performance

Estimated Detection Limit

Ranges for chemical measurements have limits. The lower limit is important because it determines whether a measurement is different from zero. Many experts disagree about the definition of this detection limit, and determining it can be difficult. The Code of Federal Regulations (40 CFR, Part 136, Appendix B) provides a procedure to determine the "Method Detection Limit" or MDL. The MDL is the lowest concentration that is different from zero with a 99% level of confidence. A measurement below this MDL may be useful, but there is a greater chance that it is actually zero.

The MDL is not fixed; it varies for each reagent lot, instrument, analyst, sample type, etc. Therefore, a published MDL may be a useful guide, but is only accurate for a specific set of circumstances. Each analyst should determine a more accurate MDL for each specific sample matrix using the same equipment, reagents and standards that will routinely be used

for measurements.

Hach provides a value called the Estimated Detection Limit (EDL) for all programs. It is the calculated lowest average concentration in a deionized water matrix that is different from zero with a 99% level of confidence. Specifically, it is the upper 99% confidence limit for zero concentration based on the calibration data used to prepare the pre-programmed calibration curve. **Do not use the EDL as the MDL.** The conditions for MDL determination must be exactly the same as the conditions used for analysis. The EDL may be useful to the analyst as a starting point in determining a MDL or as a way to compare methods. Measurements below the EDL may also be valuable because they can show a trend, indicate the presence of analyte and/or provide statistical data. However, these values have a large uncertainty.

Method Detection Limit (MDL)

This method is in accordance with the USEPA definition in 40 CFR, Part 136, Appendix B (see most current edition).

The USEPA defines the method detection limit (MDL) as the minimum concentration that can be determined with 99% confidence that the true concentration is greater than zero. Since the MDL will vary from analyst to analyst, it is important that analysts determine the MDL based on their unique operating conditions.

The procedure for determining MDL is based on replicate analyses at a concentration 1 to 5 times the estimated detection limit. The MDL value is calculated from the standard deviation of the replicate study results multiplied by the appropriate Student's *t* value for a 99% confidence interval. For this definition, the MDL does not account for variation in sample composition and can only be achieved under ideal conditions.

1. Estimate the detection limit. Use the Hach estimated detection limit (EDL) value stated in the *Method Performance* section of the analysis procedure.

2. Prepare a laboratory standard of the analyte in deionized water which is free of the analyte that is 1 to 5 times the estimated detection limit.

3. Analyze at least seven portions of the laboratory standard and record each result.

4. Calculate the average and standard deviation *(s)* of the results.

5. Compute the MDL using the appropriate Student's *t* value (see table below) and the standard deviation value:

MDL = Student's *t* x *s*

Number of Test Portions	Student's *t* Value
7	3.143
8	2.998
9	2.896
10	2.821

For example:
The EDL for measuring iron using the FerroZine method is 0.003 mg/L. An analyst accurately prepared 1 liter of a 0.010 mg/L (about 3x the EDL) laboratory standard by diluting a 10-mg/L iron standard in iron-free deionized water.

Eight portions of the standard were tested according to the FerroZine method with the following results:

Sample #	Result (mg/L)
1	0.009
2	0.010
3	0.009
4	0.010
5	0.008
6	0.011
7	0.010
8	0.009

Using a calculator program, the average concentration = 0.010 mg/L and the standard deviation (*s*) = 0.0009 mg/L

Based on the USEPA's definition, calculate the MDL as follows:

MDL for FerroZine method = 2.998 (Student's *t*) x 0.0009 (*s*)

MDL = 0.003 mg/L (agrees with initial estimate)

Note: *Occasionally, the calculated MDL may be very different than Hach's estimate of the detection limit. To test how reasonable the calculated MDL is, repeat the procedure using a standard near the calculated MDL. The average result calculated for the second MDL derivation should agree with the initial calculated MDL. Refer to 40 CFR, Part 136, Appendix B (7-1-94), pages 635-637 for detailed procedures to verify the MDL determination.*

Note: *Run a laboratory blank, containing deionized water without analyte, through the test procedure to confirm that the blank measurement is less than the calculated MDL. If the blank measurement is near the calculated MDL, repeat the MDL procedure using a separate blank for analysis for each standard solution portion analyzed. Subtract the average blank measurement from each standard and use the corrected standard values to calculate the average and standard deviation used in the MDL.*

Precision

Every measurement has some degree of uncertainty. Just as a ruler with markings of 0.1 mm leaves some doubt as to the exact length of a measurement, chemical measurements also have some degree of uncertainty. The quality of the entire chemical method determines the precision.

Uncertainty in chemical measurements may be due to systematic errors and/or random errors. A systematic error is a mistake that is always the same for every measurement made. For example, a blank can add to each measurement for a specific compound, giving consistently high results (a positive bias). Random errors are different for every test and add either positive or negative bias. Random errors may be caused by variation in analytical technique and cause response variation. Hach chemists work hard to eliminate systematic errors in Hach procedures using Hach reagents, but response variation occurs in all chemical measurements.

Estimating Precision

The method performance section in each procedure provides an estimate of the procedure's precision. The procedures use a "replicate analysis" estimate, based on real data.

In replicate analysis, a Hach chemist prepares a specific concentration of the analyte in a deionized water matrix. The standard is then analyzed seven individual times with the two reagent lots used in the calibration (14 total samples). A standard deviation of the two sets of seven values is calculated. The larger value is reported in the method. The reported value provides an estimate of the "scatter" of results at a particular point in the calibration curve.

It is important to stress that the estimates are based on a deionized water matrix. Precision on real samples with varying matrices can be quite different than these estimates.

Reagent Blank Correction

The Reagent Blank Correction subtracts the color absorbed when running the test with deionized water instead of sample. The blank value is subtracted from every result to correct for any background color due to reagents.

When using the Reagent Blank Correction feature, the blank correction should be entered before the Standard Adjust feature is used.

To enter a programmed correction for the reagent blank:

1. Run the test using deionized water with each new lot of reagents.
2. Press **READ** to obtain the blank value.
3. Press **SETUP**, scroll to **BLANK** and press **ENTER**. The display will show **BLANK?**.
4. Enter the blank value just read from the instrument.
5. Press **ENTER** to accept the value as the blank to be subtracted from each reading.
6. The display will show 0.00 mg/L (resolution and units vary) and the sample cell icon will be displayed, indicating that the reagent blank feature is enabled and the blank value will be subtracted from each reading. Repeat the reagent blank adjust for each new lot of reagents.

Note: *After entering a reagent blank adjust, the display may flash "limit" when zeroing if the sample used for zeroing has a lower absorbance value than the reagent blank.*

To disable the Reagent Blank adjust feature, press **SETUP**, scroll to **BLANK** and press **ENTER** twice. The concentration readings will be displayed without subtracting the blank. The sample cell icon will no longer appear in the display.

Do not use the Reagent Blank Adjust feature if the procedure uses a reagent blank for zeroing.

In some situations, using the pre-programmed curve may not be convenient:

a) Running tests where frequent calibration curve checks are required.

b) Testing samples which give a consistent test interference.

Consider the following before adjusting the calibration curve:

1. Will future test results be improved by adjusting the curve?
2. Are interfering substances consistent in all the samples that you will test?

Any precision and test range information provided with the procedure may not apply to an adjusted curve calibration.

You can adjust many of the calibration curves by following the steps found in the test procedures. Working carefully is important. After the adjustment, it is wise to run standard solutions of several concentrations to make sure the adjusted curve is satisfactory. Perform standard additions on typical samples to help determine if the adjusted curve is acceptable.

Think of the standard adjust measurement as a two-step process. First, the instrument measures the sample using the pre-programmed calibration. Second, it multiplies this measurement by an adjustment factor. The factor is the same for all concentrations. The instrument will remember the factor indefinitely and will display the standard adjustment icon when it is used.

Adjust the calibration curve using the reading obtained with a Hach Standard Solution or carefully prepared standard made from a concentrated Hach Standard Solution. It is important to adjust the curve in the correct concentration range. For most purposes, Hach recommends adjusting the curve using a standard concentration that is 70 to 85% of the maximum concentration range of the test.

For example, the Hach pre-programmed method for fluoride has a range of 0-2.0 mg/L F. To adjust the calibration curve, use a standard with a concentration between 1.4-1.6 mg/L. Hach provides a 1.60 mg/L Fluoride Standard Solution (80% of the full range). This is a convenient standard to use for adjusting the calibration curve.

If the range of all your samples is known to be below a concentration that is less than 50% of the full range (50% of 2.0 is 1.0 mg/L), then adjust the standard curve with a standard that is within that range. For example, if all the samples contain 0.6-0.9 mg/L F, you may use a 1.00 mg/L fluoride standard to adjust the curve. You may use the 1.00 mg/L standard because it is closer to the sample range you are working with.

If you are using a Reagent Blank Correction, the blank correction should be entered before the standard curve is adjusted.

To adjust the standard curve:

1. Prepare the standard.
2. Use the standard as the sample in the procedure.
3. When the reading for the standard is obtained, press **SETUP**.
4. Use the arrow keys to scroll to the "**STD**" setup option.
5. Press **ENTER** to activate the standard adjust option.
6. Edit the standard concentration to match that of the standard used.
7. Press **ENTER**. A small plot of a line through a point will be displayed, indicating that the curve has been adjusted with the standard.

Note: *If the attempted correction is outside the allowable adjustment limit, the instrument will beep and flash Ø and the operation will not be allowed.*

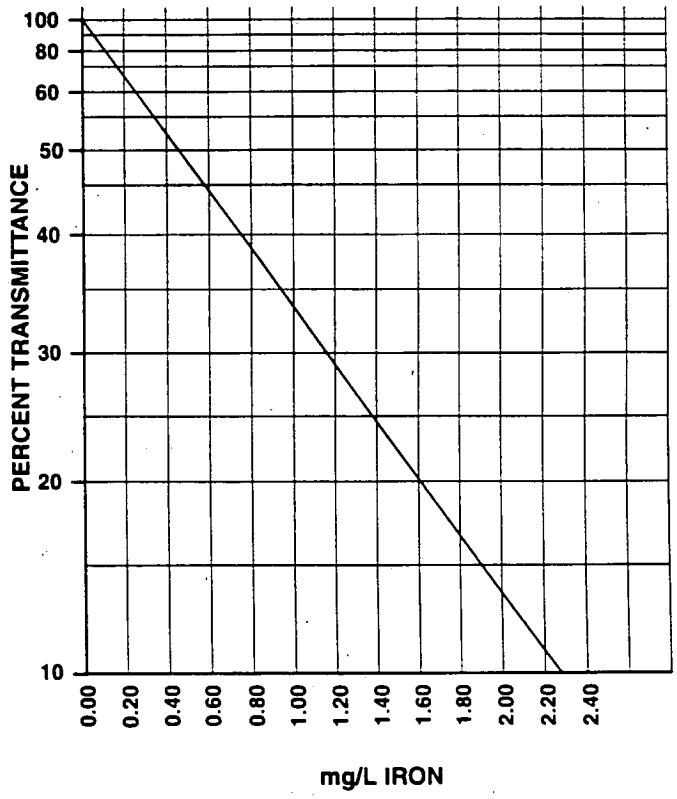
Preparing a User-Entered Calibration Curve

1. Prepare five or more standards of known concentration that cover the expected range of the test. Run tests as described in the procedure on each prepared standard. Pour the customary volume of each known solution into a separate clean sample cell of the type specified for your instrument.
2. Standardize (zero) the instrument using an untreated water sample or a reagent blank, whichever the procedure instructs you to use.
3. Measure and record the absorbance or %T of the known solutions. To use %T vs. concentration see *%T Versus Concentration Calibration.* To use absorbance vs. concentration, see *Absorbance Versus Concentration Calibration.* Or create a user-entered program by storing a custom calibration in the non-volatile memory of the instrument. Refer to the section on entering user-entered programs in the instrument manual.

%T Versus Concentration Calibration

If measuring %T, use semilogarithmic graph paper and plot %T (vertical scale) versus concentration (horizontal scale). In *Figure 11*, iron standard solutions of 0.1, 0.2, 0.4, 0.8, 1.2, 1.6, and 2.0 mg/L were measured on a spectrophotometer at 500 nm using half-inch test tubes. Results were plotted and the calibration table values were extrapolated from the curve (*Table 7*).

Figure 11 Logarithmic Calibration Curve



To convert %T readings to concentration, prepare a table such as *Table 7* and select the appropriate line from the "%T Tens" column and the appropriate column from the %T Units columns. The %T Ten value is the first number of the %T reading and the %T Units value is the second number of the %T reading. For example, if the instrument reading was 46%, the 40 line in the %T Tens column and the 6 column in the %T Units would be selected. The cell where these two intersect (0.78 mg/L) is the iron concentration of the sample.

Table 7 Calibration Table

%T Tens	%T Units									
	0	1	2	3	4	5	6	7	8	9
0										
10	2.30	2.21	2.12	2.04	1.97	1.90	1.83	1.77	1.72	1.66

Table 7 Calibration Table

20	1.61	1.56	1.51	1.47	1.43	1.39	1.35	1.31	1.27	1.24
30	1.20	1.17	1.14	1.11	1.08	1.04	1.02	.99	.97	.94
40	.92	.89	.87	.84	.82.	.80	.78	.76	.73	.71
50	.69	.67	.65	.64	.62	.60	.58	.56	.55	.53
60	.51	.49	.48	.46	.45	.43	.42	.40	.39	.37
70	.36	.34	.33	.32	.30	.29	.28	.26	.25	.24
80	.22	.21	.20	.19	.17	.16	.15	.14	.13	.12
90	.11	.09	.08	.07	.06	.05	.04	.03	.02	.01

Absorbance Versus Concentration Calibration

To read concentration values directly from the instrument, create a user-entered program. See the instrument manual for more information.

If absorbance values are measured, plot the results on linear graph paper. Plot the absorbance value on the vertical axis and the concentration on the horizontal axis.

Plot increasing absorbance values from bottom to top. Plot increasing concentration values from left to right. Values of 0.000 absorbance units and 0 concentration will begin at the bottom left corner of the graph. A calibration table can be extrapolated from the curve or the concentration values can be read directly from the graph for determining an equation for the line using the slope and the y-intercept.

USEPA Approved and Accepted Definitions

The United States Environmental Protection Agency (USEPA) establishes limits for maximum contamination levels of certain constituents in water. It also requires that specific methodology be used to analyze for these constituents. These methods originate from several sources. The USEPA has developed some of these methods. In other cases, the USEPA has evaluated and approved methods developed by manufacturers, professional groups and public agencies such as:

- American Public Health Association
- American Water Works Association
- Water Environmental Federation
- American Society for Testing and Materials
- United States Geological Survey

- Associates of Official Analytical Chemists

All USEPA approved methods are cited in the *Federal Register* and compiled in the Code of Federal Regulations. USEPA approved methods may be used for reporting results to the USEPA and other regulatory agencies.

USEPA Accepted

Hach has developed several procedures that are equivalent to USEPA approved methods. Even though minor modifications exist, the USEPA has reviewed and accepted certain procedures for reporting purposes. These methods are not published in the *Federal Register.* but are referenced to the equivalent USEPA method in the procedure.

SECTION 2 SAMPLE PRETREATMENT

Digestion

Several procedures require sample digestion. Digestion uses chemicals and heat to break down a substance into components that can be analyzed. This section has three different digestion procedures.

The Hach Digesdahl® system is a process that yields a digest suitable for the determination of metals, total phosphorus and total kjeldahl nitrogen (TKN). It is rapid, convenient and the method of choice for digesting most samples analyzed by Hach methods.

For USEPA reporting purposes, USEPA-approved digestions are required. USEPA presents two digestions (mild and vigorous) for metals analysis. These are much more inconvenient and time consuming compared to the Hach Digesdahl system. Other digestion procedures are required for phosphorus and TKN.

EPA Mild Digestion with Hot Plate for Metals Analysis Only

1. Acidify the entire sample at the time of collection with concentrated nitric acid by adding 5 mL of acid per liter (or quart) of sample.

2. Transfer 100 mL of well-mixed sample to a beaker or flask. Add 5 mL of distilled 1:1 hydrochloric acid (HCl).

3. Heat using a steam bath or hot plate until the volume has been reduced to 15-20 mL. Make certain the sample does not boil.

4. After this treatment, the sample may be filtered to remove any insoluble material.

5. Adjust the digested sample to pH 4 by drop-wise addition of 5.0 N Sodium Hydroxide Standard Solution. Mix thoroughly and check the pH after each addition.

6. Quantitatively transfer the sample with deionized water to a 100-mL volumetric flask and dilute to volume with deionized water. Continue with the procedure. This mild digestion may not suffice for all sample types. A reagent blank also should be carried through the digestion and measurement procedures.

EPA Vigorous Digestion with Hot Plate for Metals Analysis Only

A vigorous digestion can be followed to ensure all organo-metallic bonds are broken.

1. Acidify the entire sample with redistilled 1:1 Nitric Acid Solution to a pH of less than two. Do not filter the sample before digestion.
2. Transfer an appropriate sample volume (see *Table 8*) into a beaker and add 3 mL of concentrated redistilled nitric acid.
3. Place the beaker on a hot plate and evaporate to near dryness, making certain the sample does not boil.
4. Cool the beaker and add another 3 mL of the concentrated redistilled nitric acid.
5. Cover the beaker with a watch glass and return it to the hot plate. Increase the temperature of the hot plate so that a gentle reflux occurs. Add additional acid, if necessary, until the digestion is complete (generally indicated when the digestate is light in color or does not change color or appearance with continued refluxing).
6. Again, evaporate to near dryness (do not bake) and cool the beaker. If any residue or precipitate results from the evaporation, add redistilled 1:1 hydrochloric acid (5 mL per 100 mL of final volume). See *Table 8*.
7. Warm the beaker. Add 5 mL of 5.0 N sodium hydroxide and quantitatively transfer the sample with deionized water to a volumetric flask. See *Table 8* below for the suggested final volume.
8. Adjust the sample to pH 4 by drop-wise addition of 5.0 N Sodium Hydroxide Standard Solution; mix thoroughly and check the pH after each addition. Dilute to volume with deionized water. Multiply the result by the correction factor in *Table 8*. A reagent blank also should be carried through the digestion and measurement procedures.

Table 8 Vigorous Digestion Volumes

Expected Metal Concentration	Suggested Sample Vol. for Digestion	Suggested Volume of 1:1 HCl	Suggested Final Volume After Digestion	Correction Factor
1 mg/L	50 mL	10 mL	200 mL	4
10 mg/L	5 mL	10 mL	200 mL	40
100 mg/L	1 mL	25 mL	500 mL	500

General Digesdahl Digestion (Not USEPA accepted)

Many samples may be digested using the Digesdahl Digestion Apparatus (Cat. No. 23130). It is designed to digest many types of samples such as oils, wastewater, sludges, feeds, grains, plating baths, food, and soils. In this procedure the sample is oxidized by a mixture of sulfuric acid and hydrogen peroxide. Digestion of a dry sample requires less than ten minutes, while liquid samples require about 1 minute/mL. The digestion is done in a special flat-bottomed 100-mL volumetric flask. Aliquots (sample portions) are taken for analysis using colorimetric methods.

Procedures for digestion and using the Digesdahl Digestion Apparatus are based on the type and form of the sample, and are found in the Digesdahl Digestion Apparatus Instruction Manual, which is included with each Digesdahl Digestion Apparatus.

Distillation

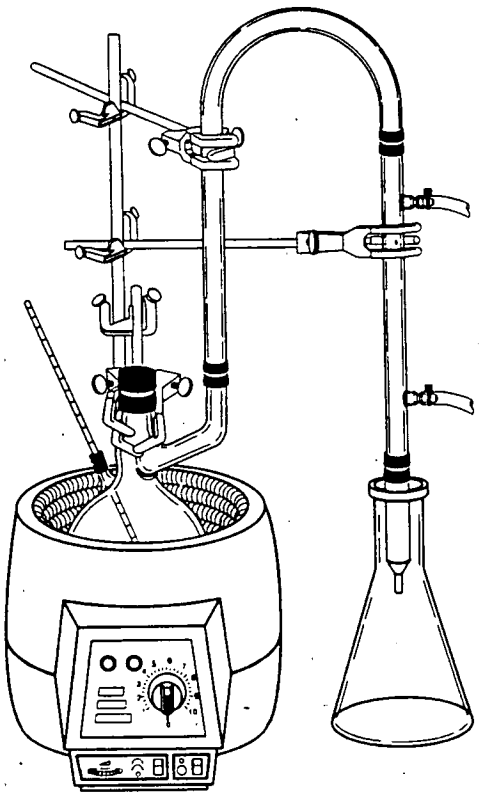
Distillation is an effective way of separating chemical components for analysis. The Hach Distillation Apparatus (see *Figure 12*) is adapted easily for many test needs and is suitable for water and wastewater samples. Sample distillations are easy and safe to perform.

Applications for the General Purpose Distillation Apparatus include:

- fluoride
- albuminoid nitrogen
- ammonia nitrogen
- phenols
- selenium
- volatile acids

Arsenic and cyanide require special glassware sets in addition to the General Purpose Set (the Arsenic Distillation Apparatus and the Cyanide Distillation Apparatus). All connecting glassware is manufactured with threaded connectors for ease and safety. The General Purpose Heater provides efficient heating and the Support Apparatus anchors the glassware.

Figure 12
General Purpose Distillation Apparatus with Heater and Support Apparatus



SECTION 3 WASTE MANAGEMENT AND SAFETY

Waste Management

This section provides guidelines for laboratory waste management. It should assist you in complying with USEPA regulations governing waste management. It summarizes basic requirements, but does not contain all USEPA regulations. It does not relieve people from complying with all regulations contained in the Code of Federal Regulations. Regulations change regularly and additional state and local laws may apply to your waste. Each waste generator is responsible for knowing and obeying the laws that apply to them.

Waste Minimization

Waste minimization is the foundation of good waste management. Minimizing waste greatly reduces the disposal problems and expense. If possible, try to generate less waste rather than recycle or re-use it. For laboratories, ways to reduce waste include:

- Use the smallest sample size possible.
- Choose methods that use non-hazardous or "less" hazardous reagents when possible.
- Buy chemicals in small quantities which will be used before they expire. This eliminates disposal of out-dated materials.
- Clean glassware and laboratory apparatus with non-hazardous soaps when possible, rather than solvents or acids which may be hazardous.

Regulatory Overview

Federal waste disposal regulations were issued in accordance with the Resource Conservation and Recovery Act (RCRA). They are given in Title 40 Code of Federal Regulations (CFR) part 260. The Act controls all forms of solid waste disposal and encourages recycling and alternative energy sources. The major emphasis is controlling hazardous waste disposal. The regulations create a system to identify wastes and track waste generation, transport, and ultimate disposal. Each facility involved in managing hazardous waste must be registered with the USEPA. This includes the generator, transporters, and treatment, storage, and disposal facilities (TSDF).

Under federal regulations, there are three categories of generators with increasingly more strict regulation for larger quantity generators. The categories are based on the amount of hazardous waste generated in any given month.

The categories are as follows:

- Conditionally Exempt Small Quantity Generator - less than 100 kg (220 lb.) per month
- Small Quantity Generator - between 100 kg (220 lb.) and 1,000 kg (2,200 lb.) per month
- Large Quantity Generator - greater than 1,000 kg (2,200 lb.) per month

Note: *If a laboratory generates acutely hazardous waste (as defined on 40 CFR 261) or accumulates more than a certain amount of waste, the facility may be moved into a larger generator status. Check with your environmental compliance manager or state and local officials to determine which category your facility is in.*

Hazardous Waste Definition

For regulatory purposes, a "hazardous waste" is a material which is subject to special laws by the USEPA under 40 CFR 261. In addition, many states or local authorities regulate additional materials as hazardous waste. Be aware that many very toxic compounds are not regulated by this definition of hazardous waste. However, improper management or disposal of these compounds may lead to legal problems under other laws such as CERCLA (Superfund) or common law tortes.

The 40 CFR 261 defines a hazardous waste as a solid waste which is not excluded from regulation and meets any of the following criteria:

- It is a discarded commercial chemical product, off-specification species, container residue, or spill residue of materials specifically listed in 40 CFR 261.33;
- It is a waste from a specific source listed in 40 CFR 261.32;
- It is a waste from a non-specific source listed in 40 CFR 261.31; or
- It displays any of the following characteristics of hazardous waste defined in 40 CFR 261.20-24:
    - ignitability
    - corrosivity
    - reactivity
    - toxicity

There are many exceptions to these regulations, and each generator should review the regulations and determine if they are excluded from the regulations.

Characteristic Hazardous Waste Codes

Hazardous wastes are categorized by specific codes assigned in 40 CFR 261.20-261.33. These codes will help you identify hazardous waste. The generator is responsible for making the actual waste code determination.

Selected characteristic waste codes for chemicals which may be generated using Hach methods for water analysis are given in the following table. A complete list of waste codes is found in 40 CFR 261.24.

USEPA Code	Characteristic	CAS No.	Regulatory Level (mg/L)
D001	Ignitability	na	na
D002	Corrosivity	na	na
D003	Reactivity	na	na
D004	Arsenic	6440-38-2	5.0
D005	Barium	6440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D008	Lead	7439-92-1	5.0
D009	Mercury	7439-97-6	0.2
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0

How to Determine if Waste is Hazardous

Federal laws do not require you to test a material to decide if it is a hazardous waste. You may apply product knowledge to decide if a material is hazardous. Often, information on a material safety data sheet (MSDS) is enough to decide. If the product is specifically listed in the regulation, it is a hazardous waste.

You also need to decide if it has any characteristics of a hazardous waste. Physical information on the MSDS may help you decide. If the flash point is below 60 °F (15 °C) or is classified by DOT as an oxidizer, the material may be ignitable. If the pH of the material is ≤2 or ≥12.5, the material may be corrosive. If the material is unstable, reacts violently with water, or may generate toxic gases, vapors, or fumes when mixed with water, it may be reactive.

Use the chemical composition data to decide if a material is toxic. This decision is based on the concentration of certain contaminants (heavy metals and a number of organic compounds). If the waste is a liquid, compare the concentration of the contaminants in the liquid to the concentrations listed in 40 CFR 261.24. If the waste is a solid, analyze the sample by the Toxicity Characteristic Leachability Procedure (TCLP) and compare the results to the concentration listed in the 40 CFR 261.24. Levels above the threshold amount listed in the table are hazardous.

See See "Sections of the MSDS" on page 58. describing the MSDS for help in finding information for making hazardous waste determinations.

Examples of Hazardous Waste

A number of chemicals used in and final solutions created from Hach procedures are hazardous wastes when they are disposed. In addition, substances in the sample matrix may be a hazardous waste. Sometimes, reagents which would be hazardous are neutralized or changed during the analytical procedure. In that case, the final solutions are not regulated. Finally, many reagents and final solutions may be non-regulated. The generator must either use their knowledge of the materials used or conduct analytical tests to determine if the final material is a hazardous waste.

Examples of tests using Hach reagents that generate hazardous waste include those containing mercury or mercury compounds such as COD tests or Nessler's reagent. Conversely, a test using Hach reagents such as ManVer 2 Hardness Indicator Powder Pillows and EDTA Titration Cartridges do not produce a hazardous waste unless the sample contains a hazardous substance.

Hazardous Waste Disposal

Hazardous waste must be managed and disposed of according to federal, state, and local regulations. The waste generator is responsible for making hazardous waste determinations. Analysts should check with the facility's environmental compliance people for specific instructions.

Hazardous wastes should be handled by treatment, storage, and disposal facilities (TSDF) that have USEPA permits. In some cases, the generator may treat the hazardous waste. In most cases, a permit from the USEPA is required to treat hazardous waste. Laboratories are not exempt from these regulations. If your facility is a "Conditionally Exempt Small Quantity Generator," special rules may apply. Check 40 CFR 261 to determine if have to comply with all the laws.

The most common allowed treatment is elementary neutralization. This refers to neutralizing wastes that are hazardous only because they are corrosive or are listed only for that reason. Neutralize acidic solutions by adding a base such as sodium hydroxide; neutralize basic solutions by adding an acid such as hydrochloric acid. Slowly add the neutralizing agent while stirring. Monitor the pH. When it is at or near 7, the material is neutralized and may be flushed down the drain. Many wastes generated from Hach procedures may be treated in this manner.

Other chemical or physical treatments such as cyanide destruction or evaporation may require a permit. Check with your environmental department or local regulators to determine which rules apply to your work facility.

Laboratory chemicals may be mixed and disposed of with other hazardous wastes generated at your facility. They may also be accumulated in accordance with 40 CFR 262.34 satellite accumulation rules. After collection they may be disposed of in a "labpack." A number of environmental and hazardous waste companies offer labpacking services. They will inventory, sort, pack, and arrange proper disposal for hazardous waste. Find companies offering these services in the Yellow Pages under "Waste Disposal - Hazardous" or contact state and local regulators for assistance.

Management of Specific Wastes

Hach has several documents to assist customers in managing waste generated from our products. You can obtain the following documents by calling 1-800-227-4224 or 970-669-3050 and requesting the literature codes given:

Literature Code	Title
1321	Waste Reduction: A Primer
9323	Mercury Waste Disposal Firms
9325	COD Waste Management
9326	COD Heavy Metal Total Concentrations

Special Considerations for Cyanide-Containing Materials

Several procedures in this manual use reagents that contain cyanide compounds. These materials are regulated as reactive (D003) waste by the Federal RCRA. Waste disposal instructions provided with each procedure tell you how to collect these materials for proper disposal. It is imperative that these materials be handled safely to prevent the release of hydrogen

cyanide gas (an extremely toxic material with the smell of bitter almonds). Most cyanide compounds are stable and can be safely stored for disposal in highly alkaline solutions (pH >11) such as 2 N sodium hydroxide. Never mix these wastes with other laboratory wastes that may contain lower pH materials such as acids or even water.

If a cyanide-containing compound is spilled, you must be careful not to be exposed to hydrogen cyanide gas. Take the following steps to destroy the cyanide compounds in an emergency:

a) Use a fume hood, supplied air or self-contained breathing apparatus.

b) While stirring, add the waste to a beaker containing a strong solution of sodium hydroxide and either calcium hypochlorite or sodium hypochlorite (household bleach).

c) Add an excess of hydroxide and hypochlorite. Let the solution stand for 24 hours.

d) Neutralize the solution and flush it down the drain with a large amount of water. If the solution contains other regulated materials such as chloroform or heavy metals, it may still need to be collected for hazardous waste disposal. Never flush hazardous wastes down the drain.

Resources

Many sources of information on proper waste management are available. The USEPA has a hotline number for questions about the Resource Conservation and Recovery Act (RCRA). The RCRA Hotline number is 1-800-424-9346. You may also get a copy of the appropriate regulations. Federal hazardous waste regulations are found in 40 CFR 260- 99. Obtain this book from the U.S. Government Printing Office or a number of other vendors. Other documents which may be helpful to the laboratory hazardous waste manager include:

1. Task Force on Laboratory Waste Management. *Laboratory Waste Management. A Guidebook*; American Chemical Society, Department of Government Relations and Science Policy: Washington, DC 1994.

2. Task Force on Laboratory Waste Management. *Waste Management Manual for Laboratory Personnel*; American Chemical Society, Department of Government Relations and Science Policy: Washington, DC 1990.

3. Task Force on Laboratory Waste Management. *Less is Better*; 2nd ed.; American Chemical Society, Department of Government Relations and Science Policy: Washington, DC 1993.

4. Committee on Chemical Safety. *Safety in Academic Chemistry Laboratories*, 5th ed.; American Chemical Society: Washington, DC, 1990.

5. Armour, Margaret-Ann. *Hazardous Laboratory Chemicals Disposal Guide*; CRC Press: Boca Raton, FL, 1991.

6. *Environmental Health and Safety Manager's Handbook*; Government Institutes, Inc.: Rockville, MD, 1988.

7. Lunn, G.; Sansone, E.B. *Destruction of Hazardous Chemicals in the Laboratory*; John Wiley and Sons: New York, 1990.

8. National Research Council. *Prudent Practices for Disposal of Chemicals from Laboratories*; National Academy Press: Washington, DC, 1983.

9. National Research Council. *Prudent Practices for Handling Hazardous Chemicals in Laboratories*; National Academy Press: Washington, DC, 1981.

10. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *The RCRA Orientation Manual*; U.S. Government Printing Office: Washington, DC, 1991.

11. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business*; U.S. Government Printing Office: Washington, DC, 1986.

Material Safety Data Sheets

Material safety data sheets (MSDS) describe the hazards of chemical products. This section describes the information provided on a Hach MSDS and how to locate important information for safety and waste disposal. The information provided on the MSDS applies to the product as sold by Hach. The properties of any mixtures obtained by using this product will be different.

How to Obtain A MSDS

Hach ships a MSDS to each customer with the first order of any chemical product. A new MSDS may be sent when the information on the data sheet is updated. Please review all new MSDS's for new information. If you need another copy of an MSDS, simply call 1-800-227-4227.

Sections of the MSDS

Each MSDS has ten sections. The sections and the information found in them are described below.

Header Information

The Hach catalog number. MSDS date. change number. company address and telephone number, and emergency telephone numbers are listed at the top of the MSDS.

1 Product Identification

This section contains:

- Hach product name
- Chemical Abstract Services (CAS) number
- Chemical name
- Chemical formula, if appropriate
- Chemical family to which the material belongs

2 Ingredients

This section lists each component in the product. It contains the following information for each component:

- PCT: Percent by weight of this component
- CAS NO.: Chemical Abstract Services (CAS) registry number for this component
- SARA: Superfund Amendments and Reauthorization Act. better known as the "Community Right to Know Law" tells you if the component is listed in SARA 313. If the component is listed and you use more than the amount listed, you must report this to the USEPA every year.
- TLV: Threshold Limit Value. The maximum airborne concentration for an 8 hour exposure that is recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).
- PEL: Permissible Exposure Limit. The maximum airborne concentration for an 8 hour exposure that is regulated by the Occupational Safety and Health Administration (OSHA).
- HAZARD: Physical and health hazards of the component are explained.

3 Physical Data

The physical properties of the product are given in this section. They include the physical state, color, odor, solubility, boiling point, melting point, specific gravity, pH, vapor density, evaporation rate, corrosivity, stability, and storage precautions.

4 Fire, Explosion Hazard And Reactivity Data

This section contains the flash point and flammable limits of the material. It also includes how to fight fires if the material catches on fire. Key terms in this section include:

- Flashpoint: The temperature at which a liquid will give off enough flammable vapor to ignite.
- Flammability and ignitability are usually defined by the flash point.
- Lower Flammable Limit (LFL or LEL): The lowest concentration that will produce a fire or flash when an ignition source is present.
- Upper Flammable Limit (UFL or UEL): The vapor concentration in air above which the concentration is too rich to burn.
- NFPA Codes: The National Fire Protection Association (NFPA) has a system to rate the degree of hazards presented by a chemical. These codes are usually placed in a colored diamond. The codes range from 0 for minimal hazard to 4 for extreme hazard. They are grouped into the following hazards: health (blue), flammability (red), reactivity (yellow), and special hazards (white).

5 Health Hazard Data

This section describes different ways the chemical can enter your body (ingestion, inhalation, skin contact). It also gives acute (immediate) and chronic (long-term) health effects. If the material causes cancer or genetic damage, it is identified in this section.

6 Precautionary Measures

This section contains special precautions for the material. These may include special storage instructions, handling instructions, conditions to avoid, and protective equipment required to use this material safely.

7 First Aid

First aid instructions for exposures to the chemical are given in this section. Be sure to read this section before inducing vomiting in a victim. Some chemicals are better treated by not inducing vomiting. Seek prompt medical attention for all chemical exposures.

8 Spill And Disposal Procedures

This section tells about safe work practices for cleaning up and disposing of spilled material. Please refer to the Waste Management section of this manual. Final determination of proper and legal disposal options is the responsibility of the waste generator. Be sure you know the federal, state, and local laws that apply to your facility.

9 Transportation Data

Domestic and International shipping information is provided in this section. It gives shipping name, hazard class, and ID number of the product.

10 References

This section lists the reference materials used to write the MSDS.

Following the Reference section, the product is listed as having SARA 313 chemicals or California Proposition 65 List Chemicals, if applicable. Also found here is any special information about the product.

Safety

Safety is the responsibility of each person performing analytical procedures. Because many of the procedures in this methods manual use potentially hazardous chemicals and equipment, it is important to prevent accidents by practicing good laboratory techniques. The following guidelines apply to water analysis. These guidelines do not cover every aspect of safety, but they are important for preventing injuries.

Material Safety Data Sheet

A material safety data sheet (MSDS) comes with the first shipment of all products. The MSDS provides environmental and safety information about the products. Always read the MSDS before using a new product.

Reading Labels Carefully

Read each reagent label carefully. Pay particular attention to the precautions given. Never remove or block the label on a reagent container while it contains reagent. Do not put a different reagent into a labeled container without changing the label. When preparing a reagent or standard solution, label the container clearly. If a label is hard to read, re-label promptly according to your facility's hazard communication program.

Warning labels also appear on some of the apparatus used with the test procedures. The protective shields with the COD Reactor and the Digesdahl Digestion Apparatus point out potential hazards. Be sure these shields are in place during use and observe the precautions on the label.

Protective Equipment

Use the right protective equipment for the chemicals and procedures. The MSDS contains this information. Protective equipment may include:

- Eye protection such as safety glasses or goggles to protect from flying objects or chemical splashes.
- Gloves to protect skin from toxic or corrosive materials, sharp objects, very hot or very cold materials, or broken glass. Use tongs or finger cots when transferring hot apparatus.
- Laboratory coats or splash aprons to protect skin and clothing from splashes.
- Footwear to protect feet from spills. Open toed shoes should not be worn in chemistry settings.
- Respirators may be needed to protect you from breathing toxic vapors if adequate ventilation, such as fume hoods, are not available.
- Use fume hoods as directed by the procedure or as recommended in the MSDS.
- For many procedures, adequate ventilation is enough. Be sure there is enough fresh air and air exhaust to protect against unnecessary exposure to chemicals.

First Aid Equipment and Supplies

Most first aid instructions for chemical splashes in eyes or on skin call for thorough flushing with water. Laboratories should have eyewash and shower stations. For field work, carry a portable eyewash unit. Laboratories should also have appropriate fire extinguishers and fume hoods.

General Safety Rules

Follow these rules to make work with toxic and hazardous chemicals safer:

1. **Never** pipet by mouth. Always use a mechanical pipet or pipet bulb to avoid ingesting chemicals.
2. Follow test procedures carefully and observe all precautionary measures. Read the entire procedure carefully before beginning.
3. Wipe up all spills promptly. Get proper training and have the right response equipment to clean up spills. See your safety director for more information.
4. **Do not** smoke, eat, or drink in an area where toxic or irritating chemicals are used.
5. Use reagents and equipment only as directed in the test procedure.
6. **Do not** use damaged labware and broken equipment.
7. Minimize all chemical exposures. **Do not** breathe vapors or let chemicals touch your skin. Wash your hands after using chemicals.
8. Keep work areas **neat** and **clean**.
9. **Do not** block exits or emergency equipment.

OSHA Chemical Hygiene Plan

The Occupational Safety and Health Administration (OSHA) enforces laws about the control exposure to hazardous chemicals in laboratories. These regulations are in Title 29 CFR 1910.1450. They apply to all employers who use hazardous chemicals. They require employers to develop and use a written Chemical Hygiene Plan and appoint a qualified person as the Chemical Hygiene Officer.

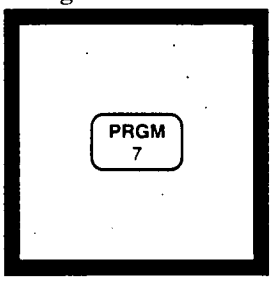
SECTION 4 PROCEDURES

IRON, FERROUS (0 to 3.00 mg/L)

For water, wastewater, and seawater

1,10 Phenanthroline Method* (Powder Pillows or AccuVac Ampuls)

Using Powder Pillows



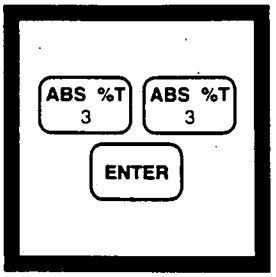
1. Enter the stored program number for Ferrous iron (Fe^{2+})-powder pillows.

Press: **PRGM**

The display will show:

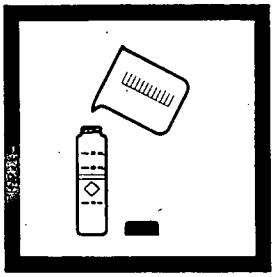
PRGM ?

Note: Analyze samples as soon as possible to prevent oxidation of ferrous iron to ferric iron, which is not determined.

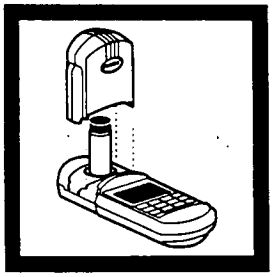


2. Press: **33 ENTER**

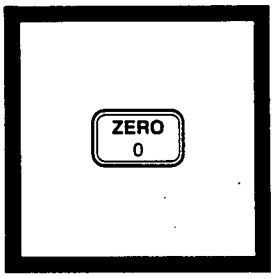
The display will show **mg/L, Fe** and the **ZERO** icon.



3. Fill a sample cell with 25 mL of sample (the blank).



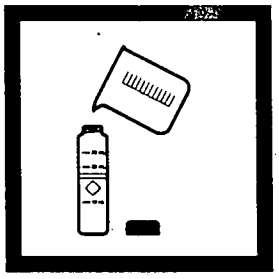
4. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



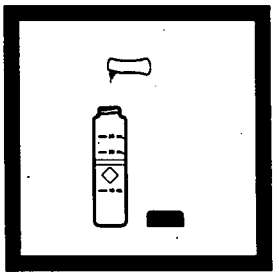
5. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.00 mg/L Fe

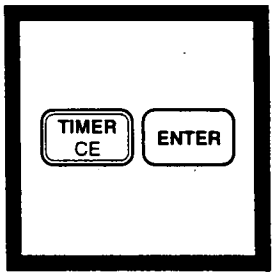


6. Fill another sample cell with 25 mL of sample.



7. Add the contents of one Ferrous Iron Reagent Powder Pillow to the sample cell (the prepared sample). Cap and invert to mix.

Note: Undissolved powder does not affect accuracy.



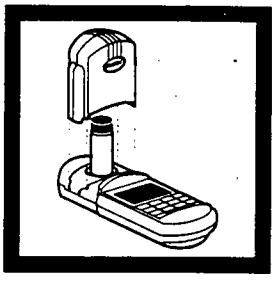
8. Press:

TIMER ENTER

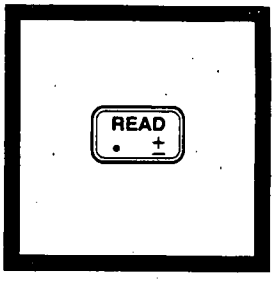
A three-minute reaction period will begin.

Note: An orange color will form if ferrous iron is present.

* Adapted from *Standard Methods for the Examination of Water and Wastewater.*



9. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

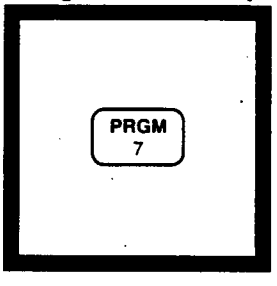


10. Press: **READ**

The cursor will move to the right, then the result in mg/L ferrous iron will be displayed.

Note: Standard Adjust may be performed using a prepared standard (see Section 1).

Using AccuVac Ampuls



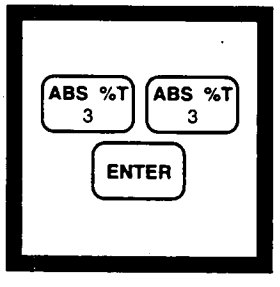
1. Enter the stored program number for ferrous iron (Fe^{2+})-AccuVac ampuls.

Press: **PRGM**

The display will show:

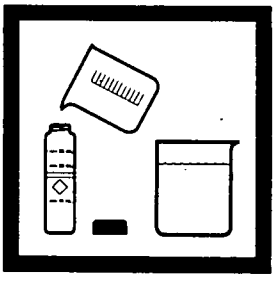
PRGM ?

Note: Analyze samples as soon as possible to prevent air oxidation of ferrous iron to ferric, which is not determined.

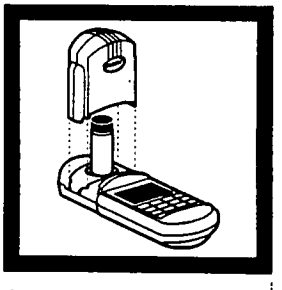


2. Press: **33 ENTER**

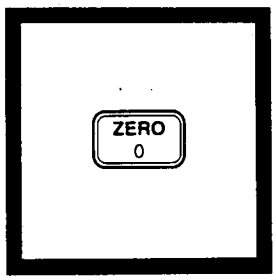
The display will show **mg/L, Fe** and the **ZERO** icon.



3. Fill a sample cell with at least 10 mL of sample (the blank). Collect at least 40 mL of sample in a 50-mL beaker.



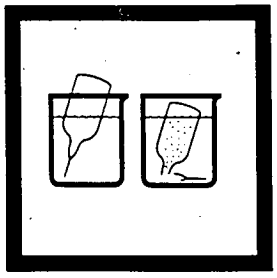
4. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



5. Press: **ZERO**

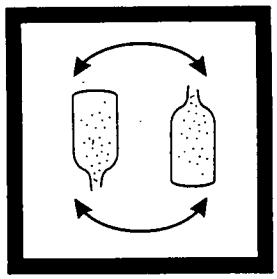
The cursor will move to the right, then the display will show:

0.00 mg/L Fe



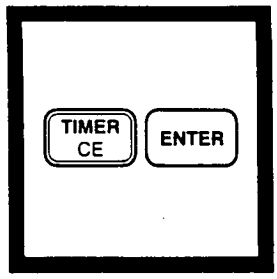
6. Fill a Ferrous Iron AccuVac Ampul with sample.

Note: Keep the tip immersed while the ampul fills completely.



7. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

Note: Undissolved powder does not affect accuracy.

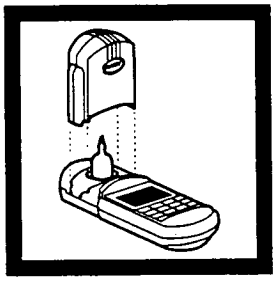


8. Press:

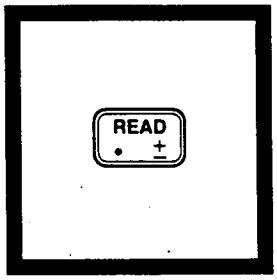
TIMER ENTER

A three-minute reaction period will begin.

Note: An orange color will form if ferrous iron is present.



9. Place the AccuVac ampul into the cell holder. Tightly cover the sample cell with the instrument cap.



10. Press: **READ**

The cursor will move to the right, then the result in mg/L ferrous iron will be displayed.

Note: Standard Adjust may be performed using a prepared standard (see Standard Adjust in Section 1).

Sampling and Storage

Ferrous iron must be analyzed immediately and cannot be stored. Analyze samples as soon as possible to prevent oxidation of ferrous iron to ferric iron, which is not measured.

Accuracy Check

Standard Solution Method

Prepare a ferrous iron stock solution (100 mg/L Fe^{2+}) by dissolving 0.7022 grams of ferrous ammonium sulfate, hexahydrate, in deionized water. Dilute to 1 liter. Prepare immediately before use. Dilute 1.00 mL of this solution to 100 mL with deionized water to make a 1.00 mg/L standard solution. Prepare immediately before use.

Run the test using the 1.00 mg/L Fe^{2+} Standard Solution by following either the powder pillow or AccuVac procedure. Results should be between 0.90 mg/L and 1.10 mg/L Fe^{2+}.

Method Performance

Precision

In a single laboratory using an iron standard solution of 2.00 mg/L Fe^{2+} and two representative lots of powder pillow reagents with the instrument, a single operator obtained a standard deviation of ±0.017 mg/L Fe^{2+}.

In a single laboratory using a standard solution of 2.00 mg/L Fe^{2+} and two representative lots of AccuVac ampuls with the instrument, a single operator obtained a standard deviation of ±0.009 mg/L Fe^{2+}.

Estimated Detection Limit

The estimated detection limit for program 33 (powder pillows and AccuVac Ampuls) is 0.03 mg/L Fe. For more information on the estimated detection limit, see *Section 1*.

Summary of Method

The 1,10-phenanthroline indicator in Ferrous Iron Reagent reacts with ferrous iron in the sample to form an orange color in proportion to the iron concentration. Ferric iron does not react. The ferric iron (Fe^{3+}) concentration can be determined by subtracting the ferrous iron concentration from the results of a total iron test.

IRON, FERROUS, continued

REQUIRED REAGENTS & APPARATUS (USING POWDER PILLOWS)

Description	Quantity Required Per Test	Units	Cat. No.
Ferrous Iron Reagent Powder Pillows	1 pillow	100/pkg	1037-69
Sample Cell, 10-20-25 mL, w/ cap	2	6/pkg	24019-06

REQUIRED REAGENTS & APPARATUS (USING ACCUVAC AMPULS)

Ferrous Iron Reagent AccuVac Ampuls	1 ampul	25/pkg	25140-25
Beaker, 50 mL	1	each	500-41

OPTIONAL REAGENTS

Ferrous Ammonium Sulfate, hexahydrate, ACS	113 g		11256-14
Water, deionized	4 L		272-56

OPTIONAL APPARATUS

AccuVac Snapper Kit	each	24052-00
Balance, analytical, 115 V	each	26103-00
Balance, analytical, 230 V	each	26103-02
Clippers, for opening powder pillows	each	968-00
Flask, volumetric, 100 mL, Class A	each	14574-42
Flask, volumetric, 1000 mL, Class A	each	14574-53
Pipet, volumetric, Class A, 1.00 mL	each	14515-35
Pipet Filler, safety bulb	each	14651-00
Weighing Boat, 67/46 mm, 8.9 cm square	500/pkg	21790-00

For Technical Assistance, Price and Ordering

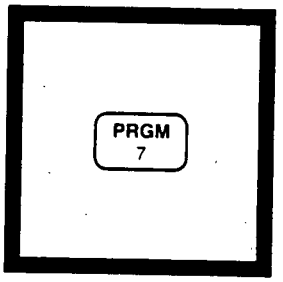
In the U.S.A.—Call 800-227-4224

Outside the U.S.A.—Contact the Hach office or distributor serving you.

NITRATE, LR (0 to 0.50 mg/L NO_3^--N)

Method 8192
For water, wastewater and seawater*

Cadmium Reduction Method



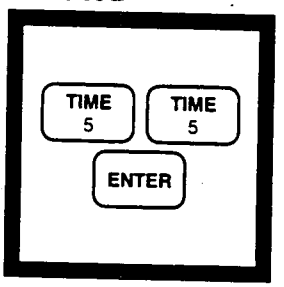
1. Enter the stored program number for low range nitrate nitrogen (NO_3^--N).

Press: **PRGM**

The display will show:

PRGM ?

Note: For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).



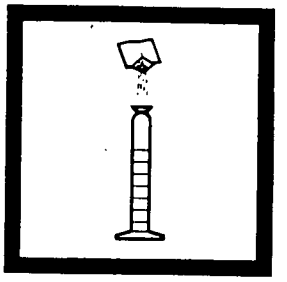
2. Press: **55 ENTER**

The display will show **mg/L, NO3-N** and the **ZERO** icon.

Note: For alternate forms (NO_3), press the **CONC** *key.*

3. Fill a 25-mL graduated mixing cylinder to the 15-mL mark with sample.

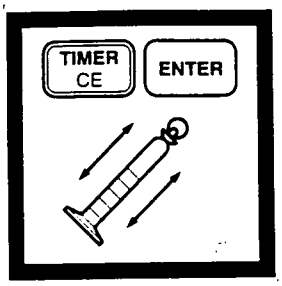
Note: Adjust the pH of stored samples before analysis.



4. Add the contents of one NitraVer 6 Nitrate Reagent Powder Pillow to the cylinder. Stopper.

Note: It is necessary to remove ***all*** *the powder from the foil pillow. Tap the pillow until no more powder pours out. Be sure to remove powder from the corners of the pillow.*

Seawater requires a manual calibration; see Interferences.

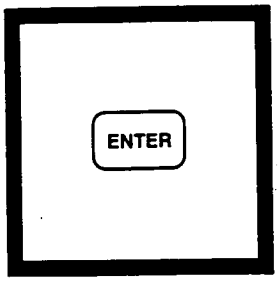


5. Press:

TIMER ENTER

A 3-minute reaction period will begin. Shake the cylinder vigorously throughout this three minute period.

Note: Shaking time and technique influence color development. For most accurate results, analyze a standard solution several times and adjust the shaking time to obtain the correct result.

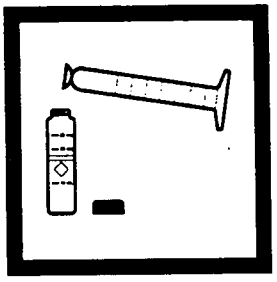


6. When the timer beeps, the display will show: **2:00 TIMER 2**

Press: **ENTER**

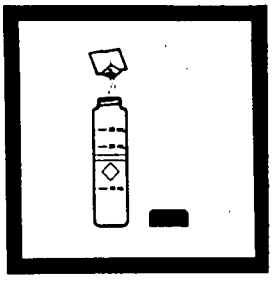
A 2-minute reaction period will begin.

Note: A deposit will remain after the powder dissolves and will not affect results.



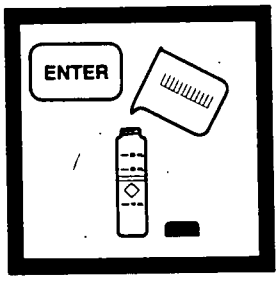
7. When the timer beeps, pour 10 mL of the sample into a sample cell.

Note: Do not transfer any cadmium particles.



8. Add the contents of one NitriVer 3 Nitrite Reagent Powder Pillow to the sample cell (the prepared sample). Cap the cell and shake gently for 30 seconds.

Note: A pink color will form if nitrate is present.

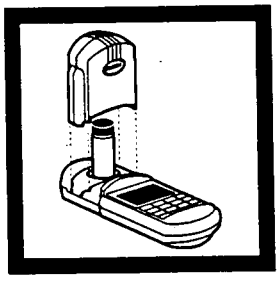


9. The display will show: **15:00 TIMER 3**

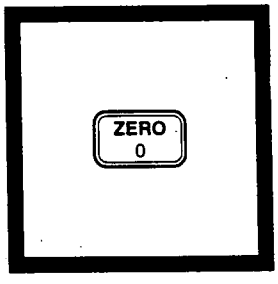
Press: **ENTER**

A 15-minute reaction period will begin.

Fill another sample cell (the blank) with 10 mL of sample.



10. When the timer beeps, place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

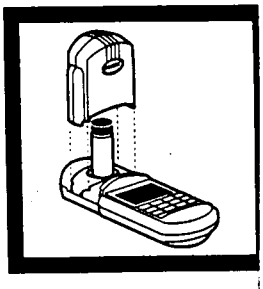


11. Press: **ZERO**

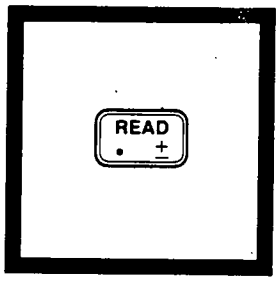
The cursor will move to the right, then the display will show:

0.00 mg/L NO3-N

Note: If Reagent Blank Correction is on, the display may flash "limit". See Section 1.



12. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.



13. Press: **READ**

The cursor will move to the right, then the result in mg/L NO_3^--N (or alternate form) will be displayed.

Note: Standard Adjust may be performed using a prepared standard (see Section 1).

Note: Rinse the sample cell and cylinder immediately after use to remove all cadmium particles.

Note: See Pollution Prevention and Waste Management for proper disposal of cadmium.

Sampling and Storage

Collect samples in clean plastic or glass bottles. Store at 4 °C (39 °F) or lower if the sample is to be analyzed within 24 to 48 hours. Warm to room temperature before running the test. For longer storage periods, adjust sample pH to 2 or less with sulfuric acid, ACS (about 2 mL per liter). Sample refrigeration is still required.

Before testing the stored sample, warm to room temperature and neutralize with 5.0 N Sodium Hydroxide Standard Solution. Do not use mercury compounds as preservatives. Correct the test result for volume additions; see *Correction for Volume Additions* (*Section 1*) for more information.

Accuracy Check

Standard additions Method

a) Fill three 25-mL graduated mixing cylinders with 15 mL of sample.

b) Snap the neck off a Nitrate Nitrogen Ampule Standard Solution, 12.0 mg/L NO_3^--N.

c) Using the TenSette Pipet, add 0.1, 0.2, and 0.3 mL of the standard to the three samples. Stopper and mix well.

d) Analyze each sample as described above. The nitrate nitrogen concentration should increase 0.08 mg/L for each 0.1 mL of standard added.

e) If these increases do not occur, see *Standard Additions* (Section 1) for more information.

Standard Solution Method

Prepare a 0.20 mg/L nitrate nitrogen standard by diluting 2.00 mL of a 10.0 mg/L Nitrate Nitrogen Standard Solution to 100.0 mL with deionized water. Use this standard in place of sample in Step 3.

Standard Adjust

To adjust the calibration curve using the reading obtained with the 0.20-mg/L standard solution, press the **SETUP** key and scroll (using the arrow keys) to the STD setup option. Press **ENTER** to activate the standard adjust option. Then enter **0.20** to edit the standard concentration to match that of the standard used. Press **ENTER** to complete the curve adjustment. If you are using a reagent blank correction, the blank correction should be entered before the Standard Adjust feature is entered. See *Section 1, Standard Curve Adjustment* for more information.

Method Performance

Precision

In a single laboratory using a standard solution of 0.25 mg/L nitrate nitrogen (NO_3^--N) and two representative lots of reagent with the instrument, a single operator obtained a standard deviation of ±0.03 mg/L nitrate nitrogen.

Estimated Detection Limit

The estimated detection limit for program 55 is 0.01 mg/L NO_3^--N. For more information on the estimated detection limit, see *Section 1*.

Interferences

Interfering Substance	Interference Levels and Treatments
Calcium	100 mg/L
Chloride	Chloride concentrations above 100 mg/L will cause low results. The test may be used at high chloride concentrations (seawater) but a calibration must be done using standards spiked to the same chloride concentration.
Ferric iron	All levels
Nitrite	All levels: This method measures both the nitrate and nitrite in the sample. If nitrite is present, the nitrite nitrogen test Program 60 should be done on the sample. Pretreat the nitrate nitrogen sample with the following pretreatment. Then subtract the amount of nitrite found from the results of the LR nitrate nitrogen test using the pretreated sample. **1.** Add 30-g/L Bromine Water dropwise to the sample in Step 3 until a yellow color remains. Mix after each drop. **2.** Add one drop of 30-g/L Phenol Solution to destroy the yellow color. **3.** Proceed with the LR Nitrate procedure.
pH	Highly buffered samples or extreme sample pH may exceed the buffering capacity of the reagents and require sample pretreatment.
Strong oxidizing and reducing substances	Interfere at all levels

Summary of Method

Cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilic acid to form an intermediate diazonium salt which couples to chromotropic acid to form a pink-colored product.

Pollution Prevention and Waste Management

NitaVer 6 contains cadmium metal. Both samples and reagent blanks will contain cadmium (D006) at a concentration regulated as hazardous wastes by the Federal RCRA. Do not pour these solutions down the drain. See *Section 3* for more information on proper disposal of these materials.

NITRATE, Low Range, continued

REQUIRED REAGENTS

Low Range Nitrate Reagent Set (100 tesets) 24298-00
Includes: (1) 21071-69, (1) 21072-49

Description	Quantity Required Per Test	Unit	Cat. No.
NitriVer 3 Nitrite Reagent Powder Pillows	1 pillow	100/pkg	21071-69
NitraVer 6 Nitrate Reagent Powder Pillows	1 pillow	100/pkg	21072-49

REQUIRED APPARATUS

Cylinder, graduated, mixing, 25 mL	1	each	1896-40
Sample Cell, 10-20-25 mL, w/ cap	2	6/pkg	24019-06

OPTIONAL REAGENTS

Description	Unit	Cat. No.
Bromine Water, 30 g/L	29 mL*	2211-20
Nitrate Nitrogen Standard Solution, 10.0 mg/L as NO_3^--N	500 mL	307-49
Nitrate Nitrogen Standard Solution, Voluette ampule, 12 mg/L as NO_3^--N, 2 mL	20/pkg	25587-20
Phenol Solution, 30 g/L	29 mL	2112-20
Pretreatment Kit, contains: (1) 2112-20, (1) 2211-20	each	2268-00
Sodium Hydroxide Standard Solution, 5.0 N	50 mL* SCDB	2450-26
Sulfuric Acid, ACS	500 mL*	979-49
Water, deionized	4 L	272-56

OPTIONAL APPARATUS

Ampule Breaker, PourRite Ampules	each	24846-00
Dropper, for 29-mL bottle	each	2258-00
Flask, volumetric, Class A, 100 mL	each	14574-42
pH Indicator Paper, 1 to 11 pH	5-roll/pkg	391-33
pH Meter, EC10, portable	each	50050-00
Pipet, serological, 2 mL	each	532-36
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet Tips, for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 2.00 mL	each	14515-36
Pipet Filler, safety bulb	each	14651-00
Thermometer, -10 to 110 °C	each	1877-01

Nitrate at these levels can be determined directly using the Nitrate Ion Selective Electrode (Cat. No. 50235-00).

For Technical Assistance, Price and Ordering

In the U.S.A.—Call 800-227-4224

Outside the U.S.A.—Contact the Hach office or distributor serving you.

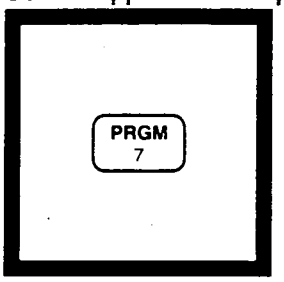
* Contact Hach for larger sizes

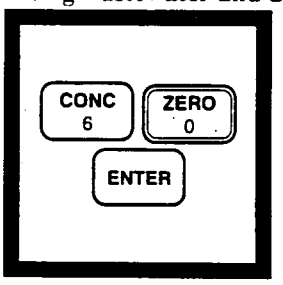
NITRITE, Low Range (0 to 0.350 mg/L NO_2^--N)

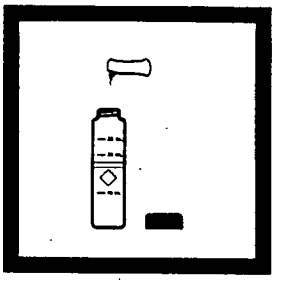
For water, wastewater, seawater

Diazotization Method* (Powder Pillows or AccuVac Ampuls);

USEPA approved for reporting wastewater and drinking water analyses.







1. Enter the stored program number for nitrite nitrogen (NO_2^--N), powder pillows.

Press: **PRGM**

The display will show:

PRGM ?

Note: For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).

2. Press: **60 ENTER**

The display will show **mg/L, NO2-N** and the **ZERO** icon.

Note: For alternate forms (NO_2^-, $NaNO_2$), press the **CONC** *key.*

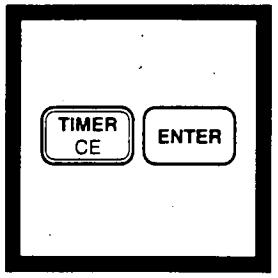
3. Fill a sample cell with 10 mL of sample.

4. Add the contents of one NitriVer 3 Nitrite Reagent Powder Pillow to the sample cell. Cap the cell and shake to dissolve.

Note: Accuracy is not affected by undissolved powder.

* *Federal Register*, 44(85) 25505 (May 1, 1979)

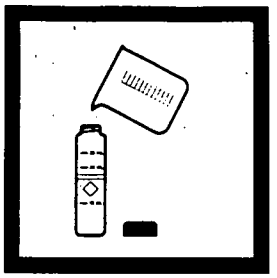
NITRITE, Low Range, continued



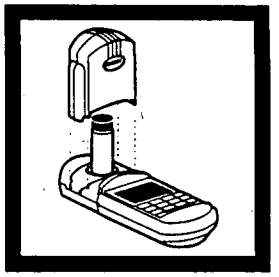
5. Press:
TIMER ENTER

A 15-minute reaction period will begin.

Note: A pink color will develop if nitrite is present.

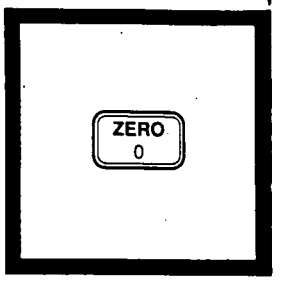


6. When the timer beeps, fill an empty sample cell with 10 mL of sample (the blank).



7. Wipe the outside of the sample cell with a towel. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

Note: Wiping with a damp cloth, followed by a dry pne, removes fingerprints and other marks.

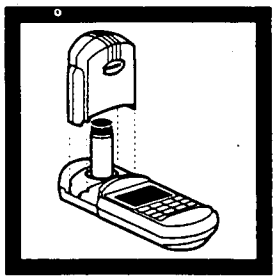


8. Press: **ZERO**

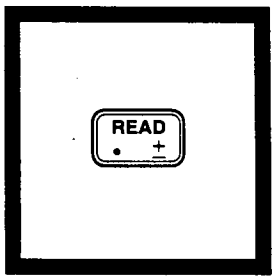
The cursor will move to the right, then the display will show:

0.000 mg/L NO2-N

Note: If Reagent Blank Correction is on, the display may flash "limit." See Section 1.



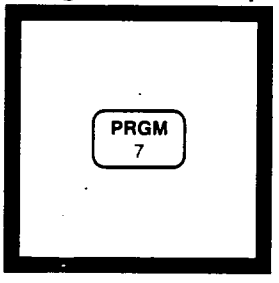
9. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.



10. Press: **READ**

The cursor will move to the right, then the result in mg/L nitrite nitrogen (or an alternate form) will be displayed.

Using AccuVac Ampuls



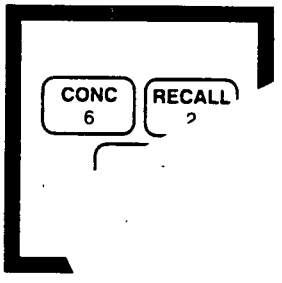
1. Enter the stored program number for nitrite nitrogen (NO_2^--N), AccuVac Ampuls.

Press: **PRGM**

The display will show:

PRGM ?

Note: For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).



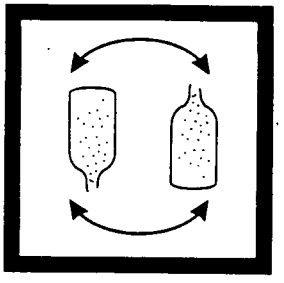
2. Pres

The displa
mg/L, NO
ZERO icon.

Note: For alternate forms (NO_2^-, $NaNO_2$), press the **CONC** *key.*

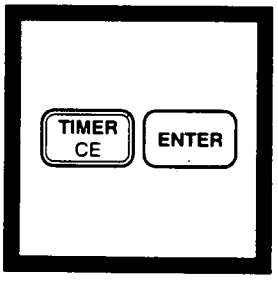
40 mL
a 50-mL
Fill a NitriVer 3
Nitrite AccuVac Ampul
with the sample.

Note: Keep the tip immersed while the ampul fills completely.



4. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

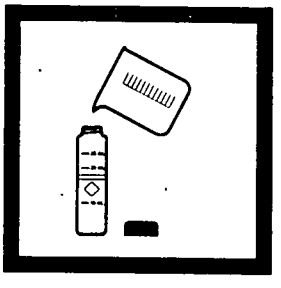
Note: Accuracy is not affected by undissolved powder.



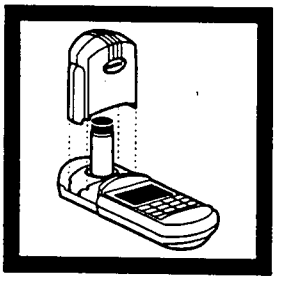
5. Press:
TIMER ENTER

A 15-minute reaction period will begin.

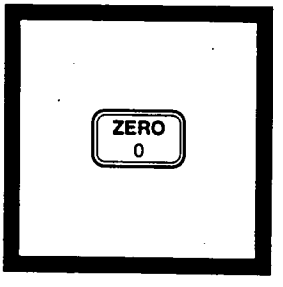
Note: A pink color will develop if nitrite is present.



6. When the timer beeps, fill a sample cell with at least 10 mL of sample (the blank).



7. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



8. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.000 mg/L NO2-N

Note: If Reagent Blank Correction is on, the display may flash "limit." See Section 1.

Sampling and Storage

Collect samples in clean plastic or glass bottles.

Store at 4 °C (39 °F) or lower and analyze within 48 hours. Warm to room temperature before running the test.

Do not use acid preservatives.

Remove the suspended solids by filtration.

Accuracy Check

Standard Solution Method

Pipet 5.00 mL of a fresh 250 mg/L NO_2^--N standard into a 250.0 mL volumetric flask. Dilute to the mark with deionized water. This makes a 5.00-mg/L intermediate standard. To prepare a 0.100-mg/L NO_2^--N standard solution, dilute 10.00 mL of the 5.00-mg/L intermediate standard to 500 mL in a volumetric flask. Prepare this solution immediately before use.

Run the test using the 0.100 mg/L NO_2^--N standard in place of the sample. Results should be between 0.090 and 0.110 mg/L NO_2^--N.

Method Performance

Precision

In a single laboratory, using a standard solution of 0.250 mg/L nitrite nitrogen and two representative lots of reagent with the instrument, a single operator obtained a standard deviation of ±0.001 mg/L NO_2^--N for the powder pillow method and ±0.003 mg/L NO_2^--N for the AccuVac method.

Estimated Detection Limit

The estimated detection limit for programs 60 and 62 is 0.005 mg/L NO_2^--N. For more information on derivation and use of Hach's estimated detection limit, see *Section 1*.

Interferences

Interfering Substance	Interference Levels
Antiminous ions	Interfere by causing precipitation
Auric ions	Interfere by causing precipitation
Bismuth ions	Interfere by causing precipitation
Chloroplatinate ions	Interfere by causing precipitation
Cupric ions	Cause low results
Ferric ions	Interfere by causing precipitation
Ferrous ions	Cause low results
Lead ions	Interfere by causing precipitation
Mercurous ions	Interfere by causing precipitation
Metavanadate ions	Interfere by causing precipitation
Nitrate	Very high levels of nitrate (>100 mg/L nitrate as N) appear to undergo a slight amount of reduction to nitrite, either spontaneously or during the course of the test. A small amount of nitrite will be found at these levels.
Silver ions	Interfere by causing precipitation
Strong oxidizing and reducing substances	Interfere at all levels

Summary of Method

Nitrite in the sample reacts with sulfanilic acid to form an intermediate diazonium salt. This couples with chromotropic acid to produce a pink colored complex directly proportional to the amount of nitrite present.

NITRITE, Low Range

REQUIRED REAGENTS

Description	Quantity Required Per Test	Unit	Cat. No.
NitriVer 3 Nitrite Reagent Powder Pillows	1 pillow	100/pkg	21071-69
or			
NitriVer 3 Nitrite Reagent AccuVac Ampuls	1 ampul	25/pkg	25120-25

REQUIRED APPARATUS

Beaker, 50 mL (for AccuVac procedure)	1	each	500-41
or			
Sample Cells, 10-20-25 mL (powder pillow procedure)	2	6/pkg	24019-06

OPTIONAL REAGENTS

Nitrite Standard Solution, 250 mg/L as NO_2^--N	500 mL	23402-49
Water, deionized	4 L	272-56

OPTIONAL APPARATUS

Description	Unit	Cat. No.
AccuVac Snapper Kit	each	24052-00
Flask, volumetric, 250 mL	each	14574-46
Flask, volumetric, 500 mL	each	14574-49
Pipet, serological, 10 mL	each	532-38
Pipet, TenSette, 1 to 10 mL	each	19700-01
Pipet Tips for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 5.00 mL	each	14515-37
Pipet, volumetric, Class A, 10.00 mL	each	14515-38
Pipet Filler, safety bulb	each	14651-00
Thermometer, -10 to 110 °C	each	1877-01

For Technical Assistance, Price and Ordering

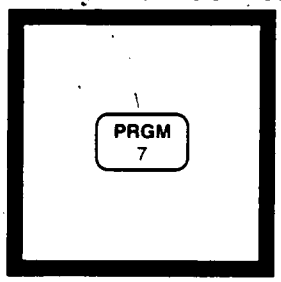
In the U.S.A. call 800-227-4224

Outside the U.S.A.—Contact the Hach office or distributor serving you.

SULFIDE (0 to 0.70 mg/L S^{2-})

For water, wastewater and seawater

Methylene Blue Method* USEPA accepted for reporting wastewater analysis**

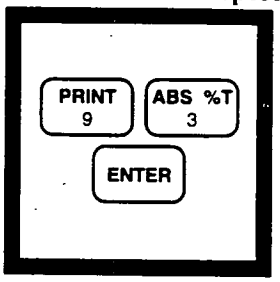


1. Enter the stored program number for sulfide (S).

Press: **PRGM**

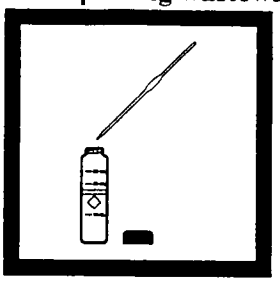
The display will show:

PRGM ?



2. Press: **93 ENTER**

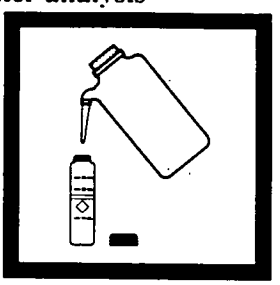
The display will show **mg/L, S** and the **ZERO** icon.



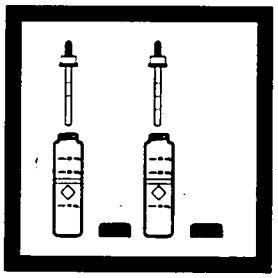
3. Pipet 25 mL of sample into a clean sample cell. This will be the prepared sample.

Note: Samples must be analyzed immediately and cannot be preserved for later analysis. Use a pipet to avoid agitation.

Note: For field testing, a 25-mL graduated cylinder may be used.

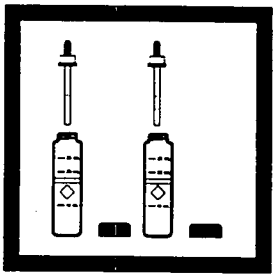


4. Fill a second sample cell with 25 mL of deionized water (the blank).



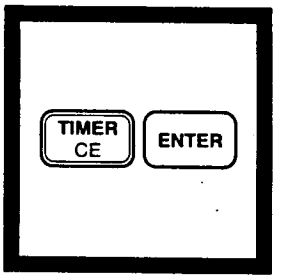
5. Add 1.0 mL of Sulfide 1 Reagent to each cell. Swirl to mix.

Note: Use the calibrated 1-mL dropper.



6. Add 1.0 mL of Sulfide 2 Reagent to each cell. Immediately swirl to mix.

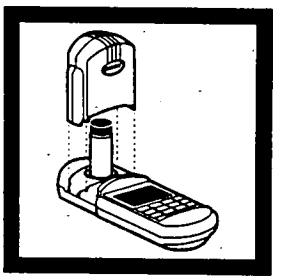
Note: A pink color will develop, then the solution will turn blue if sulfide is present.



7. Press:

TIMER ENTER

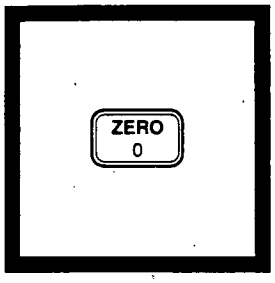
A 5-minute reaction period will begin.

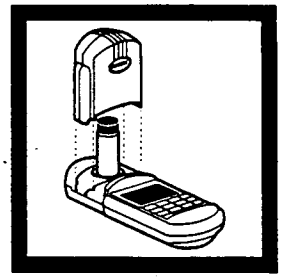


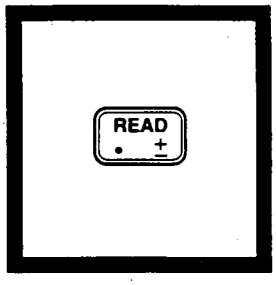
8. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

* Adapted from *Standard Methods for the Examination of Water and Wastewater.*

** Procedure is equivalent to USEPA method 376.2 or Standard Method 4500-S^{2-} D for wastewater.







9. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.00 mg/L S

10. After the timer beeps, place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

11. Press: **READ**

The cursor will move to the right, then the result in mg/L sulfide will be displayed.

Note: *Some sulfide loss may occur if dilution is necessary.*

Note: *Standard Adjust may be performed using a prepared standard (see Standard Adjust in Section 1).*

Sampling and Storage

Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Analyze samples immediately.

Method Performance

Precision

In a single laboratory, using standard solutions of 0.73 mg/L sulfide and two representative lots of reagent with the instrument, a single operator obtained a standard deviation of ± 0.02 mg/L sulfide.

Estimated Detection Limit (EDL)

The EDL for program 93 is 0.01 mg/L S^{2-}. For more information on derivation and use of Hach's estimated detection limit, see *Section 1*.

Interferences

Interfering Substance	Interference Levels and Treatments
Strong reducing substances (sulfite, thiosulfate and hydrosulfite)	Interfere by reducing the blue color or preventing its development.
Sulfide, high levels	High concentrations of sulfide may inhibit full color development and require sample dilution. Some sulfide loss may occur when the sample is diluted.
Turbidity	For turbid samples, prepare a sulfide-free blank as follows. Use it in place of the deionized water blank in the procedure. **1.** Measure 25 mL of sample into a 50-mL erlenmeyer flask. **2.** Add Bromine Water dropwise with constant swirling until a permanent yellow color just appears. **3.** Add Phenol Solution dropwise until the yellow color just disappears. Use this solution in Step 4 in place of deionized water.

Soluble Sulfides

Determine soluble sulfides by centrifuging the sample in completely filled, capped tubes and analyzing the supernatant. Insoluble sulfides are then estimated by subtracting the soluble sulfide concentration from the total sulfide result.

Summary of Method

Hydrogen sulfide and acid-soluble metal sulfides react with N, N-dimethyl-p-phenylenediamine oxalate to form methylene blue. The intensity of the blue color is proportional to the sulfide concentration. High sulfide levels in oil field waters may be determined after dilution.

Pollution Prevention and Waste Management

Sulfide 2 Reagent contains potassium dichromate. The final solution will contain hexavalent chromium (D007) at a concentration regulated as a hazardous waste by Federal RCRA. See *Section 3* for more information on proper disposal of these materials.

SULFIDE, continued

REQUIRED REAGENTS

	Cat. No.
Sulfide Reagent Set (100 tests)	22445-00
Includes: (2) 1816-42, (2) 1817-42	

Description	Quantity Required Per Test	Units	Cat. No.
Sulfide 1 Reagent	2 mL	100 mL MDB	1816-32
Sulfide 2 Reagent	2 mL	100 mL MDB	1817-32
Water, deionized	25 mL	4 L	272-56

REQUIRED APPARATUS

Cylinder, graduated, 25 mL	1	each	508-40
Pipet, volumetric, Class A, 25.00 mL	1	each	14515-40
Pipet Filler, safety bulb	1	each	14651-00
Sample Cell, 10-20-25 mL, w/ cap	2	6/pkg	24019-06

OPTIONAL REAGENTS

Description	Units	Cat. No.
Bromine Water, 30 g/L	29 mL	2211-20
Phenol Solution, 30 g/L	29 mL	2112-20
Sodium Sulfide, hydrate	114 g	785-14

OPTIONAL APPARATUS

Bottle, Wash, 250 mL	each	620-31
Dropper, for 1 oz. bottle	each	2258-00
Flask, erlenmeyer, 50 mL	each	505-41
Standard Methods for the Examination of Water and Wastewater	each	22708-00

For Technical Assistance, Price and Ordering

In the U.S.A.—Call 800-227-4224

Outside the U.S.A.—Contact the Hach office or distributor serving you.

HOW TO ORDER

By Phone:
6:30 a.m. to 5:00 p.m. MST
Monday through Friday
800-227-HACH (800-227-4224)

By Mail:
Hach Company
P. O. Box 389
Loveland, Colorado 80539-0389 U.S.A.

By Telex:
160840 (Hach Loveland)

By FAX:
970-669-2932 (Hach Loveland)

Information Required:

- Hach account number (if available)
- Billing address
- Shipping address
- Your name and phone number
- Purchase order number
- Catalog number
- Brief description or model number
- Quantity

Technical and Customer Service

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use and to take your orders. Specialists in analytical methods, they are happy to put their talents to work for you. Call **1-800-227-4224**.

International Customers

Hach maintains a network of dealers and distributors throughout the world.

In Europe, Mediterranean, Africa and the Middle East, customers can contact their local distributor or obtain help from:
Hach Europe, S.A./N.V.
Chaussée Namur, 1
B-5150 Floriffoux (Namur), Belgium
Telephone: (32) (81) 44.71.71
FAX: (32) (81) 44.13.00

In Canada
Hach Sales and Service Canada Ltd.
1313 Border Street, Unit 34
Winnipeg, Manitoba R3H 0X4
Telephone: (204) 632-5598
FAX: (204) 694-5134

In other countries, contact:
Hach Company World Headquarters
P. O. Box 389
Loveland, Colorado, U.S.A. 80539-0389
Telex: 160840
Telephone: (1) (970) 669-3050
FAX: (1) (970) 669-2932

Information presented on these pages applies only to Hach products manufactured for use within the United States. Exportation of these products renders these terms void.

Prices and Terms

Prices are subject to change without notice. All prices are FOB from the shipping point (usually Ames, Iowa). Hach offers instant credit up to $200 on Net 30 Day terms. Larger orders are subject to credit review. Customers may send remittance with orders or we can ship C.O.D. if you prefer.

Warranty

Hach warrants its products to be of high quality, to be free of material defects on the date of shipment and to be as specified. Full warranty information is on the back of Hach invoices.

ADDITIONAL INFORMATION

Limits of Usage

Our chemicals and reagents are offered for laboratory and manufacturing use ONLY. They may not be used as drugs, cosmetics or food additives.

MSDS

Hach Material Safety Data Sheets, among the most complete and informative in the industry, provide comprehensive safety data essential for day-to-day operations and safety training.

An MSDS accompanies all Hach chemical products including test kits. For an additional $15.00 per item, we will print MSDSs on your own forms.

Label Information

Labels on Hach chemicals and reagents supply the following:

- Product Name -- In French, German, Italian and Spanish as well as English is printed on all but the smallest-size labels.
- Hach Catalog Number -- Makes reordering easy and helps match the appropriate MSDS.
- Storage Information and Lot Numbers -- Lot numbers made up of letters and numbers indicate an extended shelf life; a four-digit number indicates items should be rotated and checked with a standard to confirm performance. The lot number is essential if you call for technical assistance or with questions about reagent performance.

Shipping

Our experienced warehouse staff packages your orders for safe arrival. Unless we are instructed otherwise, the best and most efficient mode of transportation is selected. Motor freight shipments will be sent freight collect unless you specify otherwise at the time you order.

If you have questions about methods for shipment and availability of special packaging, please ask when you place your order.

Claims and Returns

We take extreme care to fill, check, re-check and pack orders properly. If errors or damages should occur, please report details to our Loveland Customer Service Department and to the carrier immediately. Be sure to keep all containers and packing materials.

AUTHORIZATION MUST BE OBTAINED from Hach when returning items for any reason. Call 1-800-227-4224 toll free. **ALL "FREIGHT COLLECT" SHIPMENTS OR MERCHANDISE RETURNED WITHOUT PROPER AUTHORIZATION FROM HACH WILL BE REFUSED.**

Newsletter

News & Notes for the Analyst, Hach's informative newsletter, contains updates on federal regulations, in-depth discussions of chemical reactions, application notes and information about new products. Contact Hach for your free subscription.

OXYGEN CHEMets®
0-1 ppm (K-7501)

SAMPLING

The most critical part of any dissolved oxygen test is sampling. The sample stream must be completely leak-free. The sampling tube is vertically mounted with a tube of inert material connecting the sample point to the bottom of the sampling tube. Use a short section of surgical-grade silicone or teflon tubing. If a flowing sample is not available, the sample must be handled with as little agitation as possible. A sub-surface sampler/snapper is available to minimize sample contamination (see Reorder Information).

TEST PROCEDURE

1. To remove trapped air bubbles, the sampling tube must be purged with water that is flowing. Several purge cycles are recommended.

2. Insert a CHEMet ampoule so that the tapered tip is at the bottom of the sampling tube. Snap the ampoule tip by gently pressing the upper end of the ampoule toward the wall of the sampling tube. The ampoule will fill, leaving a bubble to facilitate mixing.

3. Quickly mix the contents by inverting the ampoule, allowing the bubble to travel from end to end. Wipe all liquid from the exterior of the ampoule. **The color comparison must be made within 30 seconds.**

4. Hold the comparator in a nearly horizontal position while standing directly beneath a bright source of light. Place the CHEMet ampoule between the color standards moving if from left to right along the comparator until the best color match is found. If the color of the CHEMet ampoule is between two color standards, a concentration estimate can be made.

TEST METHOD

The oxygen CHEMets®[1] test employs the Rhodazine D ™ Method.[2,3] Dissolved oxygen reacts with the pale yellow colored leuco form of Rhodazine D to produce a deep rose color. The resulting color is proportional to the dissolved oxygen concentration in the sample. Results are expressed in ppm (mg/Liter) O_2.

1. CHEMets is a registered trademark of CHEMetrics, Inc. U.S. Patent No. 3,634,038

2. Rhodazine D methodology was developed by and is a trademark of CHEMetrics, Inc.
3. ASTM D 5543-94, Standard Test Methods for Low Level Dissolved Oxygen in Water

SAFETY INFORMATION

Read MSDS before performing this test procedure. Wear safety glasses.

IMPORTANT NOTE

The CHEMet ampoules contain a reagent which will deteriorate upon prolonged exposure to light. They will remain stable only if stored in the dark.

Reorder Information	Cat. No.
Test Kit, complete	K-7501
Refill, 30 CHEMet ampoules	R-7501
Comparator, 0-1 ppm	C-7501
Sampling Tube, package of six	A-0020
Sub-surface Sampler/Snapper	A-0139
Mounting Clamp Adhesive, package of six	A-0022
Mounting Clamp Permanent, package of six	A-0034

Rt. 28, Calverton, VA 20138-0214 U.S.A.
Phone: (800) 356-3072; Fax: (540) 788-4856; E-Mail: prodinfo@chemetrics.com

OXYGEN CHEMets®

1-12 ppm (K-7512)

SAMPLING

The most critical part of any dissolved oxygen test is sampling. The sample stream must be completely leak-free. The sampling tube is vertically mounted with a tube of inert material connecting the sample point to the bottom of the sampling tube. Use a short section of surgical-grade silicone or teflon tubing. If a flowing sample is not available, the sample must be handled with as little agitation as possible. A sub-surface sampler/snapper is available to minimize sample contamination (see Reorder Information).

TEST PROCEDURE

1. To remove trapped air bubbles, the sampling tube must be purged with water that is flowing. Several purge cycles are recommended.

2. Insert a CHEMet ampoule so that the tapered tip is at the bottom of the sampling tube. Snap the ampoule tip by gently pressing the upper end of the ampoule toward the wall of the sampling tube. The ampoule will fill, leaving a bubble to facilitate mixing.

3. Quickly mix the contents by inverting the ampoule, allowing the bubble to travel from end to end. Wipe all liquid from the exterior of the ampoule. **Wait 2 minutes for full color development prior to color comparison.**

4. Hold the comparator in a nearly horizontal position while standing directly beneath a bright source of light. Place the CHEMet ampoule between the color standards moving if from left to right along the comparator until the best color match is found. If the color of the CHEMet ampoule is between two color standards, a concentration estimate can be made.

TEST METHOD

The oxygen CHEMets®[1] test employs the indigo carmine Method.[2] Dissolved oxygen reacts with the reduced form of indigo carmine to form a blue product. The resulting color is proportional to the dissolved oxygen concentration in the sample. Results are expressed in ppm (mg/Liter) O_2.

1. CHEMets is a registered trademark of CHEMetrics, Inc. U.S. Patent No. 3,634,038
2. ASTM D 888-87, Standard Test Methods for Dissolved Oxygen in Water

SAFETY INFORMATION

Read MSDS before performing this test procedure. Wear safety glasses.

IMPORTANT NOTE

The CHEMet ampoules contain a reagent which will deteriorate upon prolonged exposure to light. They will remain stable only if stored in the dark.

Reorder Information	Cat. No.
Test Kit, complete	K-7512
Refill, 30 CHEMet ampoules	R-7512
Comparator, 0-1 ppm	C-7512
Sampling Tube, package of six	A-0020
Sub-surface Sampler/Snapper	A-0139
Mounting Clamp Adhesive, package of six	A-0022
Mounting Clamp Permanent, package of six	A-0034

Rt. 28, Calverton, VA 20138-0214 U.S.A.
Phone: (800) 356-3072; Fax: (540) 788-4856; E-Mail: prodinfo@chemetrics.com