522580

Routine Calculations Report
In Support of Task 3 of AP-088

Calculation of Culebra Freshwater Heads in 1980, 1990, and 2000 for Use in T-Field Calibration

(AP-088: Analysis Plan for Evaluation of the Effects of Head Changes on Calibration of Culebra Transmissivity Fields)

WBS 1.3.5.3.1.2

Report Date: June 13, 2002

Author: Richard L. Beauheim, 6821 — Date: 6/13/02

Technical Review: Dennis W. Powers, Consulting Geologist — Date: 6/13/02

QA Review: Mario J. Chavez, 6820, Carlsbad Programs Group — Date: 6/18/02

WIPP ~~WBS~~: 1.3.5.3.1.2 : TD : QA : AP-088 Task 3 : 522085 DPRP1 6/20/02 6/24/02

1. Title of Calculation:
   Calculation of Culebra Freshwater Heads in 1980, 1990, and 2000 for Use in T Field Calibration

2. Planning Document:
   AP-088 Analysis Plan for Evaluation of the Effects of Head Changes on Calibration of Culebra Transmissivity Fields

3. Description of calculation process:
   A. Hydrographs (plots) of water-level data provided by Westinghouse TRU Solution (WTS) were prepared for each well. The hydrographs were examined visually to identify representative water levels in late 1980, late 1990, and late 2000. In most cases, these were the December measurements, but measurements were sometimes selected from other months if the December measurements were unavailable or appeared to reflect a disturbance of some sort. For wells near the center of the WIPP site, no measurements were selected for 1990 because water levels were affected by leakage into the WIPP shafts at that time.
   B. Uncertainty in the water-level measurements was estimated by dividing the uncertainty into two components: error in the measurement of depth to water and variation in the depth to water caused by barometric effects. The measurement error was estimated as ±0.20 m based on comparisons of measurements made by different Solinst meters (the type of instrument used by WTS) and a steel tape reported in SAND89-7056 (pages included in this records package). The barometric effects were estimated as ±0.5 psi (approximately 0.3 m in most cases), based on a typical barometric pressure range of 0.7 psi (see Figures 5-23, 5-33, and 5-41 in SAND98-0049) and typical barometric efficiencies of 0.7 (see p. 67 in SAND98-0049). The barometric effects in units of pressure (psi) were converted to water-level uncertainty in units of meters using the fluid density reported for each well. Sources of the fluid density (and corresponding uncertainty) data are given in the notes for Excel file TFieldHeads.xls.
   The equation used to calculate the total water-level uncertainty is:

   Uncertainty=(0.5 lb/in^2/(62.4 lb/ft^3*(fluid density of water in well [g/cm^3] /density of freshwater [1.00 g/cm^3])/144 in^2/ft^2))*0.3048 m/ft+0.2 m

   C. Freshwater heads were calculated by subtracting the elevation of the center of the Culebra (taken from Table TFIELD-1 in the CCA) from the measured water-level elevations, multiplying the remainder by the density of the fluid in the well, and adding the elevation of the center of the Culebra to that product. Uncertainty in the freshwater head was calculated by adding (or subtracting) the uncertainty in the water level to the water level measurement, adding (or subtracting) the uncertainty in the fluid density to the fluid density measurement, and recalculating freshwater head.

4. Identification/listing of input, input sources, and output:
   Given in Excel spreadsheet TFieldHeads.xls

5. Data qualification for compliance decision analysis:
   Data sources are either published WIPP reports or data transmittals from WTS

6. Software used:
   Excel 2000 run on a Hewlett Packard Kayak XAs PC with a 450-MHz Pentium II processor and 128 Mbytes of RAM under Windows 2000 Professional

7. Reviews:
   Technical: Dennis Powers, 6/13/02
   QA: Mario Chavez, 6820, 6/14/02

8. References

Beauheim, R.L., and G.J. Ruskauff. 1998. *Analysis of Hydraulic Tests of the Culebra and Magenta Dolomites and Dewey Lake Redbeds Conducted at the Waste Isolation Pilot Plant Site.* SAND98-0049. Albuquerque, NM: Sandia National Laboratories.

Cauffman, T.L., A.M. LaVenue, and J.P. McCord. 1990. *Ground-Water Flow Modeling of the Culebra Dolomite, Volume II: Data Base.* SAND89-7068/2. Albuquerque, NM: Sandia National Laboratories.

Crawley, M. 2002. "Results of the Pressure Density Surveys Conducted During the Calendar Years 2000 and 2001," memo to Rick Beauheim, Sandia National Laboratories, June 3, 2002. DA:02:01768, UFC:5480.00. Carlsbad, NM: Westinghouse TRU Solutions. ERMS 522425.

Environmental Science and Research Foundation. 2001. *Waste Isolation Pilot Plant CY 2000 Site Environmental Report.* DOE/WIPP 01-2225. Carlsbad, NM: U.S. DOE.

Lambert, S.J., and K.L. Robinson. 1984. *Field Geochemical Studies of Groundwaters in Nash Draw, Southeastern New Mexico.* SAND83-1122. Albuquerque, NM: Sandia National Laboratories.

Mercer, J.W. 1983. *Geohydrology of the Proposed Waste Isolation Pilot Plant Site, Los Medanos Area, Southeastern New Mexico.* Water-Resources Investigation Report 83-4016. Albuquerque, NM: U.S. Geological Survey.

Stensrud, W.A. M.A. Bame, K.D. Lantz, J.B. Palmer, and G.J. Saulnier, Jr. 1990. *WIPP Hydrology Program, Waste Isolation Pilot Plant, Southeastern New Mexico, Hydrologic Data Report #8.* SAND89-7056. Albuquerque, NM: Sandia National Laboratories.

U.S. Department of Energy. 1996. *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant, Appendix TFIELD.* DOE/CAO-1996-2184, Volume XVIII. Carlsbad, NM: U.S. DOE.

List of Attachments:

1. Printout of Excel file TFieldHeads.xls
2. Printout of formulas used in Excel file TFieldHeads.xls
3. Crawley June 2, 2002 memo to R. Beauheim on results of pressure-density surveys (ERMS 522425)
4. Table 1.4 from Stensrud et al. (1990) on comparison of water level measurements made with a steel tape and Solinst meters
5. Table TFIELD-1. Center of Culebra Elevations from DOE/CAO-1996-2184
6. Table TFIELD-3. Culebra Undisturbed Head Values and Uncertainties from DOE/CAO-1996-2184.
7. Hydrographs for all wells showing selected water levels
8. Technical Review by Dennis Powers
9. QA Review by Mario Chavez

File: TFieldHeads.xls
Calculation of Culebra Heads at Different Times
R.L. Beauheim 6/13/02

Well	Center of Culebra Elevation (m amsl)	1980 Water Level (m amsl)	Water Level Uncertainty ± (m)	1980 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)	1980 Freshwater Head (m amsl)	1980 Freshwater Head Uncertainty ± (m)	1990 Water Level (m amsl)	Water Level Uncertainty ± (m)	1990 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)
AEC-7	845.59	NA						924.89	0.52	1.090	0.01
CB-1	856.88	NA						910.98	0.54	1.031	0.01
D-268	883.32	NA						915.59	0.55	0.991	+0.01
DOE-1	802.72	NA						907.08	0.52	1.083	0.02
DOE-2	787.38	NA						931.09	0.54	1.028	0.01
ERDA-9	820.92	NA						NE	0.54	1.049	0.01
H-1	826.13	919.55	0.54	1.036	0.02	922.91	2.44	NE			
H-2b2	836.25	NA						NE			
H-3b1	825.17	913.40	0.54	1.036	0.02	916.58	2.33	NE			
H-3b2	823.37	NA						NE			
H-4b	862.48	911.46	0.54	1.024	0.02	912.64	1.55	914.10	0.54	1.021	0.01
H-5b	791.53	920.55	0.52	1.104	0.01	933.97	1.87	920.52	0.52	1.104	0.01
H-6b	832.73	929.23	0.54	1.038	0.01	932.90	1.53	928.32	0.54	1.038	0.01
H-7b1	886.37	912.22	0.55	1.005	+0.01	912.35	+0.82/-0.55	913.06	0.55	1.005	+0.01
H-8b	863.16	910.61	0.55	1.001	+0.01	910.66	+1.03/-0.55	913.78	0.55	1.001	+0.01
H-9b	836.43	908.46	0.55	1.001	+0.01	908.53	+1.28/-0.55	911.59	0.55	1.001	+0.01
H-10b	705.07	911.26	0.54	1.047	0.01	920.95	2.63	911.12	0.54	1.047	0.01
H-11b2	812.67	NA						907.26	0.53	1.076	0.01
H-11b4	815.44	NA						NA			
H-12	789.27	NA						904.48	0.52	1.098	0.01
H-14	849.47	NA						914.88	0.55	1.013	+0.01
H-15	794.98	NA						900.46	0.51	1.151	0.01
H-17	812.42	NA						899.71	0.50	1.166	0.01
H-18	826.82	NA						929.21	0.54	1.044	0.01
H-19b0	812.25	NA						NA			
P-14	846.05	926.52	0.55	1.012	0.01	927.49	1.36	926.31	0.55	1.015	0.01
P-15	879.58	915.27	0.53	1.080	0.05	918.13	2.38	917.49	0.55	1.006	+0.01
P-17	842.85	NA						909.57	0.53	1.065	0.01
WIPP-12	807.35	NA						921.86	0.52	1.096	-0.02
WIPP-13	820.79	NA						930.80	0.54	1.029	0.01

WIPP-18	810.43	NA						NE	0.52	1.100	0.01
WIPP-19	812.47	NA						NE			
WIPP-21	815.68	NA						NE			
WIPP-22	814.67	NA						NE			
WIPP-25	839.10	926.96	0.55	1.014	0.02	928.19	2.32	930.20	0.55	1.000	0.01
WIPP-26	900.45	916.06	0.55	1.013	0.02	916.26	0.88	919.73	0.55	1.002	+0.01
WIPP-27	875.43	936.65	0.52	1.094	0.02	942.40	1.81	937.35	0.54	1.029	0.01
WIPP-28	888.07	933.61	0.54	1.044	0.02	935.61	1.48	NA			
WIPP-29	899.14	904.80	0.50	1.158	+0.04/-0.01	905.69	+0.83/-0.63	904.54	0.50	1.185	+0.01/-0.04
WIPP-30	849.01	NA						933.26	0.54	1.025	0.01
WQSP-1	825.61	NA						NA			
WQSP-2	805.28	NA						NA			
WQSP-3	799.52	NA						NA			
WQSP-4	809.18	NA						NA			
WQSP-5	830.03	NA						NA			
WQSP-6	844.39	NA						NA			
USGS-1	881.66			1.000	+0.01					1.000	+0.01

Data sources:
Col. B: center of Culebra elevations--Table TFIELD-1, CCA
Col. C, I, and O: Water levels taken from hydrographs included in this records package
Col. D, J, and P: Water-level uncertainty comprises two factors--actual measurement error and barometric effects. Measurement error is estimated as +/
Barometric effects are estimated as +/- 0.5 psi (approx. 0.3 m), based on barometric pressure range of 0.7 psi (12.6 to 13.3 psi--Figures 5-23, 5-33, and 5
Col. E and F: 1980 fluid density and uncertainty--SAND89-7068/2, Appendix F (Cauffman et al., 1990) except as noted below
Col. E and F: 1980 fluid density and uncertainty for WIPP-25, 26, 27, and 28--USGS WRI Report 83-4016, Table 2 (Mercer, 1983) and SAND83-1122 (La
Col. G, M, and S: Freshwater Heads calculated as shown in this worksheet
Col. H, N, and T: Freshwater Head Uncertainty calculated as shown in this worksheet, except where density uncertainty is asymmetrical--those head unce
Col. K and L: 1990 fluid density and uncertainty--SAND89-7068/2, Appendix F (Cauffman et al., 1990), except as noted below.
Col. M and N: 1990 fluid density and uncertainty for WIPP-25--raised density to 1.000 from 0.990 given in SAND89-7068/2, Appendix F (Cauffman et al.,
Col. Q: 2000 fluid density--M. Crawley, June 3, 2002 memo on WTS pressure-density survey results for 2000 and 2001 (ERMS 522245) except as noted
Col. Q: 2000 fluid density--used 1990 values when no other data available (these values shown in bold red)
Col. Q and R: 2000 fluid density and uncertainty for WQSP wells--DOE/WIPP 01-2225, Tables 6.2-6.7 (Environmental Science and Research Foundation
Col. U and V: CCA heads and uncertainties--Table TFIELD-3, CCA
NA: not available
NE: not equilibrated
NU: not used

1990 Freshwater Head (m amsl)	1990 Freshwater Head Uncertainty ± (m)	2000 Water Level (m amsl)	Water Level Uncertainty ± (m)	2000 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)	2000 Freshwater Head (m amsl)	2000 Freshwater Head Uncertainty ± (m)	CCA Freshwater Head (m amsl)	CCA Freshwater Head Uncertainty ± (m)
932.03	1.37	926.05	0.52	1.0888	0.01	933.19	1.38	932.0	0.8
912.66	1.10	NE						911.1	0.7
915.30	+0.88/-0.55	NA						915.2	+0.4/-0.1
915.74	2.67	906.54	0.52	1.0964	0.01	916.55	1.61	914.3	+4.3/-2.2
935.11	2.00	932.02	0.53	1.0554	0.01	940.03	2.01	934.7	1.5
		916.89	0.54	**1.049**	0.01	921.59	1.53	NU	
		925.24	0.54	1.0197	0.01	927.19	1.55	921.6	2
		925.56	0.55	1.0119	0.005	926.62	1.00	924.8	+1.8/-0.1
		NA						914.8	1.9
		913.83	0.54	1.0368	0.01	917.16	1.47	914.8	1.9
915.18	1.08	914.57	0.55	1.0189	0.01	915.55	1.08	911.4	0.6
933.93	1.87	923.03	0.52	1.1006	0.01	936.26	1.89	934.2	1.4
931.95	1.52	930.16	0.54	1.0415	0.01	934.20	1.54	932.0	1
913.19	+0.83/-0.55	913.72	0.55	**1.005**	+0.01	913.86	+0.83/-0.55	912.7	+0.5/-0.1
913.83	+1.06/-0.55	NA						NU	
911.67	+1.31/-0.55	911.41	0.55	1.0022	0.005	911.57	0.93	906.4	+1.2/-0.1
920.80	2.63	NA						921.3	2.2
914.45	1.52	908.33						912.4	+3.0/-1.0
		909.40	0.53	1.0646	0.01	915.47	1.51	912.4	+3.0/-1.0
915.77	1.73	905.02	0.52	1.0833	0.015	914.66	2.31	913.5	1.2
915.73	+1.21/-0.56	917.38	0.54	1.0421	0.01	920.24	1.24	916.9	+3.9/-0.1
916.39	1.64	902.83	0.50	1.1580	0.01	919.87	1.67	916.1	+4.2/-0.1
914.20	1.46	902.46	0.51	1.1434	0.005	915.37	1.03	911.0	0.9
933.72	1.59	932.57	0.54	**1.044**	0.01	937.22	1.62	932.4	+2.5/-1.1
		911.05	0.53	1.0615	0.005	917.13	1.06	NU	
927.51	1.36	NA						926.9	0.9
917.72	+0.94/-0.55	NA	0.55	1.0133				917.8	0.8
913.91	1.24	909.15	0.52	1.0912	0.01	915.20	1.24	909.3	0.7
932.85	+0.57/-2.85	924.09	0.52	**1.096**	-0.02	935.30	+0.57/-2.90	933.6	+2.2/-0.1
933.99	1.66	931.95	0.54	**1.029**	0.01	935.17	1.67	933.7	+1.5/-1.3

		924.66	0.52	**1.100**	0.01	936.08	1.72	930.5	+3.0/-1.2
		926.33	0.53	1.0556	0.01	932.66	1.71	NU	
		919.15	0.53	1.0759	0.01	927.00	1.61	NU	
		923.36	0.53	1.0699	0.01	930.96	1.66	NU	
930.20	1.47	932.70	0.55	**1.000**	0.01	932.70	1.49	928.7	1.0
919.77	+0.75/-0.55	921.02	0.55	**1.002**	+0.01	921.06	+0.76/-0.55	918.5	+0.4/-0.1
939.15	1.18	939.16	0.54	**1.029**	0.01	941.01	1.20	938.1	0.7
		NA						937.5	+0.9/-1.2
905.54	+0.65/-0.78	904.39	0.50	**1.185**	+0.01/-0.04	905.36	+0.65/-0.78	NU	
935.37	1.40	934.74	0.54	**1.025**	0.01	936.88	1.42	934.1	+0.9/-1.3
		930.65	0.54	1.0475	0.0025	935.64	0.83	NU	
		932.76	0.54	1.0475	0.0025	938.82	0.88	NU	
		918.31	0.51	1.148	0.003	935.89	0.94	NU	
		910.28	0.53	1.0713	0.0013	917.49	0.70	NU	
		915.00	0.54	1.0261	0.0039	917.22	0.89	NU	
		919.14	0.55	1.0118	0.0018	920.02	0.69	NU	
				1.000	+0.01			909.8	+0.4/-0.1

0.2 m based on Table 1.4 in Appendix F of HDR#8 (SAND89-7056)
41 in SAND98-0049) and typical barometric efficiency of 0.7 (e.g., SAND98-0049, p. 67)

mbert and Robinson, 1984)

ertainties calculated by hand and entered

990) to agree better with measurements made on water as opposed to pressure-density surveys.
below

2001)

File: TField
Calculation
R.L. Beauh

Well	Center of Culebra Elevation (m amsl)	1980 Water Level (m amsl)	Water Level Uncertainty ± (m)	1980 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)	1980 Freshwater Head (m amsl)
AEC-7	845.59	NA				
CB-1	856.88	NA				
D-268	883.32	NA				
DOE-1	802.72	NA				
DOE-2	787.38	NA				
ERDA-9	820.92	NA				
H-1	826.13	919.55	=(0.5/((62.4*E12)/144))*0.3048+0.2	1.036	0.02	=(C12-$B12)*E12+$B12
H-2b2	836.25	NA				
H-3b1	825.17	913.4	=(0.5/((62.4*E14)/144))*0.3048+0.2	1.036	0.02	=(C14-$B14)*E14+$B14
H-3b2	823.37	NA				
H-4b	862.48	911.46	=(0.5/((62.4*E16)/144))*0.3048+0.2	1.024	0.02	=(C16-$B16)*E16+$B16
H-5b	791.53	920.55	=(0.5/((62.4*E17)/144))*0.3048+0.2	1.104	0.01	=(C17-$B17)*E17+$B17
H-6b	832.73	929.23	=(0.5/((62.4*E18)/144))*0.3048+0.2	1.038	0.01	=(C18-$B18)*E18+$B18
H-7b1	886.37	912.22	=(0.5/((62.4*E19)/144))*0.3048+0.2	1.005	+0.01	=(C19-$B19)*E19+$B19
H-8b	863.16	910.61	=(0.5/((62.4*E20)/144))*0.3048+0.2	1.001	+0.01	=(C20-$B20)*E20+$B20
H-9b	836.43	908.46	=(0.5/((62.4*E21)/144))*0.3048+0.2	1.001	+0.01	=(C21-$B21)*E21+$B21
H-10b	705.07	911.26	=(0.5/((62.4*E22)/144))*0.3048+0.2	1.047	0.01	=(C22-$B22)*E22+$B22
H-11b2	812.67	NA				
H-11b4	815.44	NA				
H-12	789.27	NA				
H-14	849.47	NA				
H-15	794.98	NA				
H-17	812.42	NA				
H-18	826.82	NA				
H-19b0	812.25	NA				
P-14	846.05	926.52	=(0.5/((62.4*E31)/144))*0.3048+0.2	1.012	0.01	=(C31-$B31)*E31+$B31
P-15	879.58	915.27	=(0.5/((62.4*E32)/144))*0.3048+0.2	1.08	0.05	=(C32-$B32)*E32+$B32
P-17	842.85	NA				
WIPP-12	807.35	NA				
WIPP-13	820.79	NA				

WIPP-18	810.43	NA				
WIPP-19	812.47	NA				
WIPP-21	815.68	NA				
WIPP-22	814.67	NA				
WIPP-25	839.1	926.96	=(0.5/((62.4*E40)/144))*0.3048+0.2	1.014	0.02	=(C40-$B40)*E40+$B40
WIPP-26	900.45	916.06	=(0.5/((62.4*E41)/144))*0.3048+0.2	1.013	0.02	=(C41-$B41)*E41+$B41
WIPP-27	875.43	936.65	=(0.5/((62.4*E42)/144))*0.3048+0.2	1.094	0.02	=(C42-$B42)*E42+$B42
WIPP-28	888.07	933.61	=(0.5/((62.4*E43)/144))*0.3048+0.2	1.044	0.02	=(C43-$B43)*E43+$B43
WIPP-29	899.14	904.8	=(0.5/((62.4*E44)/144))*0.3048+0.2	1.158	+0.04/-0.01	=(C44-$B44)*E44+$B44
WIPP-30	849.01	NA				
WQSP-1	825.61	NA				
WQSP-2	805.28	NA				
WQSP-3	799.52	NA				
WQSP-4	809.18	NA				
WQSP-5	830.03	NA				
WQSP-6	844.39	NA				
USGS-1	881.66			1	+0.01	

Data sourc
Col. B: cen
Col. C, I, ai
Col. D, J, a
Barometric
Col. E and
Col. E and
Col. G, M,
Col. H, N, a
Col. K and
Col. M and
Col. Q: 20
Col. Q: 20
Col. Q and
Col. U and
NA: not av
NE: not ec
NU: not us

1980 Freshwater Head Uncertainty ± (m)	1990 Water Level (m amsl)	Water Level Uncertainty ± (m)	1990 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)	1990 Freshwater Head (m amsl)
	924.89	=(0.5/((62.4*K6)/144))*0.3048+0.2	1.09	0.01	=(I6-$B6)*K6+$B6
	910.98	=(0.5/((62.4*K7)/144))*0.3048+0.2	1.031	0.01	=(I7-$B7)*K7+$B7
	915.59	=(0.5/((62.4*K8)/144))*0.3048+0.2	0.991	+0.01	=(I8-$B8)*K8+$B8
	907.08	=(0.5/((62.4*K9)/144))*0.3048+0.2	1.083	0.02	=(I9-$B9)*K9+$B9
	931.09	=(0.5/((62.4*K10)/144))*0.3048+0.2	1.028	0.01	=(I10-$B10)*K10+$B10
	NE	=(0.5/((62.4*K11)/144))*0.3048+0.2	1.049	0.01	
=((((C12+D12)-$B12)*(E12+F12))+$B12)-G12	NE				
	NE				
=((((C14+D14)-$B14)*(E14+F14))+$B14)-G14	NE				
	NE				
=((((C16+D16)-$B16)*(E16+F16))+$B16)-G16	914.1	=(0.5/((62.4*K16)/144))*0.3048+0.2	1.021	0.01	=(I16-$B16)*K16+$B16
=((((C17+D17)-$B17)*(E17+F17))+$B17)-G17	920.52	=(0.5/((62.4*K17)/144))*0.3048+0.2	1.104	0.01	=(I17-$B17)*K17+$B17
=((((C18+D18)-$B18)*(E18+F18))+$B18)-G18	928.32	=(0.5/((62.4*K18)/144))*0.3048+0.2	1.038	0.01	=(I18-$B18)*K18+$B18
+0.82/-0.55	913.06	=(0.5/((62.4*K19)/144))*0.3048+0.2	1.005	+0.01	=(I19-$B19)*K19+$B19
+1.03/-0.55	913.78	=(0.5/((62.4*K20)/144))*0.3048+0.2	1.001	+0.01	=(I20-$B20)*K20+$B20
+1.28/-0.55	911.59	=(0.5/((62.4*K21)/144))*0.3048+0.2	1.001	+0.01	=(I21-$B21)*K21+$B21
=((((C22+D22)-$B22)*(E22+F22))+$B22)-G22	911.12	=(0.5/((62.4*K22)/144))*0.3048+0.2	1.047	0.01	=(I22-$B22)*K22+$B22
	907.26	=(0.5/((62.4*K23)/144))*0.3048+0.2	1.076	0.01	=(I23-$B23)*K23+$B23
	NA				
	904.48	=(0.5/((62.4*K25)/144))*0.3048+0.2	1.098	0.01	=(I25-$B25)*K25+$B25
	914.88	=(0.5/((62.4*K26)/144))*0.3048+0.2	1.013	+0.01	=(I26-$B26)*K26+$B26
	900.46	=(0.5/((62.4*K27)/144))*0.3048+0.2	1.151	0.01	=(I27-$B27)*K27+$B27
	899.71	=(0.5/((62.4*K28)/144))*0.3048+0.2	1.166	0.01	=(I28-$B28)*K28+$B28
	929.21	=(0.5/((62.4*K29)/144))*0.3048+0.2	1.044	0.01	=(I29-$B29)*K29+$B29
	NA				
=((((C31+D31)-$B31)*(E31+F31))+$B31)-G31	926.31	=(0.5/((62.4*K31)/144))*0.3048+0.2	1.015	0.01	=(I31-$B31)*K31+$B31
=((((C32+D32)-$B32)*(E32+F32))+$B32)-G32	917.49	=(0.5/((62.4*K32)/144))*0.3048+0.2	1.006	+0.01	=(I32-$B32)*K32+$B32
	909.57	=(0.5/((62.4*K33)/144))*0.3048+0.2	1.065	0.01	=(I33-$B33)*K33+$B33
	921.86	=(0.5/((62.4*K34)/144))*0.3048+0.2	1.096	-0.02	=(I34-$B34)*K34+$B34
	930.8	=(0.5/((62.4*K35)/144))*0.3048+0.2	1.029	0.01	=(I35-$B35)*K35+$B35

	NE	=(0.5/((62.4*K36)/144))*0.3048+0.2	1.1	0.01	
	NE				
	NE				
	NE				
=((((C40+D40)-$B40)*(E40+F40))+$B40)-G40	930.2	=(0.5/((62.4*K40)/144))*0.3048+0.2	1	0.01	=(I40-$B40)*K40+$B40
=((((C41+D41)-$B41)*(E41+F41))+$B41)-G41	919.73	=(0.5/((62.4*K41)/144))*0.3048+0.2	1.002	+0.01	=(I41-$B41)*K41+$B41
=((((C42+D42)-$B42)*(E42+F42))+$B42)-G42	937.35	=(0.5/((62.4*K42)/144))*0.3048+0.2	1.029	0.01	=(I42-$B42)*K42+$B42
=((((C43+D43)-$B43)*(E43+F43))+$B43)-G43	NA				
+0.83/-0.63	904.54	=(0.5/((62.4*K44)/144))*0.3048+0.2	1.185	+0.01/-0.04	=(I44-$B44)*K44+$B44
	933.26	=(0.5/((62.4*K45)/144))*0.3048+0.2	1.025	0.01	=(I45-$B45)*K45+$B45
	NA				
	NA				
	NA				
	NA				
	NA				
	NA				
			1	+0.01	

1990 Freshwater Head Uncertainty ± (m)	2000 Water Level (m amsl)	Water Level Uncertainty ± (m)	2000 Fluid Density (g/cm³)	Fluid Density Uncertainty ± (g/cm³)	2000 Freshwater Head (m amsl)
=((((I6+J6)-$B6)*(K6+L6))+$B6)-M6	926.05	=(0.5/((62.4*Q6)/144))*0.3048+0.2	1.0888	0.01	=(O6-$B6)*Q6+$B6
=((((I7+J7)-$B7)*(K7+L7))+$B7)-M7	NE				
+0.88/-0.55	NA				
=((((I9+J9)-$B9)*(K9+L9))+$B9)-M9	906.54	=(0.5/((62.4*Q9)/144))*0.3048+0.2	1.0964	0.01	=(O9-$B9)*Q9+$B9
=((((I10+J10)-$B10)*(K10+L10))+$B10)-M10	932.02	=(0.5/((62.4*Q10)/144))*0.3048+0.2	1.0554	0.01	=(O10-$B10)*Q10+$B10
	916.89	=(0.5/((62.4*Q11)/144))*0.3048+0.2	**1.049**	0.01	=(O11-$B11)*Q11+$B11
	925.24	=(0.5/((62.4*Q12)/144))*0.3048+0.2	1.0197	0.01	=(O12-$B12)*Q12+$B12
	925.56	=(0.5/((62.4*Q13)/144))*0.3048+0.2	1.0119	0.005	=(O13-$B13)*Q13+$B13
	NA				
	913.83	=(0.5/((62.4*Q15)/144))*0.3048+0.2	1.0368	0.01	=(O15-$B15)*Q15+$B15
=((((I16+J16)-$B16)*(K16+L16))+$B16)-M16	914.57	=(0.5/((62.4*Q16)/144))*0.3048+0.2	1.0189	0.01	=(O16-$B16)*Q16+$B16
=((((I17+J17)-$B17)*(K17+L17))+$B17)-M17	923.03	=(0.5/((62.4*Q17)/144))*0.3048+0.2	1.1006	0.01	=(O17-$B17)*Q17+$B17
=((((I18+J18)-$B18)*(K18+L18))+$B18)-M18	930.16	=(0.5/((62.4*Q18)/144))*0.3048+0.2	1.0415	0.01	=(O18-$B18)*Q18+$B18
+0.83/-0.55	913.72	=(0.5/((62.4*Q19)/144))*0.3048+0.2	**1.005**	+0.01	=(O19-$B19)*Q19+$B19
+1.06/-0.55	NA				
+1.31/-0.55	911.41	=(0.5/((62.4*Q21)/144))*0.3048+0.2	1.0022	0.005	=(O21-$B21)*Q21+$B21
=((((I22+J22)-$B22)*(K22+L22))+$B22)-M22	NA				
=((((I23+J23)-$B23)*(K23+L23))+$B23)-M23	908.33				
	909.4	=(0.5/((62.4*Q24)/144))*0.3048+0.2	1.0646	0.01	=(O24-$B24)*Q24+$B24
=((((I25+J25)-$B25)*(K25+L25))+$B25)-M25	905.02	=(0.5/((62.4*Q25)/144))*0.3048+0.2	1.0833	0.015	=(O25-$B25)*Q25+$B25
+1.21/-0.56	917.38	=(0.5/((62.4*Q26)/144))*0.3048+0.2	1.0421	0.01	=(O26-$B26)*Q26+$B26
=((((I27+J27)-$B27)*(K27+L27))+$B27)-M27	902.83	=(0.5/((62.4*Q27)/144))*0.3048+0.2	1.158	0.01	=(O27-$B27)*Q27+$B27
=((((I28+J28)-$B28)*(K28+L28))+$B28)-M28	902.46	=(0.5/((62.4*Q28)/144))*0.3048+0.2	1.1434	0.005	=(O28-$B28)*Q28+$B28
=((((I29+J29)-$B29)*(K29+L29))+$B29)-M29	932.57	=(0.5/((62.4*Q29)/144))*0.3048+0.2	**1.044**	0.01	=(O29-$B29)*Q29+$B29
	911.05	=(0.5/((62.4*Q30)/144))*0.3048+0.2	1.0615	0.005	=(O30-$B30)*Q30+$B30
=((((I31+J31)-$B31)*(K31+L31))+$B31)-M31	NA				
+0.94/-0.55	NA	=(0.5/((62.4*Q32)/144))*0.3048+0.2	1.0133		
=((((I33+J33)-$B33)*(K33+L33))+$B33)-M33	909.15	=(0.5/((62.4*Q33)/144))*0.3048+0.2	1.0912	0.01	=(O33-$B33)*Q33+$B33
+0.57/-2.85	924.09	=(0.5/((62.4*Q34)/144))*0.3048+0.2	**1.096**	-0.02	=(O34-$B34)*Q34+$B34
=((((I35+J35)-$B35)*(K35+L35))+$B35)-M35	931.95	=(0.5/((62.4*Q35)/144))*0.3048+0.2	**1.029**	0.01	=(O35-$B35)*Q35+$B35

	924.66	=(0.5/((62.4*Q36)/144))*0.3048+0.2	**1.1**	0.01	=(O36-$B36)*Q36+$B36
	926.33	=(0.5/((62.4*Q37)/144))*0.3048+0.2	1.0556	0.01	=(O37-$B37)*Q37+$B37
	919.15	=(0.5/((62.4*Q38)/144))*0.3048+0.2	1.0759	0.01	=(O38-$B38)*Q38+$B38
	923.36	=(0.5/((62.4*Q39)/144))*0.3048+0.2	1.0699	0.01	=(O39-$B39)*Q39+$B39
=((((I40+J40)-$B40)*(K40+L40))+$B40)-M40	932.7	=(0.5/((62.4*Q40)/144))*0.3048+0.2	**1**	0.01	=(O40-$B40)*Q40+$B40
+0.75/-0.55	921.02	=(0.5/((62.4*Q41)/144))*0.3048+0.2	**1.002**	+0.01	=(O41-$B41)*Q41+$B41
=((((I42+J42)-$B42)*(K42+L42))+$B42)-M42	939.16	=(0.5/((62.4*Q42)/144))*0.3048+0.2	**1.029**	0.01	=(O42-$B42)*Q42+$B42
	NA				
+0.65/-0.78	904.39	=(0.5/((62.4*Q44)/144))*0.3048+0.2	**1.185**	+0.01/-0.04	=(O44-$B44)*Q44+$B44
=((((I45+J45)-$B45)*(K45+L45))+$B45)-M45	934.74	=(0.5/((62.4*Q45)/144))*0.3048+0.2	**1.025**	0.01	=(O45-$B45)*Q45+$B45
	930.65	=(0.5/((62.4*Q46)/144))*0.3048+0.2	1.0475	0.0025	=(O46-$B46)*Q46+$B46
	932.76	=(0.5/((62.4*Q47)/144))*0.3048+0.2	1.0475	0.0025	=(O47-$B47)*Q47+$B47
	918.31	=(0.5/((62.4*Q48)/144))*0.3048+0.2	1.148	0.003	=(O48-$B48)*Q48+$B48
	910.28	=(0.5/((62.4*Q49)/144))*0.3048+0.2	1.0713	0.0013	=(O49-$B49)*Q49+$B49
	915	=(0.5/((62.4*Q50)/144))*0.3048+0.2	1.0261	0.0039	=(O50-$B50)*Q50+$B50
	919.14	=(0.5/((62.4*Q51)/144))*0.3048+0.2	1.0118	0.0018	=(O51-$B51)*Q51+$B51
			1	+0.01	

2000 Freshwater Head Uncertainty ± (m)	CCA Freshwater Head (m amsl)	CCA Freshwater Head Uncertainty ± (m)
=((((O6+P6)-$B6)*(Q6+R6))+$B6)-S6	932	0.8
	911.1	0.7
	915.2	+0.4/-0.1
=((((O9+P9)-$B9)*(Q9+R9))+$B9)-S9	914.3	+4.3/-2.2
=((((O10+P10)-$B10)*(Q10+R10))+$B10)-S10	934.7	1.5
=((((O11+P11)-$B11)*(Q11+R11))+$B11)-S11	NU	
=((((O12+P12)-$B12)*(Q12+R12))+$B12)-S12	921.6	2
=((((O13+P13)-$B13)*(Q13+R13))+$B13)-S13	924.8	+1.8/-0.1
	914.8	1.9
=((((O15+P15)-$B15)*(Q15+R15))+$B15)-S15	914.8	1.9
=((((O16+P16)-$B16)*(Q16+R16))+$B16)-S16	911.4	0.6
=((((O17+P17)-$B17)*(Q17+R17))+$B17)-S17	934.2	1.4
=((((O18+P18)-$B18)*(Q18+R18))+$B18)-S18	932	1
+0.83/-0.55	912.7	+0.5/-0.1
	NU	
=((((O21+P21)-$B21)*(Q21+R21))+$B21)-S21	906.4	+1.2/-0.1
	921.3	2.2
	912.4	+3.0/-1.0
=((((O24+P24)-$B24)*(Q24+R24))+$B24)-S24	912.4	+3.0/-1.0
=((((O25+P25)-$B25)*(Q25+R25))+$B25)-S25	913.5	1.2
=((((O26+P26)-$B26)*(Q26+R26))+$B26)-S26	916.9	+3.9/-0.1
=((((O27+P27)-$B27)*(Q27+R27))+$B27)-S27	916.1	+4.2/-0.1
=((((O28+P28)-$B28)*(Q28+R28))+$B28)-S28	911	0.9
=((((O29+P29)-$B29)*(Q29+R29))+$B29)-S29	932.4	+2.5/-1.1
=((((O30+P30)-$B30)*(Q30+R30))+$B30)-S30	NU	
	926.9	0.9
	917.8	0.8
=((((O33+P33)-$B33)*(Q33+R33))+$B33)-S33	909.3	0.7
+0.57/-2.90	933.6	+2.2/-0.1
=((((O35+P35)-$B35)*(Q35+R35))+$B35)-S35	933.7	+1.5/-1.3

=((((O36+P36)-$B36)*(Q36+R36))+$B36)-S36	930.5		+3.0/-1.2
=((((O37+P37)-$B37)*(Q37+R37))+$B37)-S37	NU		
=((((O38+P38)-$B38)*(Q38+R38))+$B38)-S38	NU		
=((((O39+P39)-$B39)*(Q39+R39))+$B39)-S39	NU		
=((((O40+P40)-$B40)*(Q40+R40))+$B40)-S40	928.7	1	
+0.76/-0.55	918.5		+0.4/-0.1
=((((O42+P42)-$B42)*(Q42+R42))+$B42)-S42	938.1	0.7	
	937.5		+0.9/-1.2
+0.65/-0.78	NU		
=((((O45+P45)-$B45)*(Q45+R45))+$B45)-S45	934.1		+0.9/-1.3
=((((O46+P46)-$B46)*(Q46+R46))+$B46)-S46	NU		
=((((O47+P47)-$B47)*(Q47+R47))+$B47)-S47	NU		
=((((O48+P48)-$B48)*(Q48+R48))+$B48)-S48	NU		
=((((O49+P49)-$B49)*(Q49+R49))+$B49)-S49	NU		
=((((O50+P50)-$B50)*(Q50+R50))+$B50)-S50	NU		
=((((O51+P51)-$B51)*(Q51+R51))+$B51)-S51	NU		
	909.8		+0.4/-0.1

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June 3, 2002

Mr. Rick Beauheim
Sandia National Laboratories
4100 National Parks Highway
Carlsbad, NM 88220

Subject: RESULTS OF THE PRESSURE DENSITY SURVEYS CONDUCTED DURING THE CALENDAR YEARS 2000 AND 2001

Dear Mr. Beauheim:

This letter presents the results of pressure-density surveys conducted at several wells in the Waste Isolation Pilot Plant (WIPP) groundwater surveillance-network. As you know, WIPP conducts these surveys in wells to define the average density of fluids standing in the well bores of surveillance wells. The resulting data are used by WTS and SNL to calculate equivalent freshwater heads at well sites. The data presented are from the calendar years 2000 and 2001. The program was able to conduct surveys during the year 2000 for a large number of area wells. The year 2001 program was abbreviated due to equipment failure. We hope these data will be useful to your efforts related to WIPP area hydrologic studies.

YEAR 2000 SURVEYS

- H-02b2, first test — average density is 1.0117
- H-02b2, second test — average density is 1.0120
- H-15 — average density is 1.1580
- DOE-1 — average density is 1.0998
- H-12 — average density is 1.0833
- H-01, PIP — average density is 1.0197
- WIPP-19 — average density is 1.0556
- WIPP-22 — average density is 1.0699
- WIPP-21 — average density is 1.0759
- DOE-2 — average density is 1.0554
- P-17 — average density is 1.0912

▪ P-15	average density is 1.0133
▪ H-14	average density is 1.0421
▪ H-05b	average density is 1.103
▪ H-03b2	average density is 1.0401
▪ H-19b7	average density is 1.0612
▪ H-19b0	average density is 1.0610
▪ H-19b5	average density is 1.070
▪ H-19b4	average density is 1.0661
▪ H-09b	average density is 1.0043
▪ AEC-7, PIP	average density is 1.0888
▪ H-11b4	average density is 1.0682
▪ H-17	average density is 1.1468
▪ H-06b	average density is 1.0459
▪ H-04b	average density is 1.0223

YEAR 2001 SURVEYS

▪ H-06b	average density is 1.0371
▪ DOE-1	average density is 1.0930
▪ H-11b2 Magenta	average density is 1.0703
▪ H-03b2	average density is 1.0334
▪ H-04b	average density is 1.0154
▪ H-19b0	average density is 1.0620
▪ H-11b4	average density is 1.0610
▪ H-17	average density is 1.1400
▪ H-09b	average density is 1.0000
▪ H-14 Magenta	average density is 1.0294
▪ H-15 Magenta	average density is 1.0760

- H-18 Magenta average density is 1.0054
- DOE-2 Magenta average density is 1.0553
- WIPP-18 Magenta average density is 1.0423
- H-06c average density is 1.0030
- H-05b average density is 1.0981
- H-05c average density is 1.0045
- H-03b1 average density is 1.0051

If you have any questions concerning this subject, please contact me at 234-8653.

Sincerely,

Original signed by M. Crawley

M. Crawley
Environmental Monitoring

mw

cc: S. B. Jones, WTS
R. Patterson, CBFO
T. Pfeifle, SNL
R. G. Richardson, WTS
R. Salness, Portage

HDR#8 SAND89-7056

TABLE 1.4
COMPARISON OF WATER-LEVEL MEASUREMENTS MADE WITH A 1000-FOOT STEEL TAPE TO MEASUREMENTS MADE WITH APPLICABLE SOLINST METERS

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)	
Measurements made on 18 January 1989				
steel tape #1	018:09:15	H-4c	58.83	
Solinst #1	018:09:18	H-4c	58.89	
Solinst #2	018:09:21	H-4c	58.91	
Solinst #3	018:09:24	H-4c	58.87	total
Solinst #4	018:09:27	H-4c	58.92	range = 0.09 m
Solinst #5	018:09:30	H-4c	58.91	
Solinst #7	018:09:33	H-4c	58.88	
Solinst #8	018:09:36	H-4c	58.89	Solinst range = 0.05 m
Solinst #9	018:09:39	H-4c	58.88	
Solinst #11	018:09:42	H-4c	58.89	
steel tape #1	018:09:45	H-4c	58.83	
steel tape #1	018:09:50	H-4b	102.69	
Solinst #1	018:09:54	H-4b	102.78	
Solinst #2	018:09:58	H-4b	102.79	
Solinst #3	018:10:02	H-4b	102.74	total
Solinst #4	018:10:06	H-4b	102.83	range = 0.15 m
Solinst #5	018:10:10	H-4b	102.82	
Solinst #7	018:10:14	H-4b	102.76	
Solinst #8	018:10:18	H-4b	102.78	Solinst range = 0.09 m
Solinst #9	018:10:22	H-4b	102.77	
Solinst #11	018:10:26	H-4b	102.75	
steel tape #1	018:10:30	H-4b	102.68	
steel tape #1	018:11:00	WIPP-19	133.72	
Solinst #1	018:11:05	WIPP-19	133.84	
Solinst #2	018:11:10	WIPP-19	133.86	
Solinst #3	018:11:15	WIPP-19	133.81	total
Solinst #4	018:11:20	WIPP-19	133.89	range = 0.20 m
Solinst #5	018:11:25	WIPP-19	133.92	
Solinst #7	018:11:30	WIPP-19	133.84	
Solinst #8	018:11:35	WIPP-19	133.86	Solinst range = 0.12 m
Solinst #9	018:11:40	WIPP-19	133.84	
Solinst #11	018:11:45	WIPP-19	133.80	
steel tape #1	018:11:50	WIPP-19	133.72	
Measurements made on 17 March 1989				
steel tape #1	077:09:50	H-4c	58.73	
Solinst #1	077:09:55	H-4c	58.77	
Solinst #2	077:09:57	H-4c	58.78	
Solinst #3	077:09:59	H-4c	58.76	total
Solinst #4	077:10:01	H-4c	58.81	range = 0.08 m
Solinst #5	077:10:03	H-4c	58.80	
Solinst #7	077:10:05	H-4c	58.77	
Solinst #8	077:10:07	H-4c	58.77	
Solinst #9	077:10:09	H-4c	58.77	Solinst range = 0.05 m
Solinst #11	077:10:15	H-4c	58.74	

TABLE 1.4 (continued)
COMPARISON OF WATER-LEVEL MEASUREMENTS MADE WITH A 1000-FOOT STEEL TAPE TO MEASUREMENTS MADE WITH APPLICABLE SOLINST METERS

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)
steel tape #1	077:10:20	H-4b	103.66
Solinst #1	077:10:28	H-4b	103.76
Solinst #2	077:10:31	H-4b	103.74
Solinst #3	077:10:35	H-4b	103.73
Solinst #4	077:10:38	H-4b	103.81
Solinst #5	077:10:41	H-4b	103.81
Solinst #7	077:10:44	H-4b	103.75
Solinst #8	077:10:47	H-4b	103.76
Solinst #9	077:10:49	H-4b	103.74
Solinst #11	077:10:52	H-4b	103.70

total range = 0.15 m
Solinst range = 0.11 m

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)
steel tape #1	077:13:40	H-15	162.96
Solinst #1	077:13:45	H-15	163.02
Solinst #2	077:13:49	H-15	163.03
Solinst #3	077:13:55	H-15	163.02
Solinst #4	077:14:00	H-15	163.09
Solinst #5	077:14:05	H-15	163.16
Solinst #7	077:14:10	H-15	163.04
Solinst #8	077:14:15	H-15	163.08
Solinst #9	077:14:20	H-15	163.04
Solinst #11	077:14:25	H-15	162.99

total range = 0.20 m
Solinst range = 0.17 m

Measurements made on 30 November 1989

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)
steel tape #1	334:10:02	H-4c	58.75
Solinst #1	334:10:05	H-4c	58.83
Solinst #2	334:10:11	H-4c	58.85
Solinst #4	334:10:15	H-4c	58.86
Solinst #5	334:10:20	H-4c	58.84
Solinst #7	334:10:24	H-4c	58.82
Solinst #8	334:10:27	H-4c	58.83
Solinst #9	334:10:30	H-4c	58.88
Solinst #11	334:10:34	H-4c	58.85
steel tape #1	334:10:39	H-4c	58.76

total range = 0.13 m
Solinst range = 0.06 m

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)
steel tape #1	334:10:47	H-4b	102.31
Solinst #1	334:10:55	H-4b	102.42
Solinst #2	334:10:59	H-4b	102.44
Solinst #4	334:11:03	H-4b	102.47
Solinst #5	334:11:05	H-4b	102.47
Solinst #7	334:11:08	H-4b	102.40
Solinst #8	334:11:11	H-4b	102.43
Solinst #9	334:11:15	H-4b	102.47
Solinst #11	334:11:19	H-4b	102.44
steel tape #1	334:11:25	H-4b	102.31

total range = 0.16 m
Solinst range = 0.07 m

DEVICE	TIME DAY:HR:MIN	OBSERVATION WELL	WATER-LEVEL MEASUREMENT (m)
steel tape #1	334:13:05	WIPP-19	133.10
Solinst #1	334:13:15	WIPP-19	133.23
Solinst #2	334:13:18	WIPP-19	133.24
Solinst #4	334:13:21	WIPP-19	133.27
Solinst #5	334:13:25	WIPP-19	133.31
Solinst #7	334:13:29	WIPP-19	133.22
Solinst #8	334:13:33	WIPP-19	133.26
Solinst #9	334:13:37	WIPP-19	133.29
Solinst #11	334:13:50	WIPP-19	133.24
steel tape #1	334:13:55	WIPP-19	133.10

total range = 0.21 m
Solinst range = 0.09 m

1 **Table TFIELD-1. Center of Culebra Elevations**

UTM E (meter)	UTM N (meter)	Elevation (m amsl)	Borehole
613423.	3581684.	826.13	H-1
612663.	3581641.	836.31	H-2A
612651.	3581651.	836.56	H-2B1
612661.	3581649.	836.25	H-2B2
612666.	3581668.	836.58	H-2C
613729.	3580895.	825.17	H-3B1
613701.	3580906.	823.37	H-3B2
613705.	3580876.	824.07	H-3B3
612407.	3578469.	861.01	H-4A
612380.	3578483.	862.48	H-4B
612406.	3578499.	862.73	H-4C
616888.	3584776.	791.58	H-5A
616872.	3584801.	791.53	H-5B
616903.	3584802.	790.74	H-5C
610580.	3584982.	832.64	H-6A
610594.	3585008.	832.73	H-6B
610610.	3584983.	832.84	H-6C
608124.	3574648.	886.37	H-7B1
608095.	3574640.	886.33	H-7C
608683.	3563556.	863.16	H-8B
608664.	3563537.	862.96	H-8C
613958.	3568260.	836.38	H-9A
613989.	3568261.	836.43	H-9B
613974.	3568234.	836.53	H-9C
622975.	3572473.	705.07	H-10B
622976.	3572443.	704.89	H-10C
615346.	3579130.	813.21	H-11B1
615348.	3579107.	812.67	H-11B2
615367.	3579127.	812.46	H-11B3
615313.	3579131.	815.44	H-11B4

Table TFIELD-1. Center of Culebra Elevations (Continued)

UTM E (meter)	UTM N (meter)	Elevation (m amsl)	Borehole
617023.	3575452.	789.27	H-12
612341.	3580354.	849.47	H-14
615315.	3581859.	794.98	H-15
613369.	3582212.	821.79	H-16
615718.	3577513.	812.42	H-17
612264.	3583166.	826.82	H-18
614514.	3580718	812.30	H-19
615203.	3580333.	802.72	DOE-1
613683.	3585294.	787.38	DOE-2
612338.	3580341.	851.40	P-1
615316.	3581848.	794.82	P-2
612799.	3581898.	831.81	P-3
614935.	3580319.	808.57	P-4
613685.	3583535.	809.64	P-5
610609.	3581084.	855.02	P-6
612308.	3578478.	860.36	P-7
613830.	3578467.	841.49	P-8
615356.	3579125.	811.67	P-9
617087.	3581203.	781.67	P-10
617016.	3583457.	786.66	P-11
610456.	3583452.	832.56	P-12
610531.	3585029.	832.10	P-13
609084.	3581976.	846.05	P-14
610624.	3578747.	879.58	P-15
612695.	3577321.	856.89	P-16
613926.	3577466.	842.85	P-17
618367.	3580350.	777.64	P-18
617681.	3582418.	781.59	P-19
618532.	3583768.	788.46	P-20
616898.	3584849.	792.07	P-21

23

Table TFIELD-1. Center of Culebra Elevations (Continued)

UTM E (meter)	UTM N (meter)	Elevation (m amsl)	Borehole
613791.	3586475.	783.49	W-11
613710.	3583524.	807.35	W-12
612644.	3584247.	820.79	W-13
613735.	3583179.	810.43	W-18
613739.	3582782.	812.47	W-19
613743.	3582319.	815.68	W-21
613739.	3582653.	814.67	W-22
606385.	3584028.	839.10	W-25
604014.	3581162.	900.45	W-26
604426.	3593079.	875.43	W-27
611266.	3594680.	888.07	W-28
596981.	3578694.	899.14	W-29
613721.	3589701.	849.01	W-30
621126.	3589381.	845.59	AEC-7
617525.	3586442.	818.74	AEC-8
618220.	3589008.	858.83	ER-6
613696.	3581958.	820.92	ER-9
606685.	3570515.	878.15	ER-10
613191.	3578049.	856.88	CB-1
614953.	3567454.	837.78	ENGLE
606462.	3569415.	881.66	USGS1
605841.	3569887.	892.19	USGS4
605879.	3569888.	894.13	USGS8
608702.	3578877.	883.32	D-268
607461.	3590055.	883.94	FFG-107
599239.	3572224.	905.80	FFG-153
601859.	3573206.	907.16	FFG-165
604215.	3568693.	926.54	FFG-181
603881.	3562585.	841.50	FFG-188
629277.	3596967.	599.54	FFG-225

24

Table TFIELD-1. Center of Culebra Elevations (Continued)

UTM E (meter)	UTM N (meter)	Elevation (m amsl)	Borehole
620854.	3597026.	678.74	FFG-236
627179.	3589332.	717.34	FFG-244
592523.	3591566.	922.94	FFG-426
595800.	3585222.	961.21	1-DANF
601312.	3588916.	969.23	1-DUNC
612561.	3583427.	825.61	WQSP-1
613776.	3583973.	805.28	WQSP-2
614686.	3583518.	799.52	WQSP-3
614728.	3580766.	809.18	WQSP-4
613668.	3580353.	830.03	WQSP-5
612605.	3580736.	844.39	WQSP-6

TFIELD.2.2.2 Culebra Fluid-Density Data

The fluid-density data deemed representative of the Culebra were described by Cauffman et al. (1990). These data are repeated in Table TFIELD-2. Densities ranging from 1.00 to 1.03 grams per cubic centimeter occur in a wide region extending from boreholes WIPP-28 to H-7 (Figure TFIELD-4). Higher fluid densities are located east of this region with values ranging from 1.04 to 1.16 grams per cubic centimeter (Figure TFIELD-4).

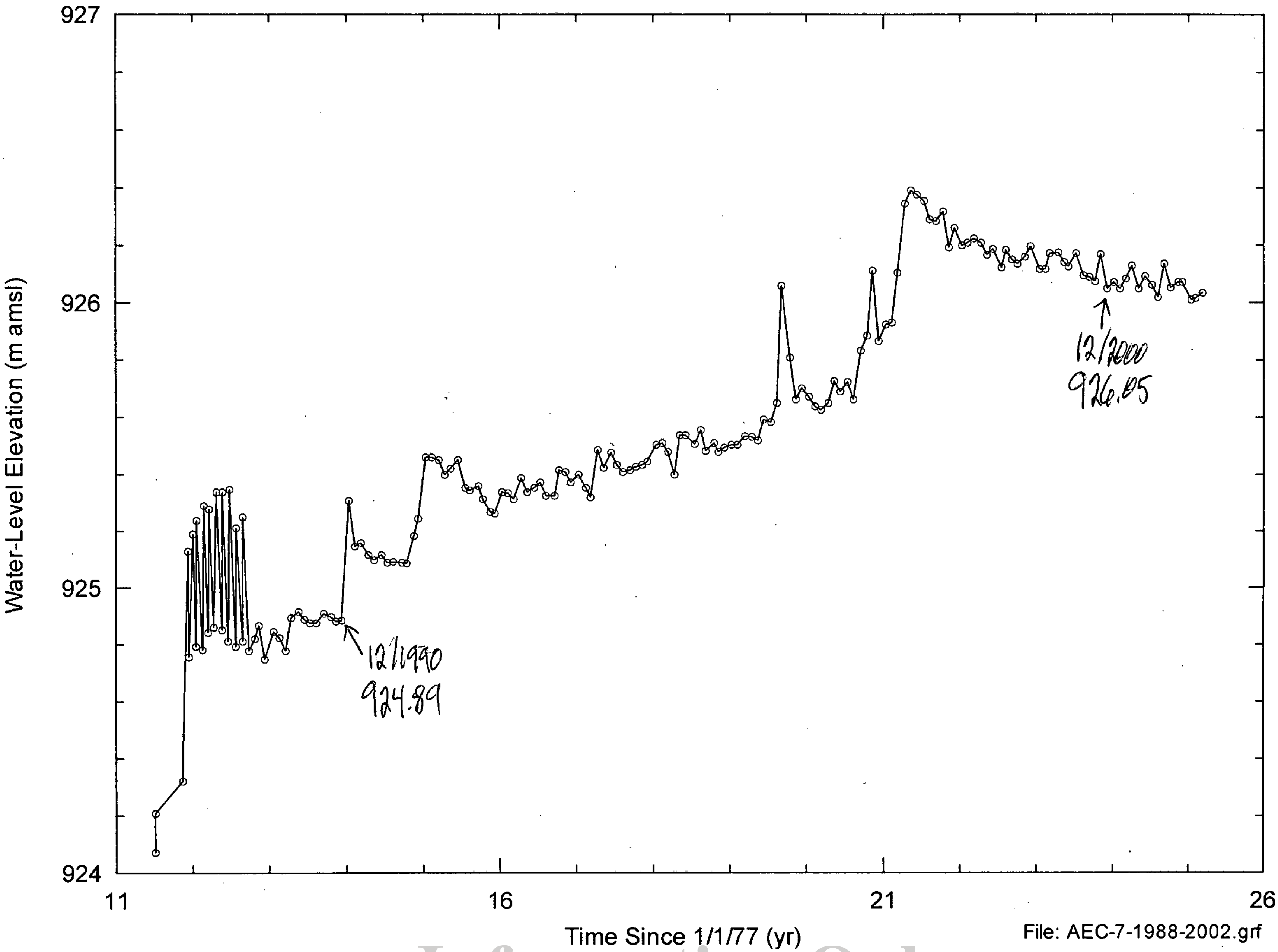
In this model, formation-fluid densities are assigned to grid blocks and held constant over the 15-year simulation. Thus, in the simulation, the formation-fluid densities appear to represent steady-state conditions. It should be noted that geochemical investigations (Lambert and Harvey 1987; Chapman 1986; Lambert and Carter 1987; and Lambert 1987) suggest that the chemical constituents within the Culebra flow field are currently not at steady state. However, the time period for reaching steady state is considered to be several thousand years. Thus, for a small unit of time, such as 15 years, the fluid-density conditions would appear to be fixed. Conceptually, one may consider this phenomenon similar to the flow of glass in a window, which will shift over many years, yet seems fixed on a daily basis. Therefore, the decision was made to hold formation-fluid densities constant over the simulation time period.

The decision to assign a fluid-density value to each grid block (rather than using one value for all) also meant that the effects of variable fluid densities on the present-day flow field (that is, the calculated pressures and Darcy velocities) were included in the Culebra transmissivity fields produced by GRASP-INV.

Table TFIELD-3. Culebra Undisturbed Head Values and Uncertainties						
Well	**Undisturbed Head* (meters)**	**Residual Effects in the Data (meters)**	**Range of Trends (meters)**	**Overall Head Uncertainty due to Measuremen t Error (meters)**	**Overall Head Variance**	**Steady-State Head Weight**
H-1	921.6 (D)		3.4	±2.0	1.5	0.7
H-2	924.8 (I)		1.6	+1.8/-0.1	0.3	3.3
H-3	914.8 (D)		4.6	±1.9	2.0	0.5
H-4	911.4 (D)		2.8	±0.6	0.4	2.5
H-5	934.2 (I)		0.3	±1.4	0.3	3.3
H-6	932.0 (D)		1.2	±1.0	0.3	3.3
H-7	912.7 (S)		1.1	+0.5/-0.1	0.1	10.0
H-9	906.4 (D)		3.5	+1.2/-0.1	0.6	1.7
H-10	921.3 (S)		1.0	±2.2	0.8	NA
H-11	912.4 (D)	2.0	2.4	+3.0/-1.0	1.1	0.9
H-12	913.5 (S)		1.0	+1.2/-1.2	0.3	3.3
H-14	916.9 (D)	3.2	0.5	+3.9/-0.1	0.6	1.7
H-15	916.1 (D)	2.9	0.4	+4.2/-0.1	0.6	1.7
H-17	911.0		0.0	±0.9	0.3	3.3
H-18	932.4	1.4	0.0	+2.5/-1.1	0.4	2.5
DOE-1	914.3	2.2	0.0	+4.3/-2.2	0.8	1.3
DOE-2	934.7 (S)		2.7	±1.5	0.9	1.1
P-14	926.9 (S)		1.9	±0.9	0.6	1.7
P-15	917.8(I)		2.6	±0.8	0.5	2.0
P-17	909.3 (D)		4.6	±0.7	1.0	1.0
W-12	933.6 (S)	0.9	1.0	+2.2/-0.1	0.3	3.3
W-13	933.7 (D)	0.3	0.8	+1.5/-1.3	0.4	2.5
W-18	930.5 (D)	1.8	0.8	+3.0/-1.2	0.7	1.4
W-25	928.7 (S)		1.4	±1.0	0.3	3.3
W-26	918.5 (D)		2.0	+0.4/-0.1	0.2	5.0
W-27	938.1		0.0	±0.7	0.1	NA
W-28	937.5 (I)		0.8	+0.9/-1.2	0.2	5.0
W-30	934.1 (D)		2.0	+0.9/-1.3	0.5	2.0
CB-1	911.1 (S)		0.6	±0.7	0.1	10.0
USGS-1	909.8 (S)		1.6	+0.4/-0.1	0.1	10.0
D-268	915.2		0.0	+0.4/-0.1	0.3	3.3
AEC7	932.0		0.0	±0.8	0.3	3.3

* As the result of including the trend in the uncertainty, the 1996 head value, shown in column 2, was either increased (I) from the 1990 value to accommodate a downward trend, decreased (D) to accommodate a rising trend, or remained the same (S) to reflect that the trend did not significantly contribute to the uncertainty. For example, the rising trend of 3.4 m for Well H-1 meant that the 1996 head value was lower than the 1990 value.

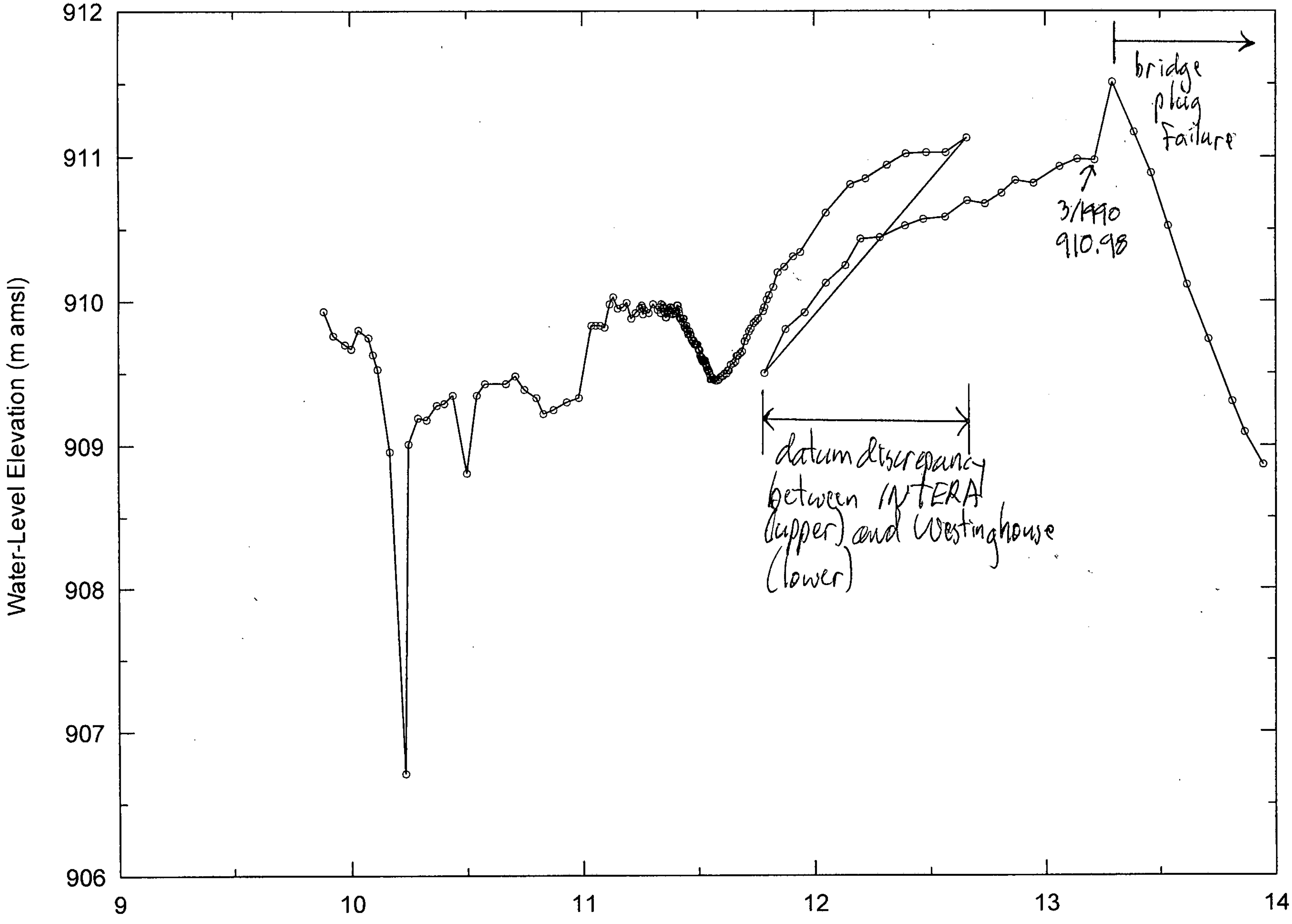
AEC-7 Culebra Hydrograph, 1988-2002



File: AEC-7-1988-2002.grf

27

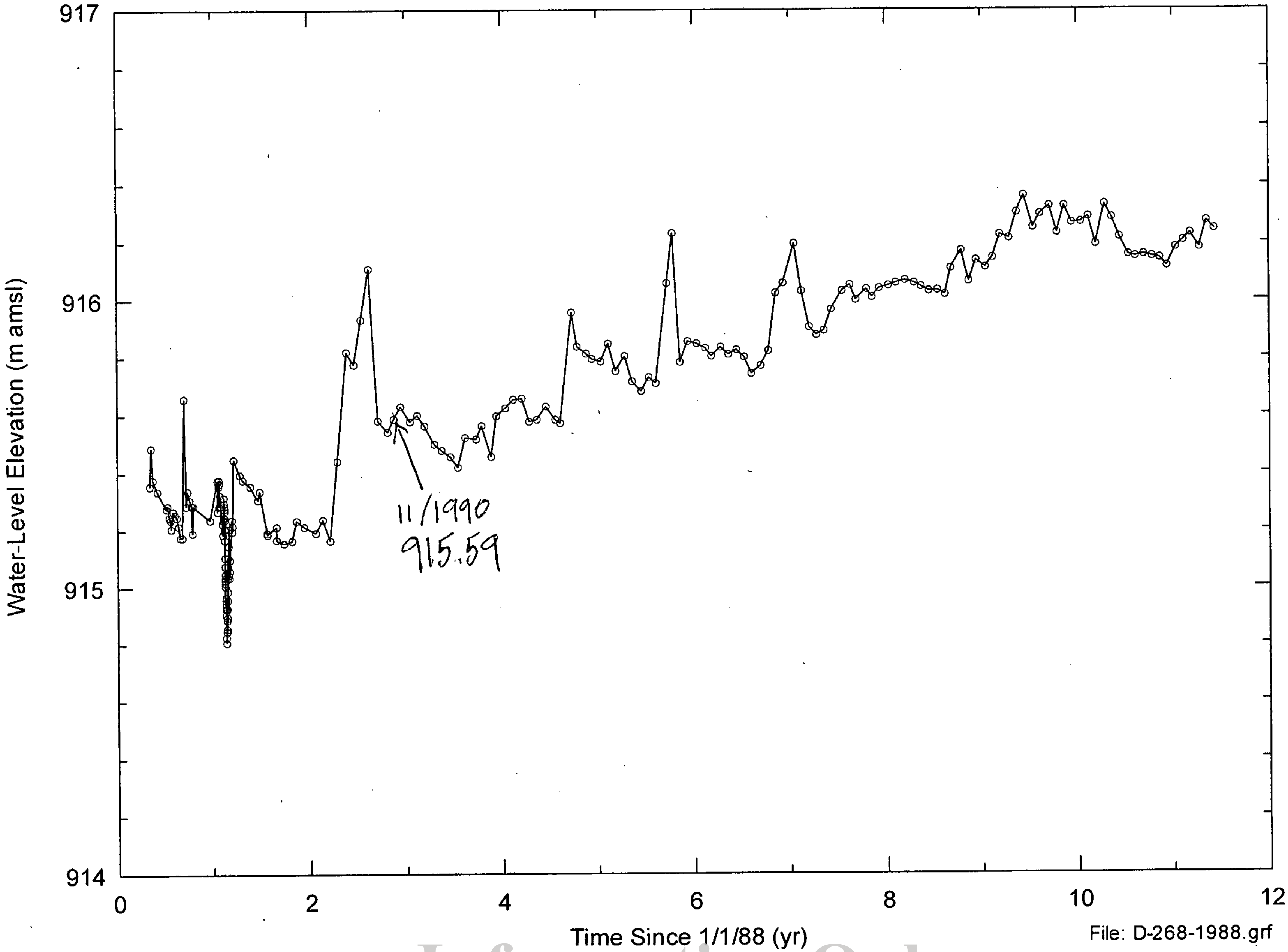
CB-1 Culebra Hydrograph, 1986-1990



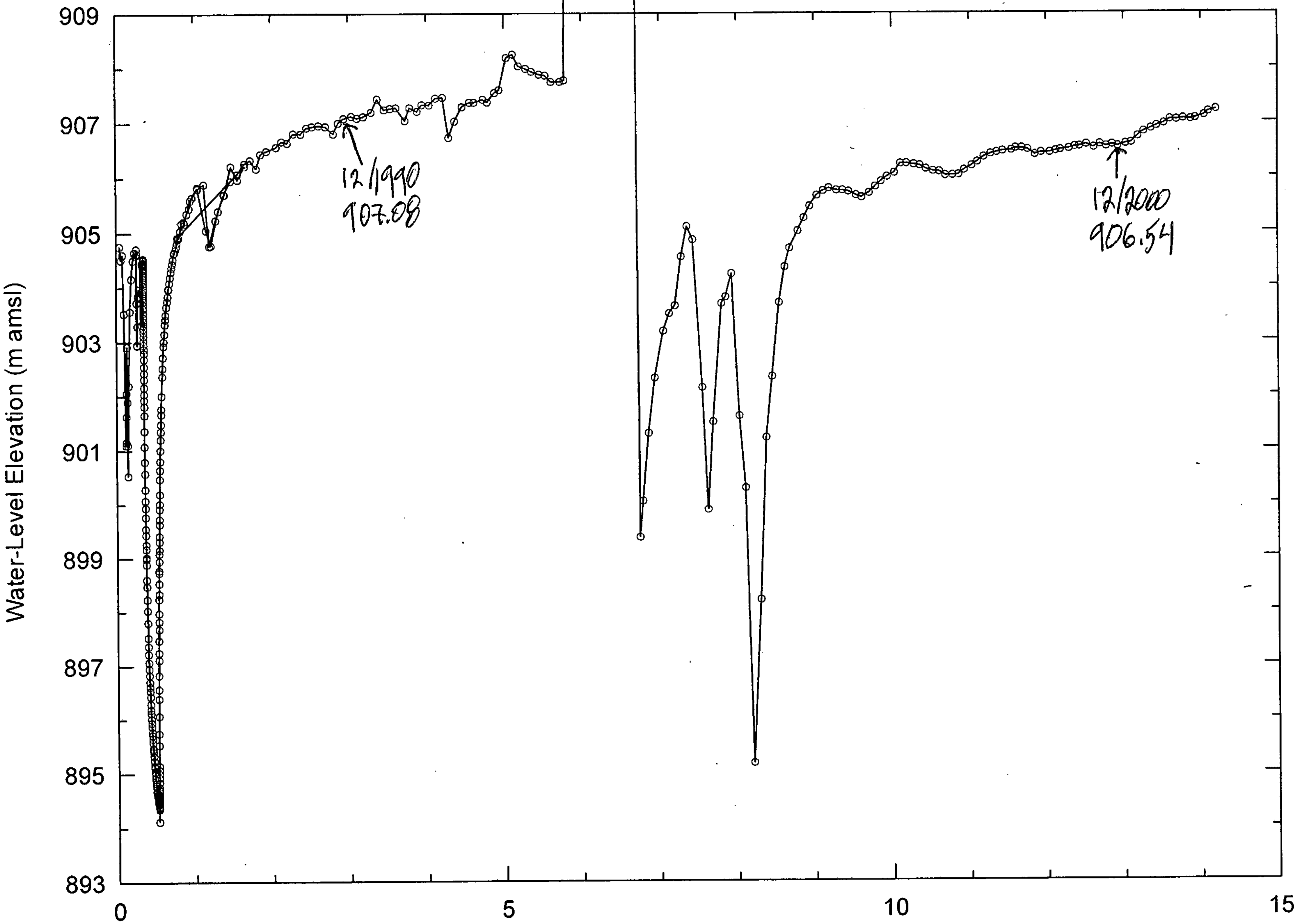
File: CB-1-1986-1990.grf

28

D-268 Culebra Hydrograph, 1988-1999

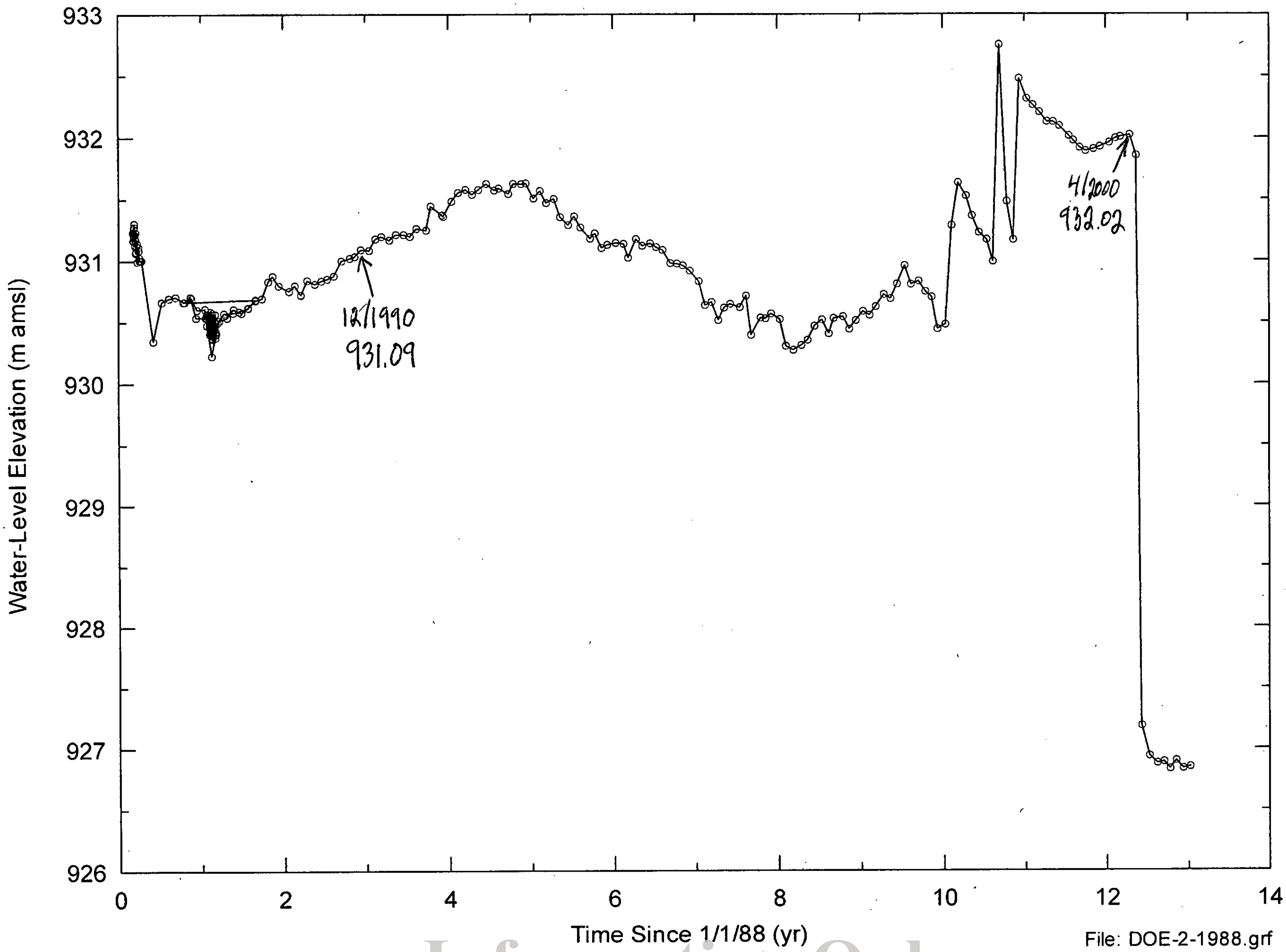


DOE-1 Culebra Hydrograph, 1988-2002

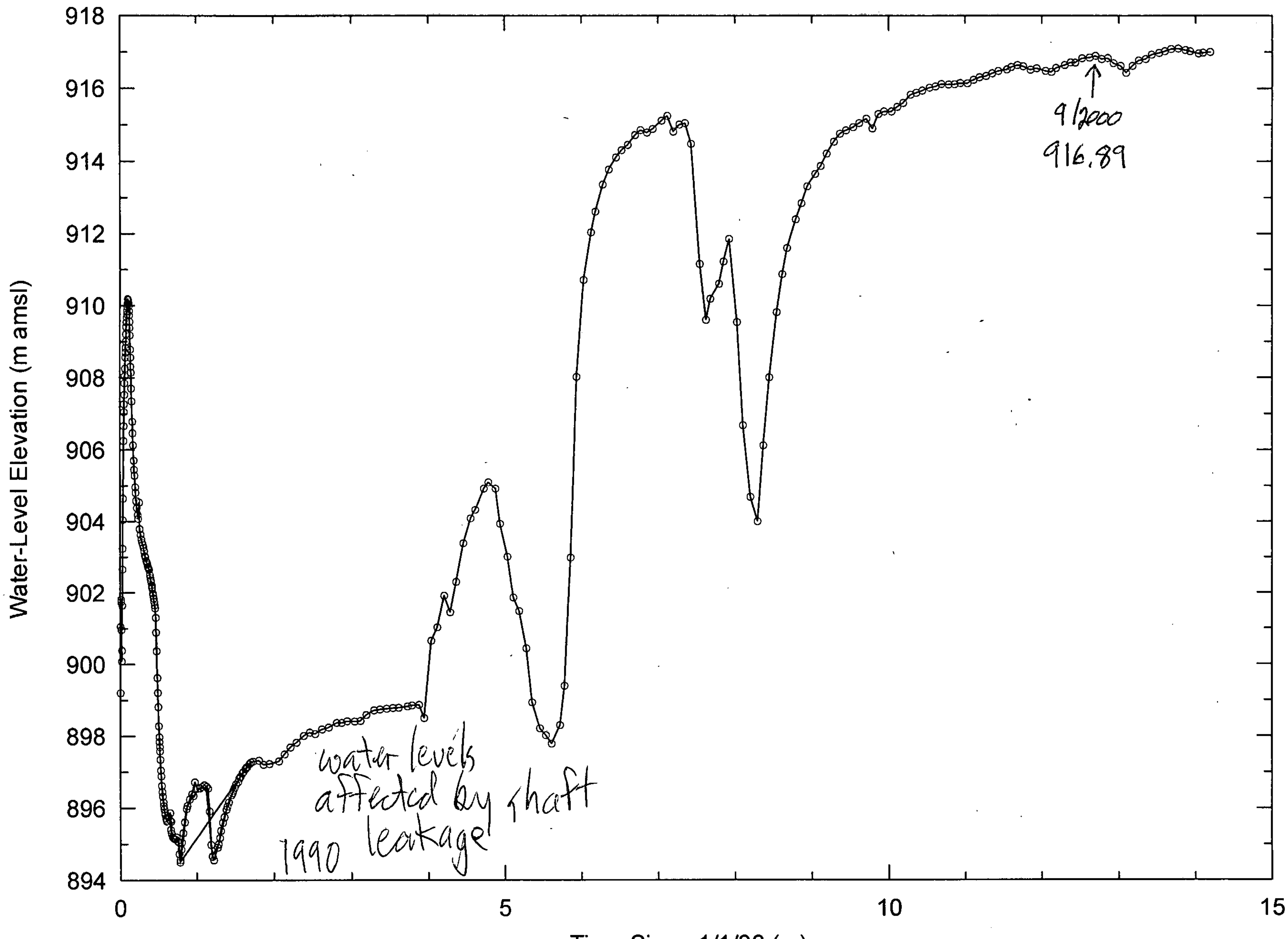


File: DOE-1-1988.grf

DOE-2 Culebra Hydrograph, 1988-1/2001



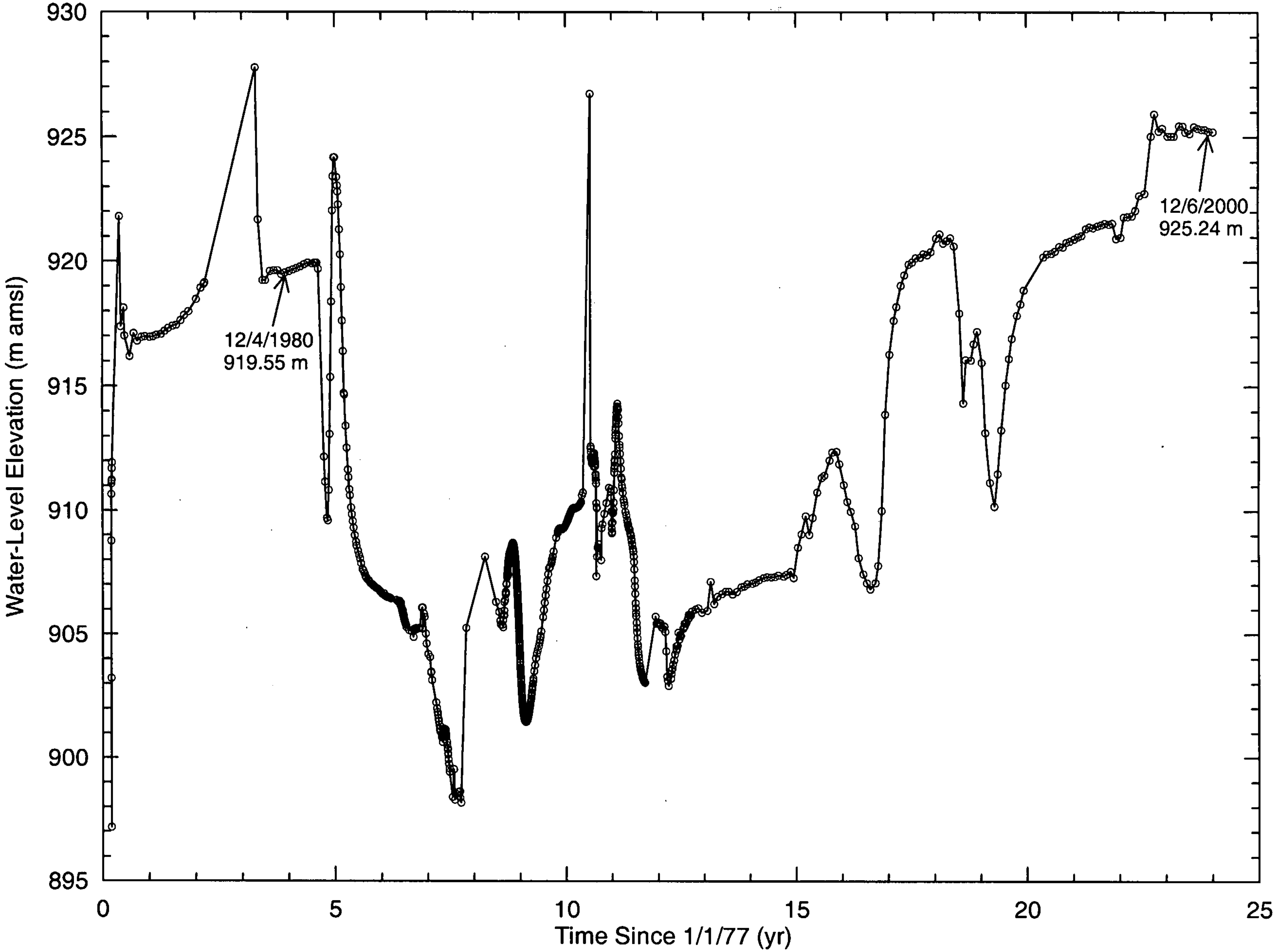
ERDA-9 Culebra Hydrograph, 1988-2002



File: ERDA-9-1988.grf

32

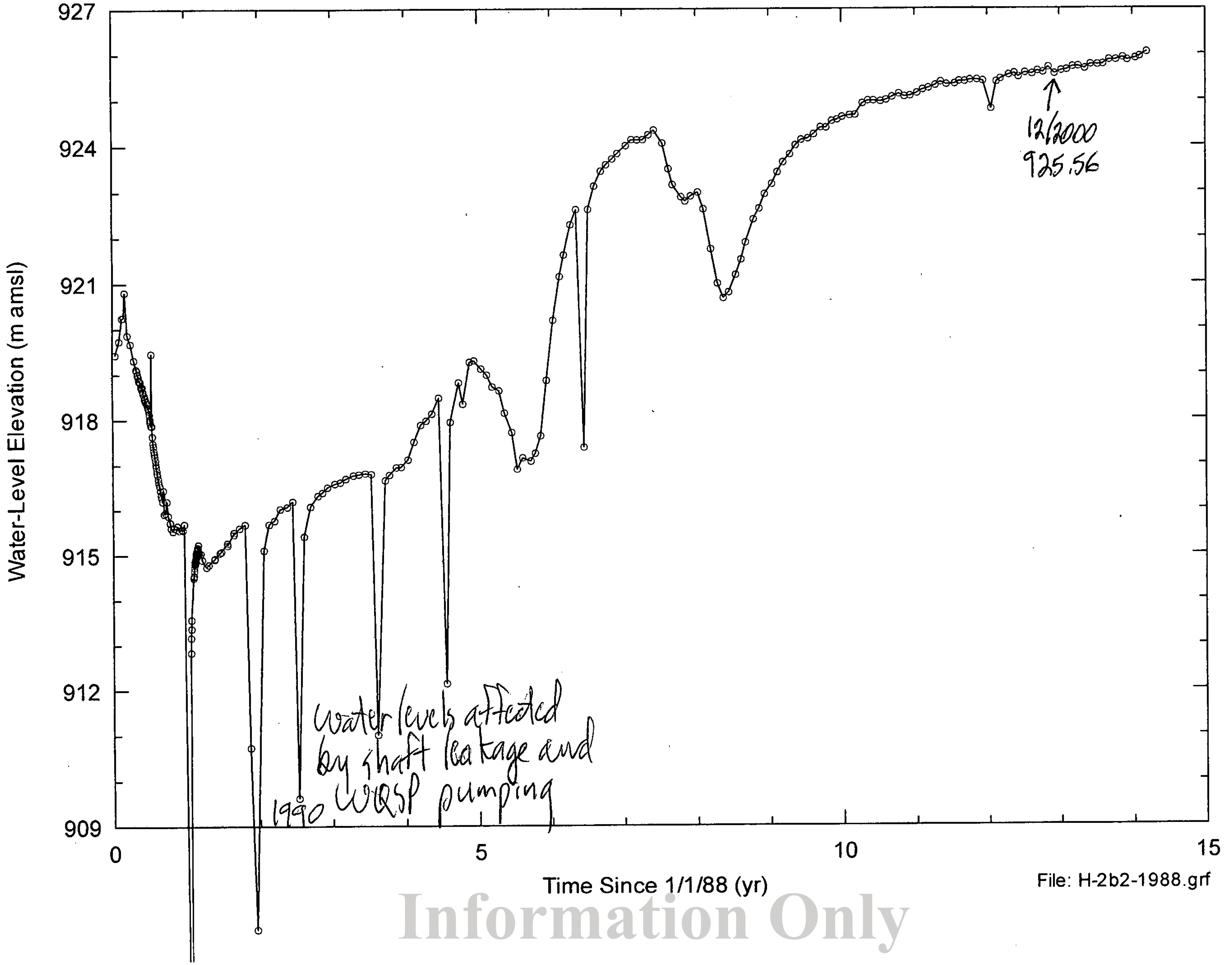
H-1 Culebra Hydrograph, 1977-1/2001



file: H-1-1977.grf

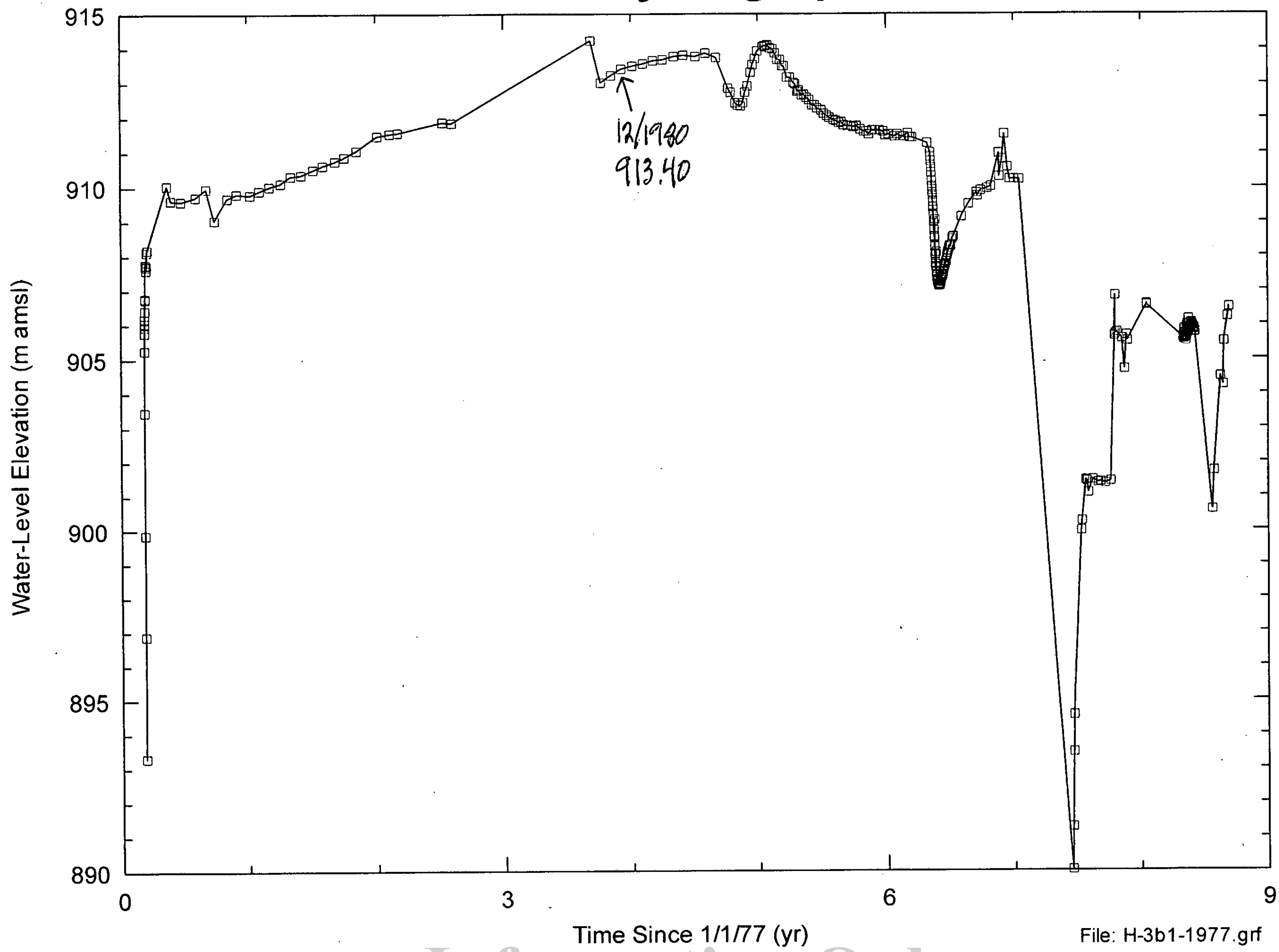
33

H-2b2 Culebra Hydrograph, 1988-2002

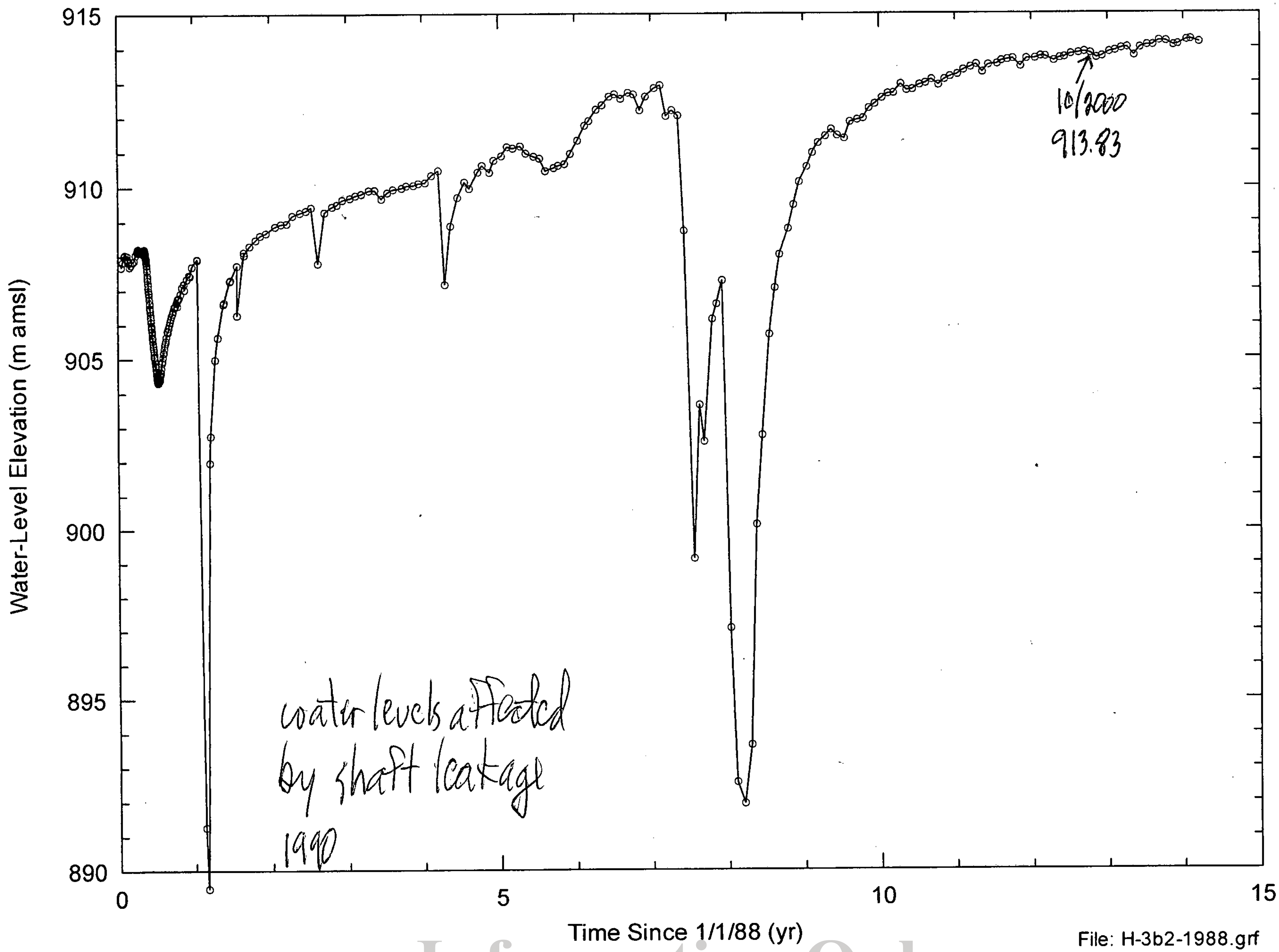


34

H-3b1 Culebra Hydrograph, 1977-1985



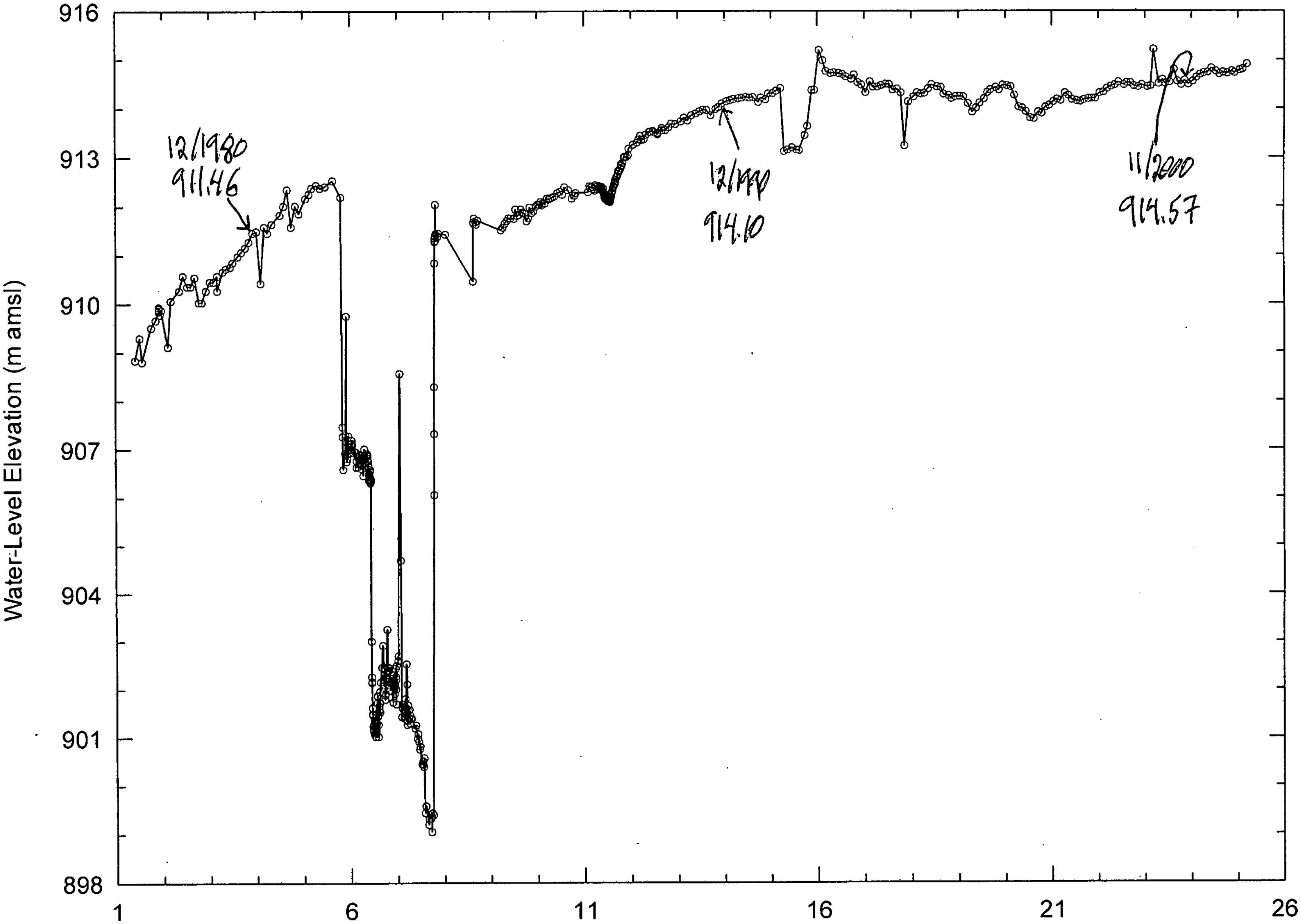
H-3b2 Culebra Hydrograph, 1988-2002



File: H-3b2-1988.grf

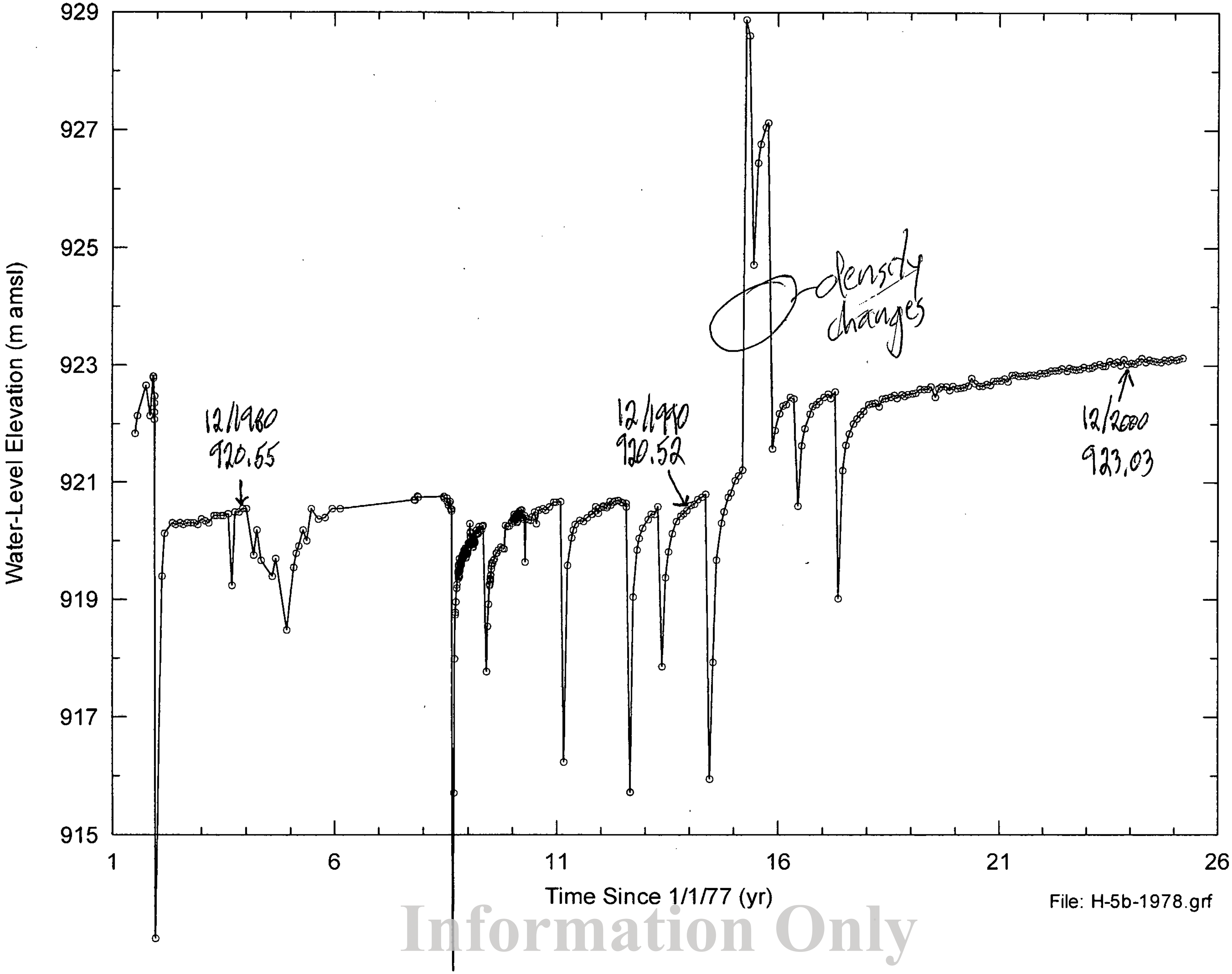
36

H-4b Culebra Hydrograph, 1977-2002



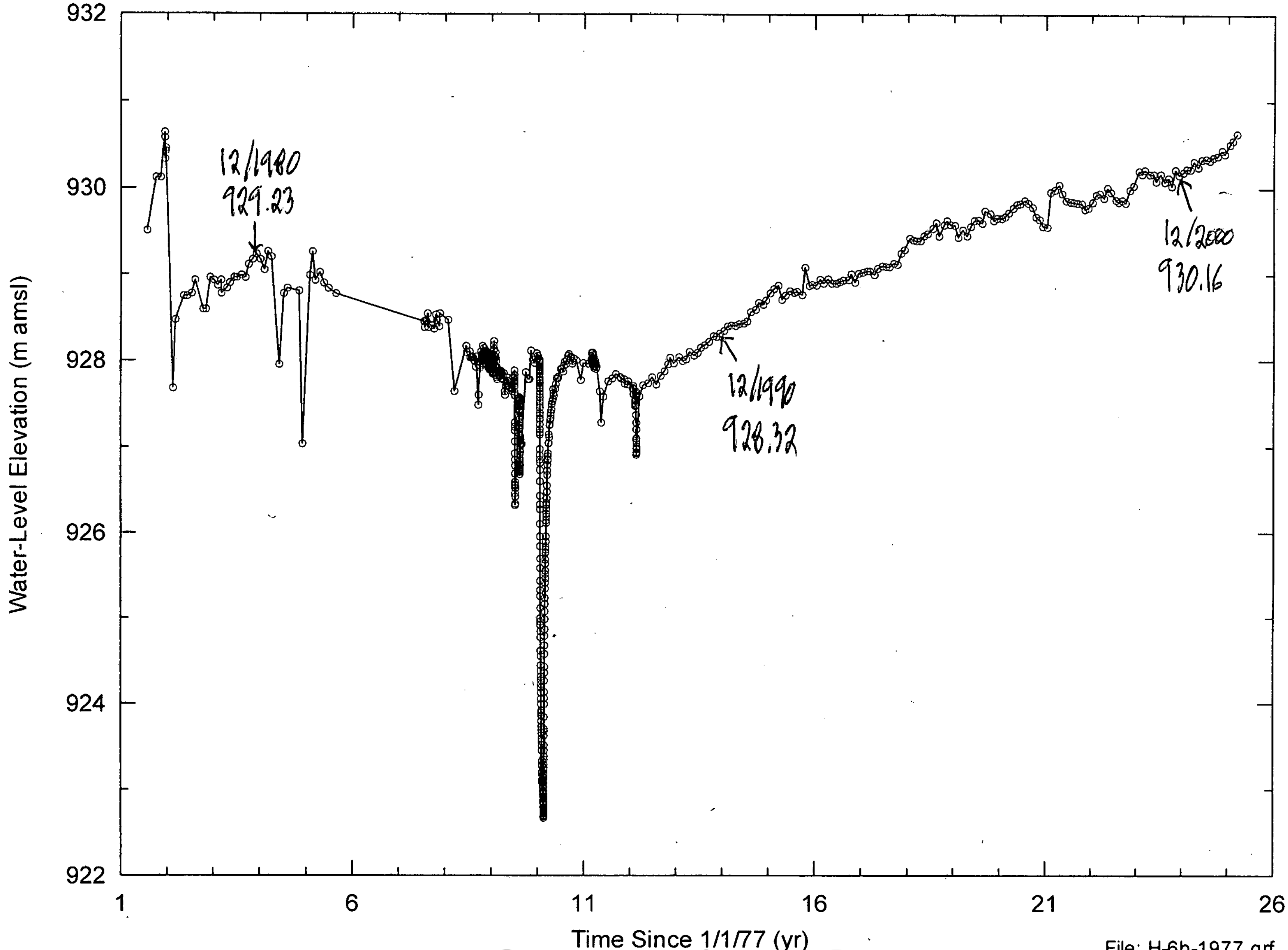
File: H-4b-1977.grf

H-5b Culebra Hydrograph, 1978-2002



38

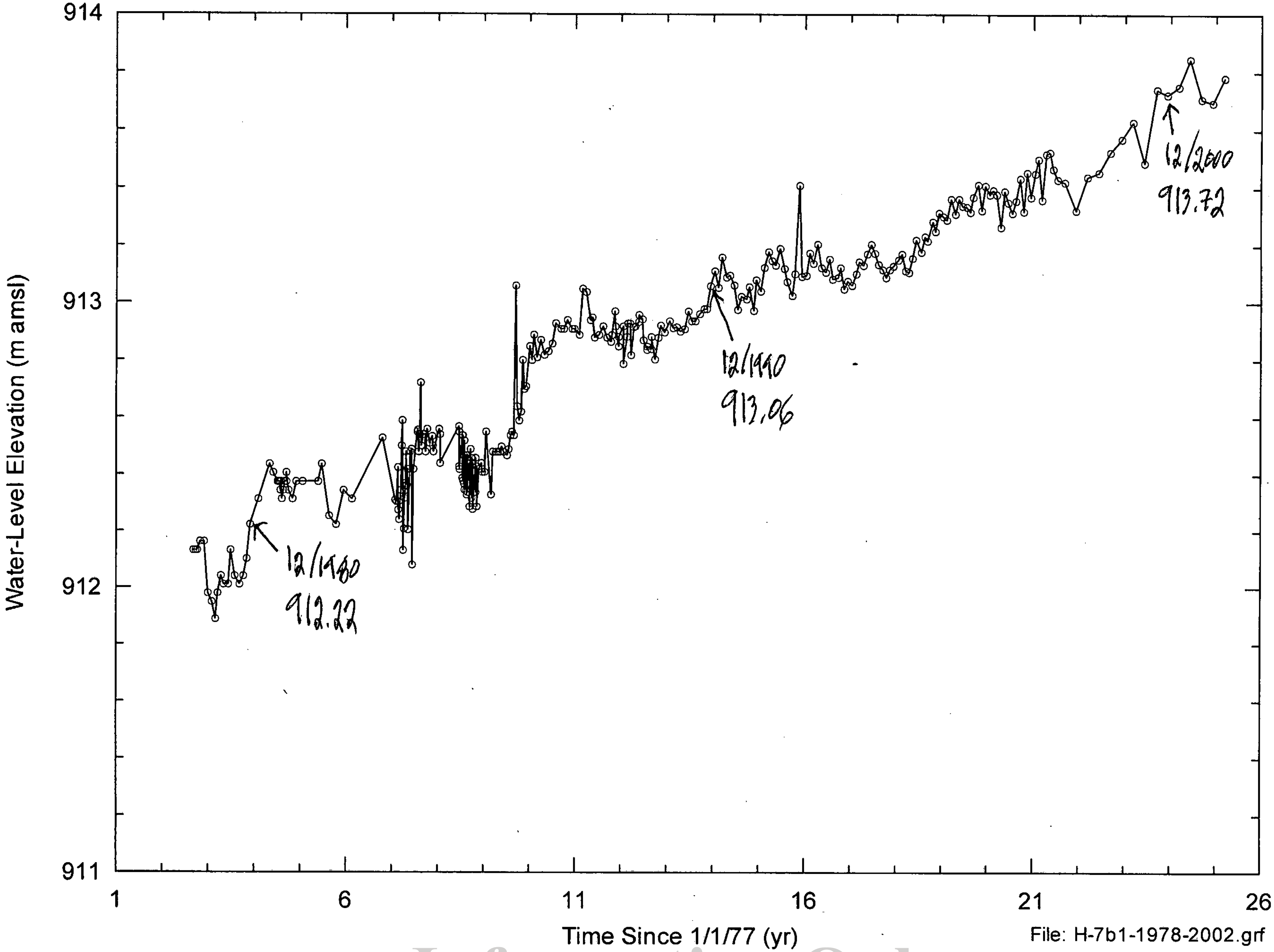
H-6b Culebra Hydrograph, 1978-2002



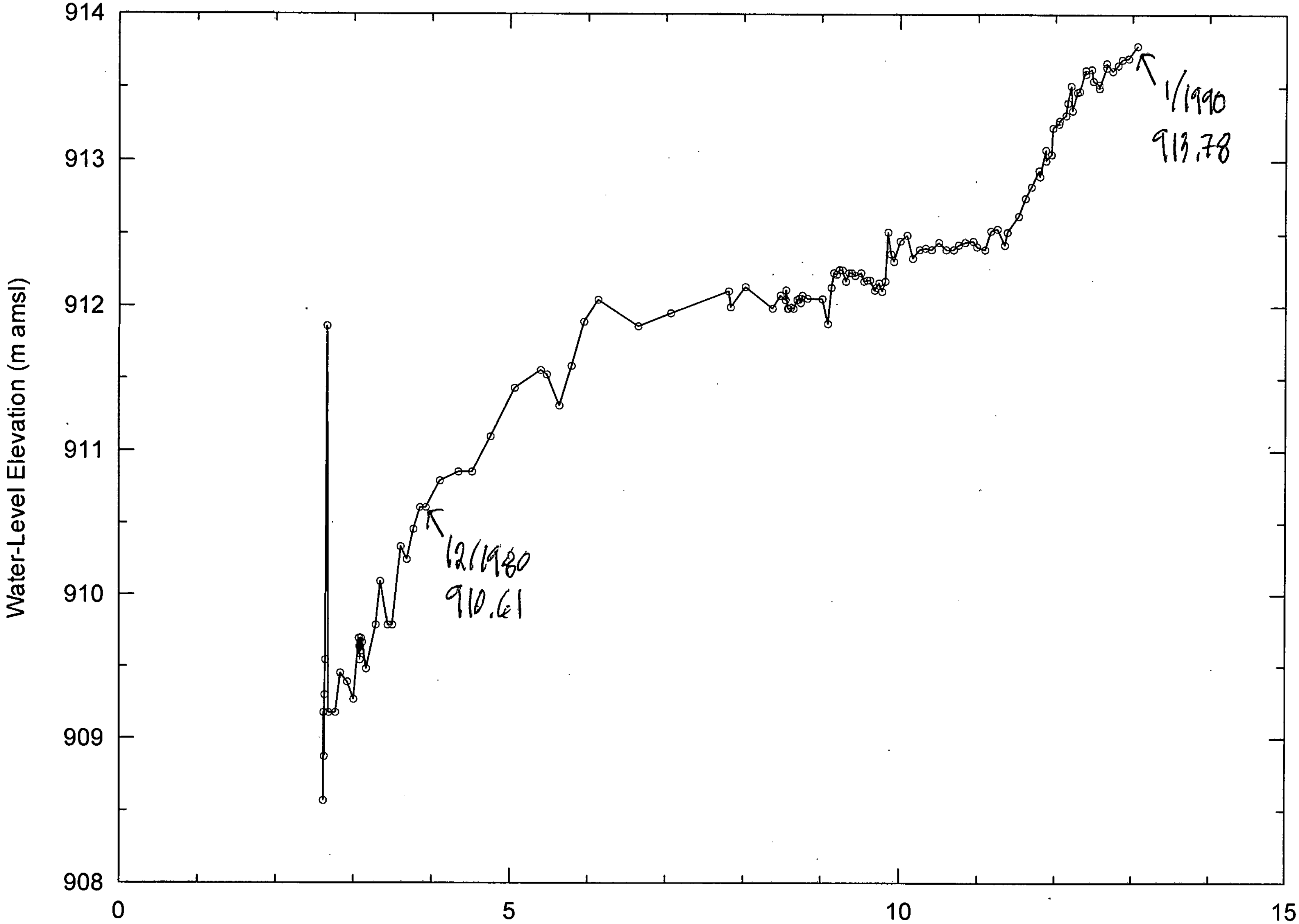
File: H-6b-1977.grf

39

H-7b1 Culebra Hydrograph, 1978-2002



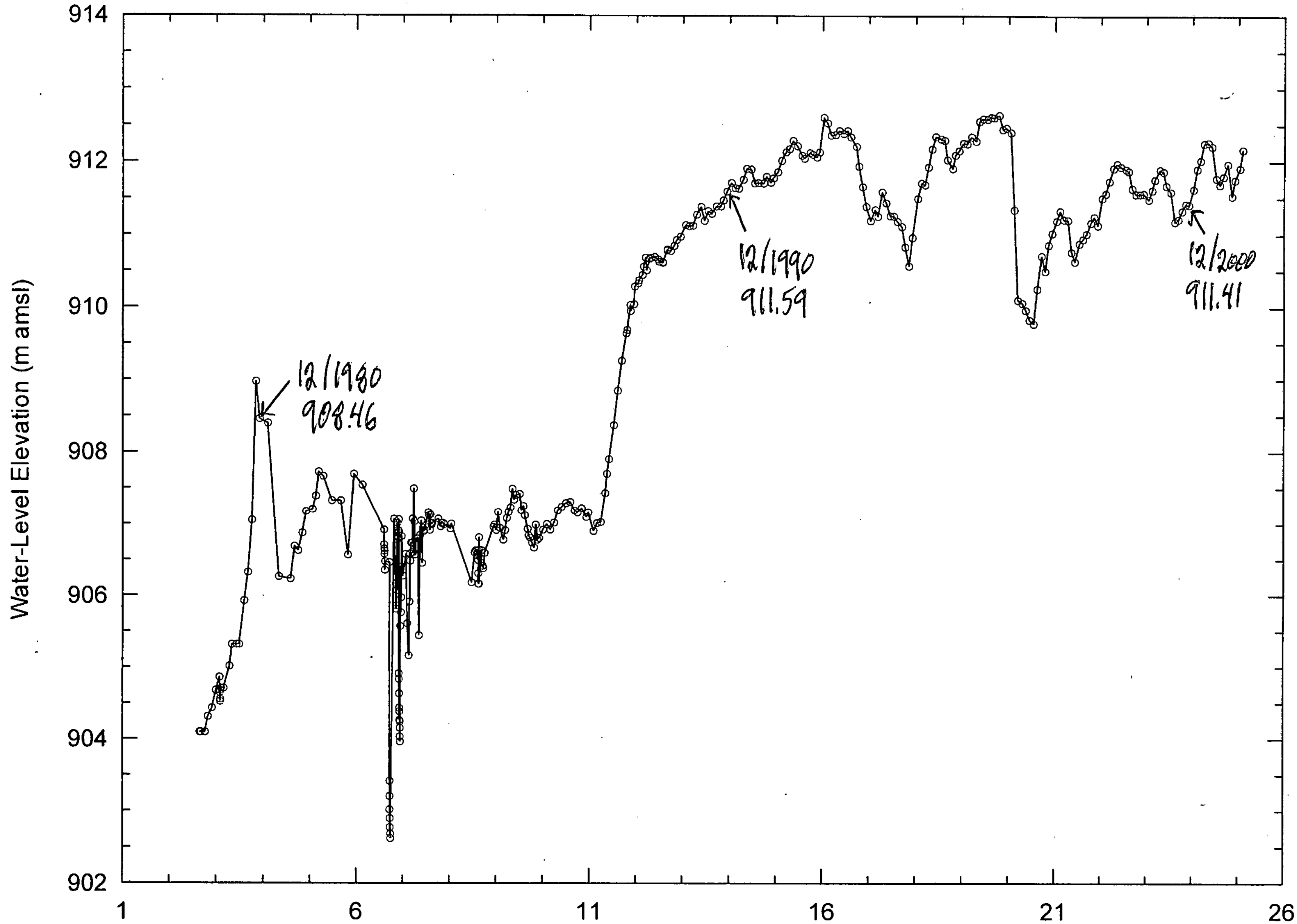
H-8b Culebra Hydrograph, 1977-1/1990



File: H-8b-1977.grf

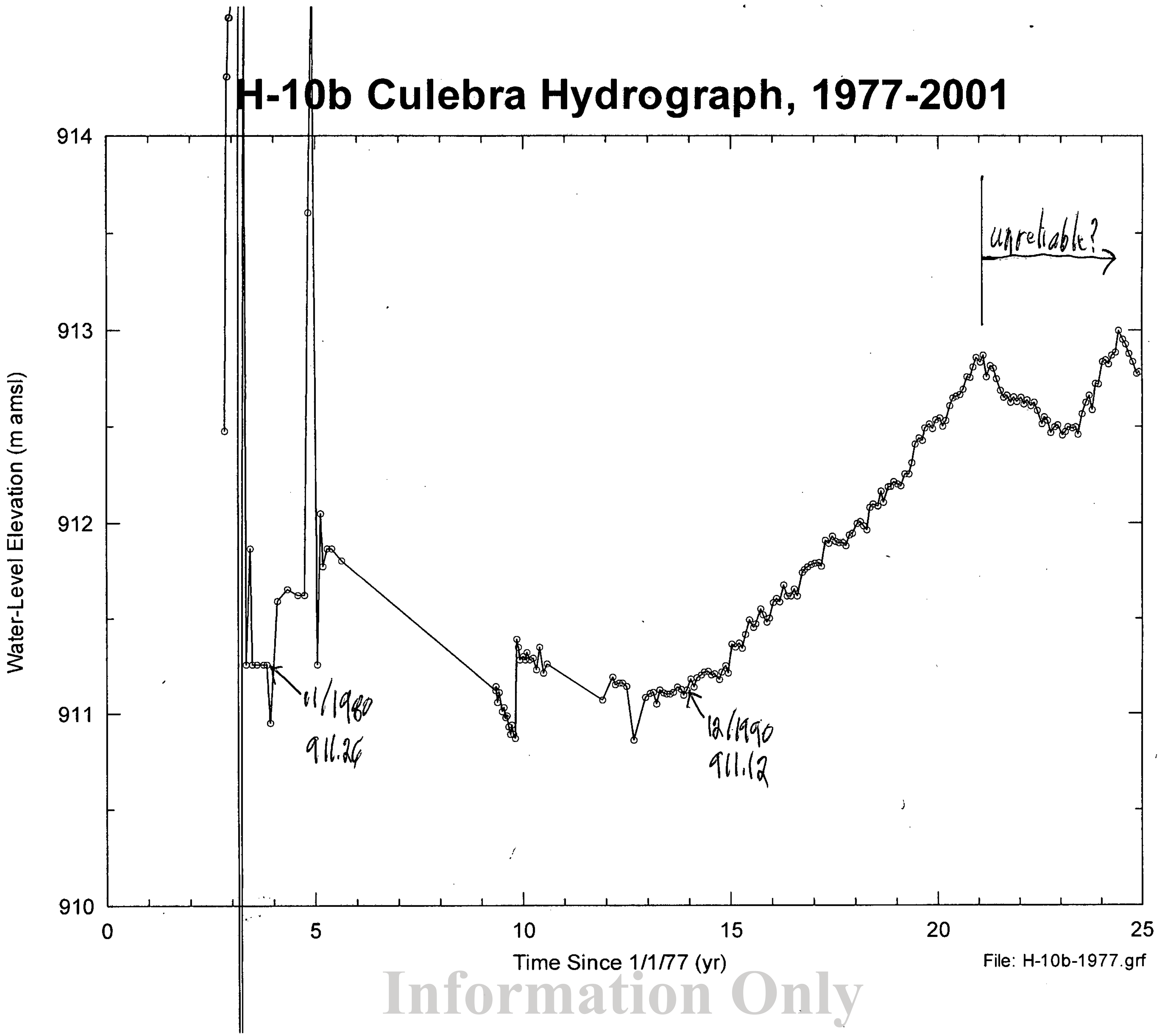
91

H-9b Culebra Hydrograph, 1977-2002



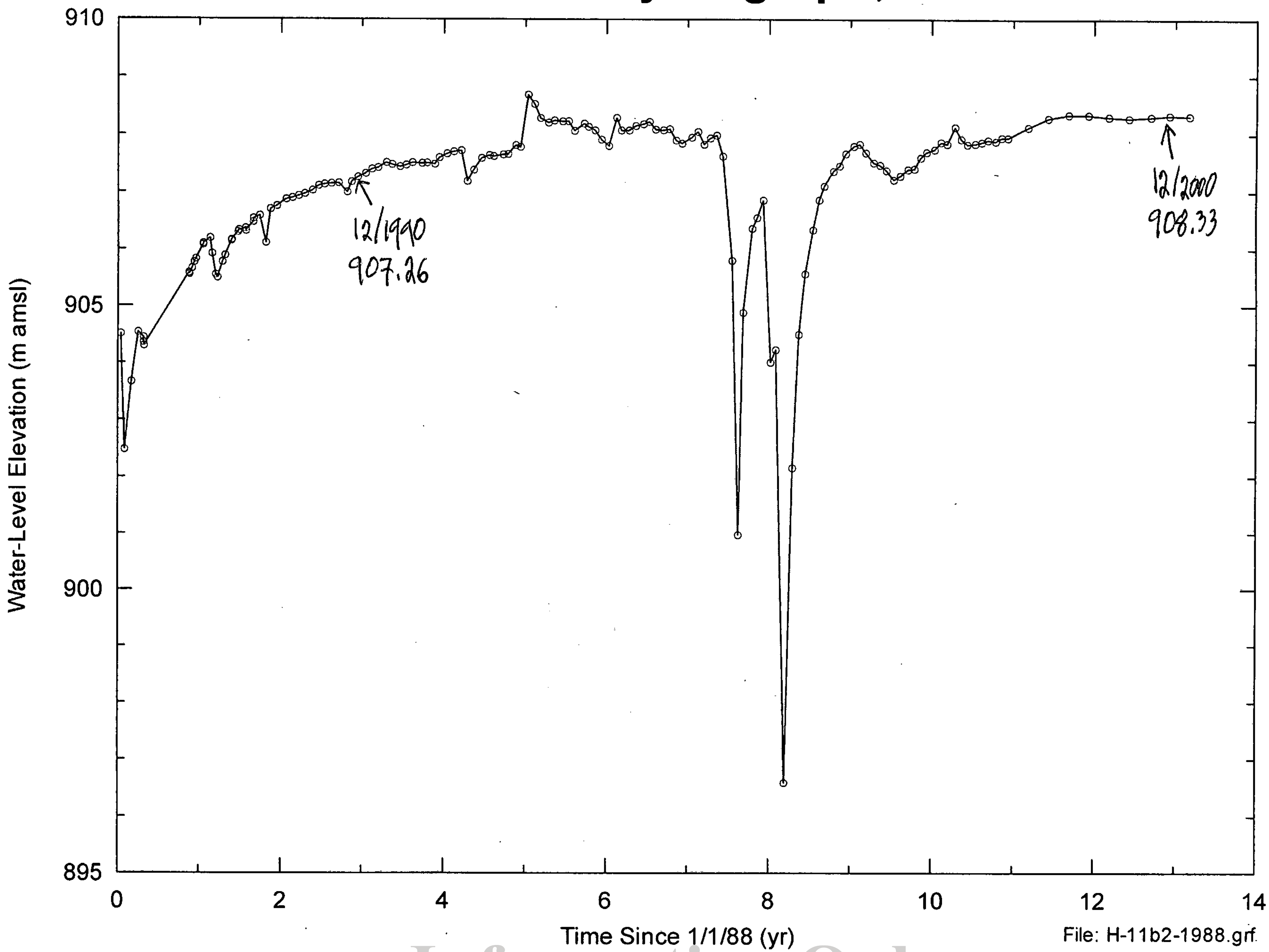
File: H-9b-1977.grf

H-10b Culebra Hydrograph, 1977-2001



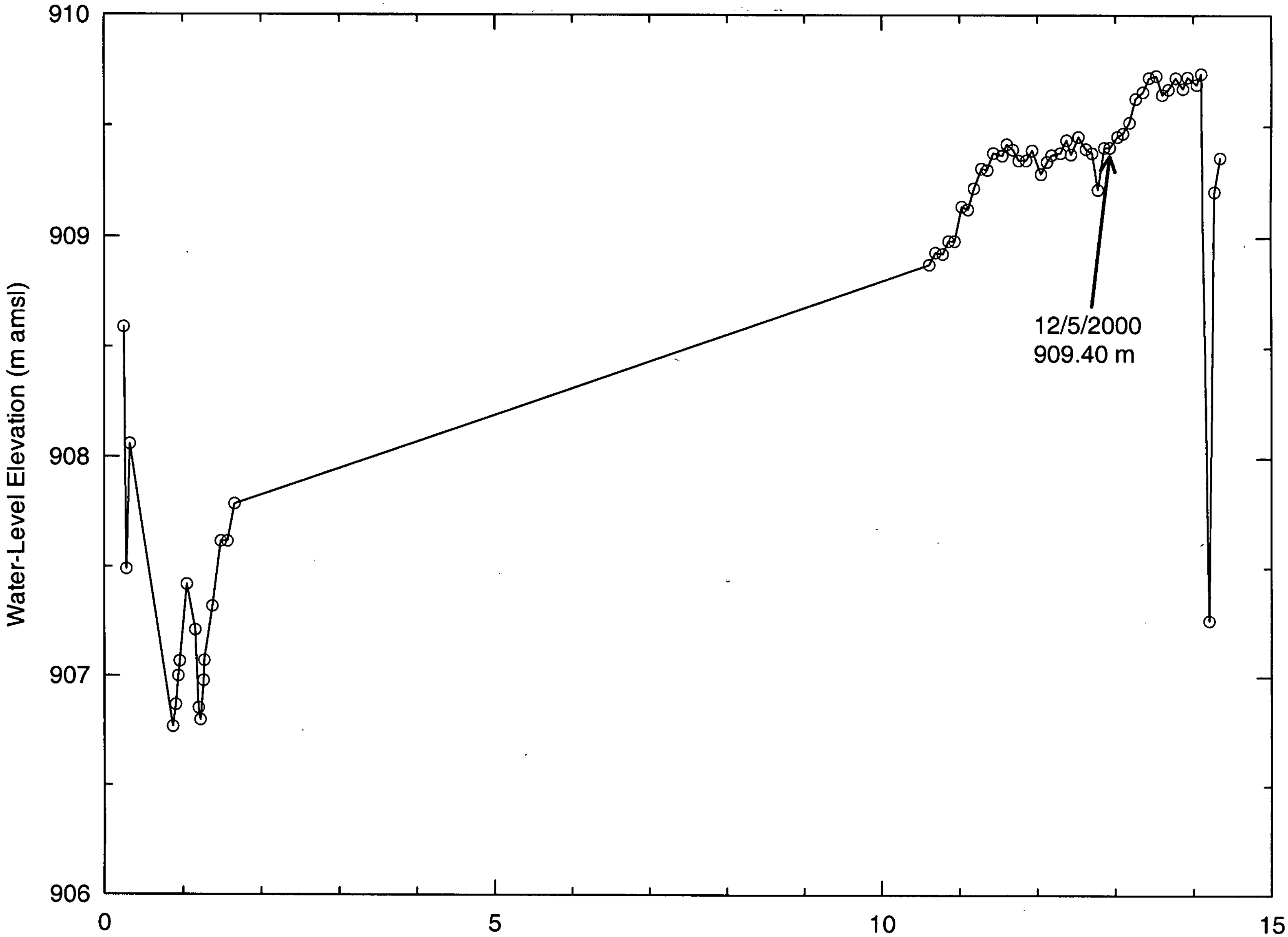
File: H-10b-1977.grf

H-11b2 Culebra Hydrograph, 1988-3/2001



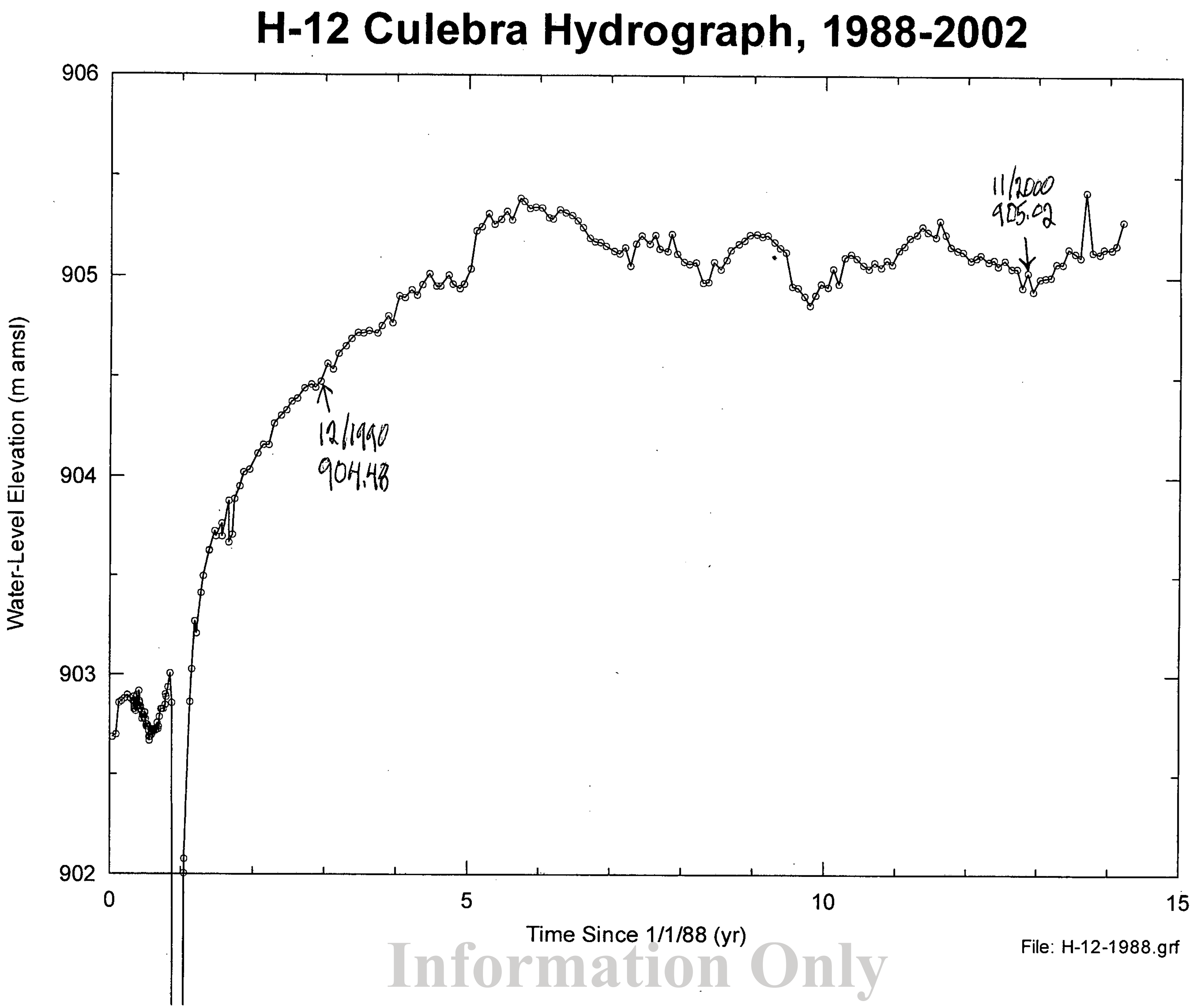
File: H-11b2-1988.grf

H-11b4 Culebra Hydrograph, 1988-2002



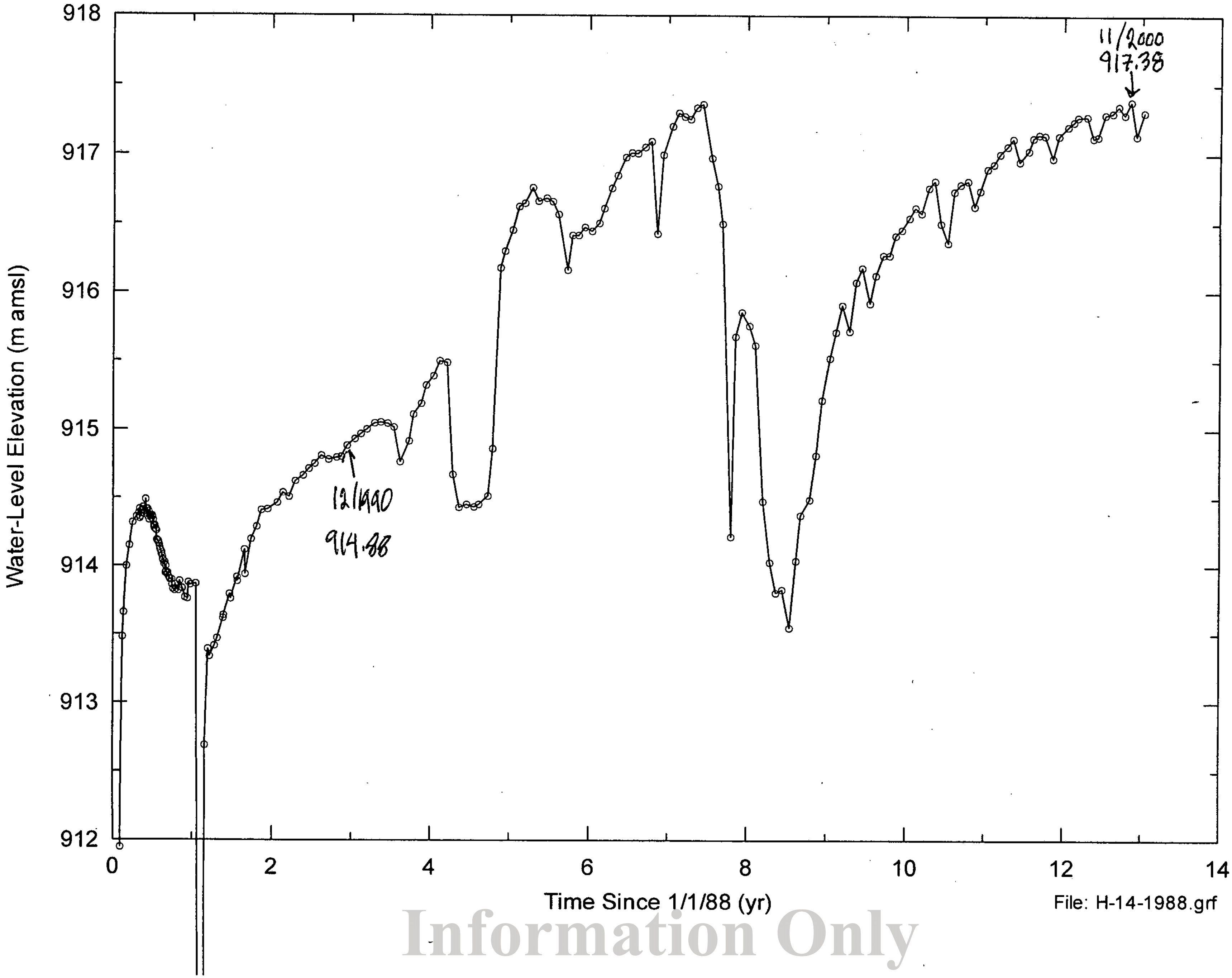
File: H-11b4-1988.grf

95



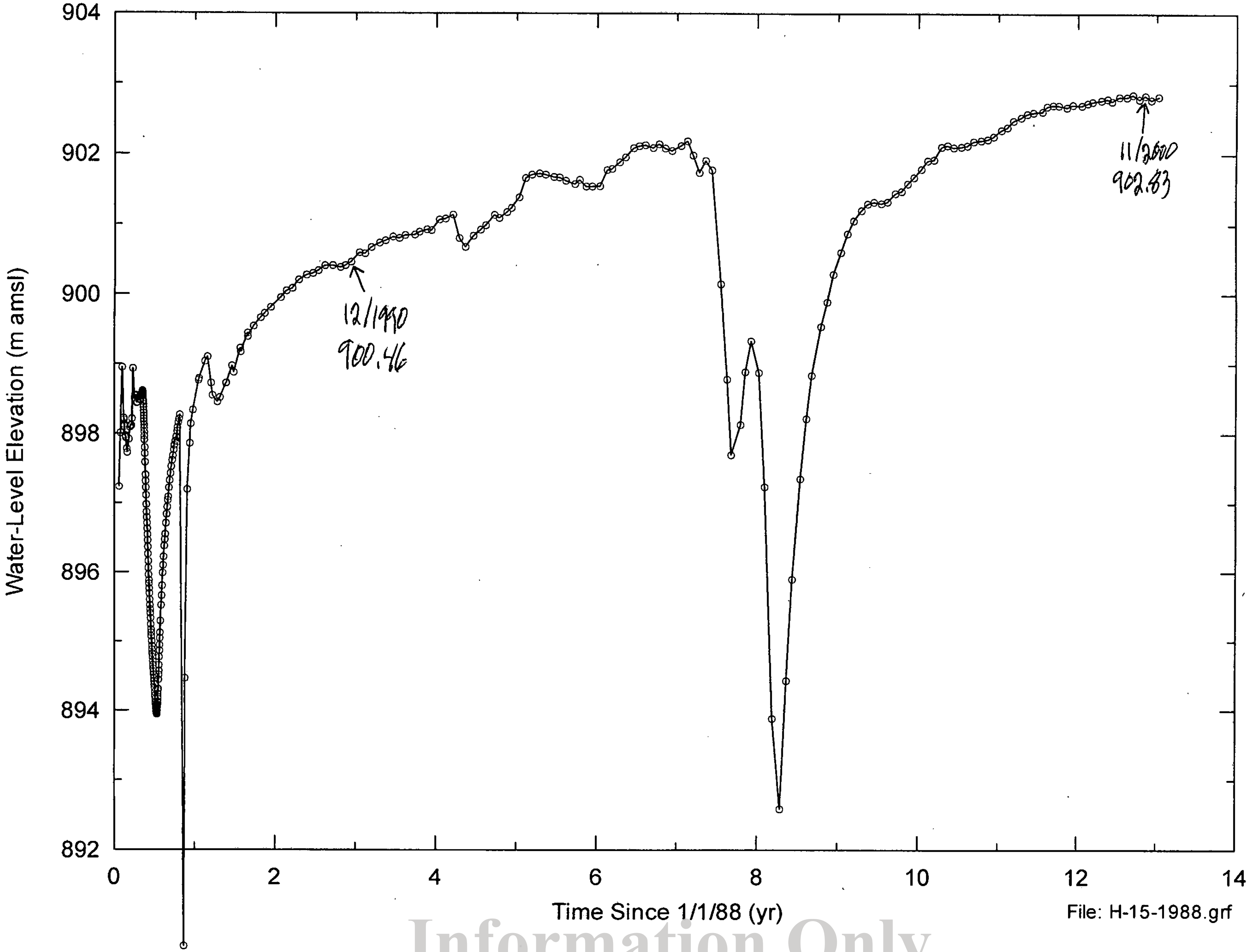
H-12 Culebra Hydrograph, 1988-2002
906
905
904
903
902
0
5
10
15
Water-Level Elevation (m amsl)
Time Since 1/1/88 (yr)
12/1990
904.48
11/2000
905.02
File: H-12-1988.grf

H-14 Culebra Hydrograph, 1988-1/2001



File: H-14-1988.grf

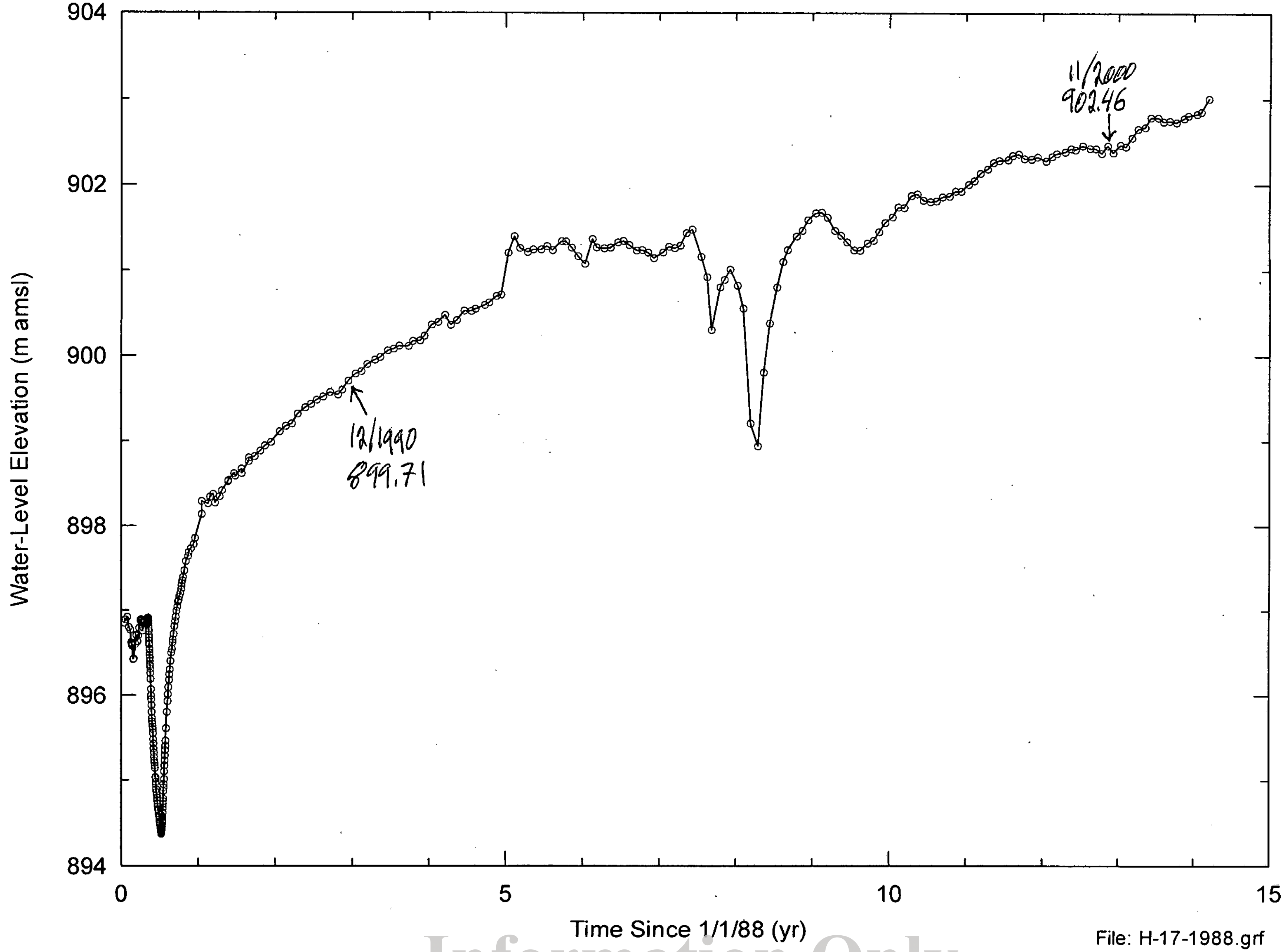
H-15 Culebra Hydrograph, 1988-1/2001



File: H-15-1988.grf

48

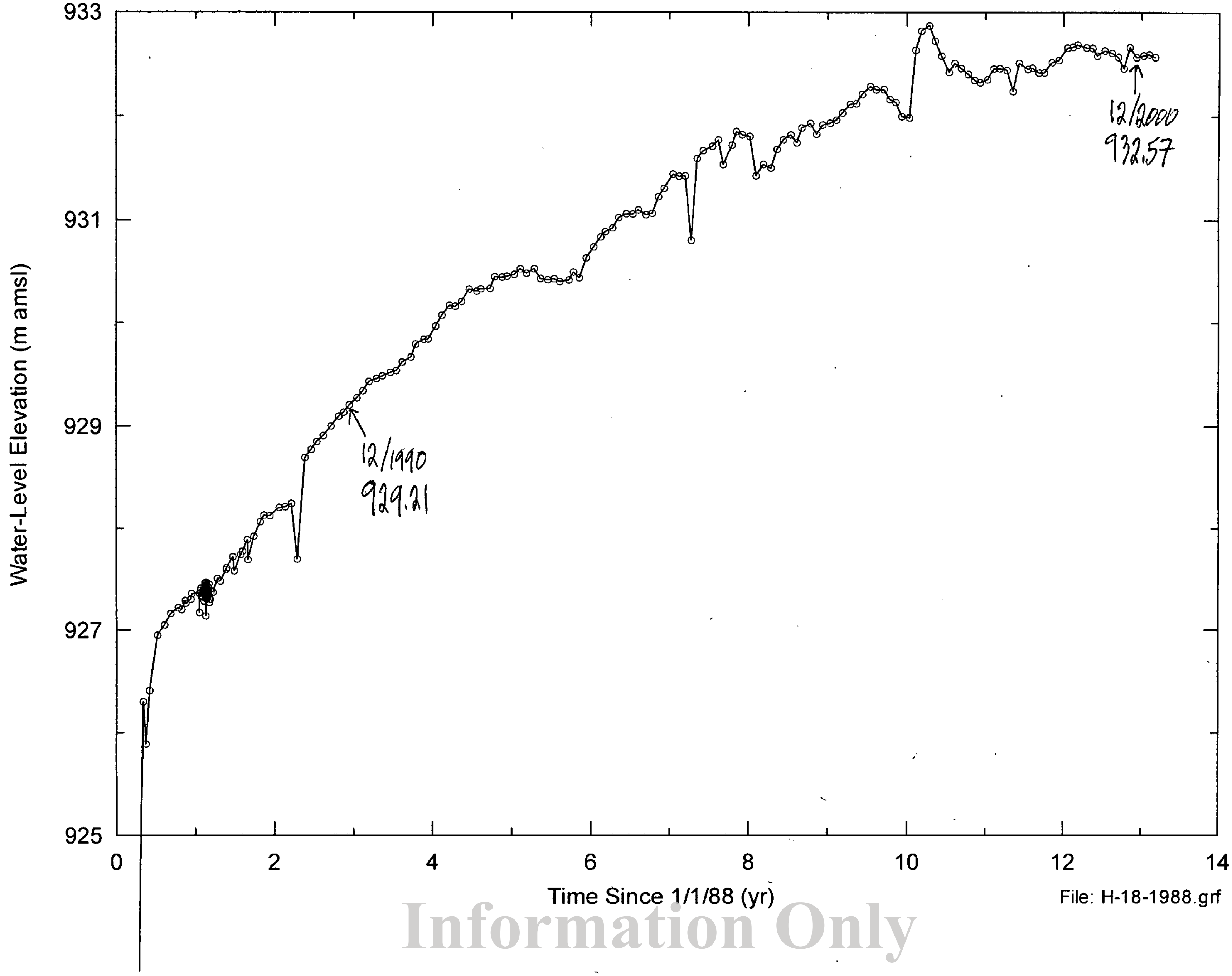
H-17 Culebra Hydrograph, 1988-2002



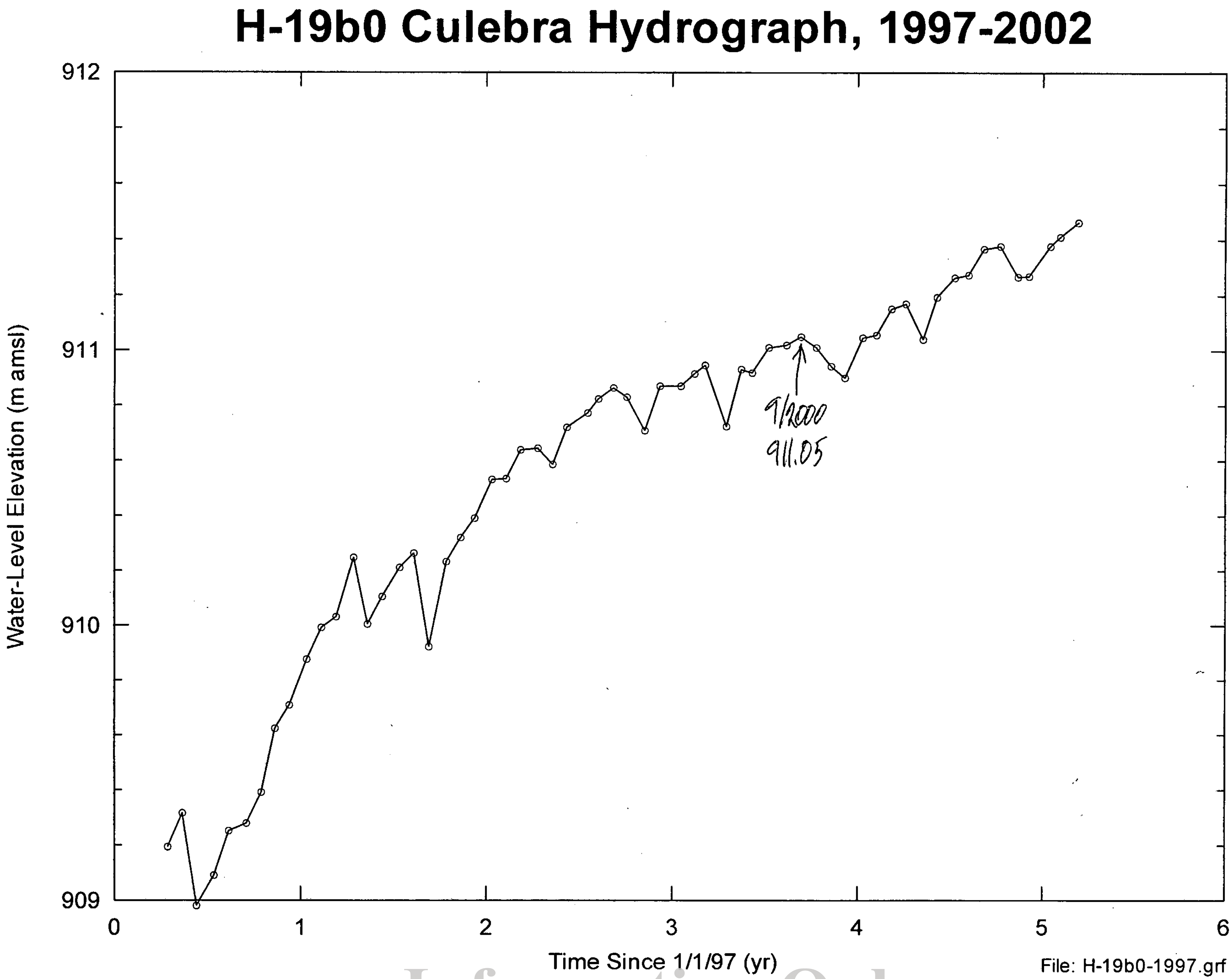
File: H-17-1988.grf

49

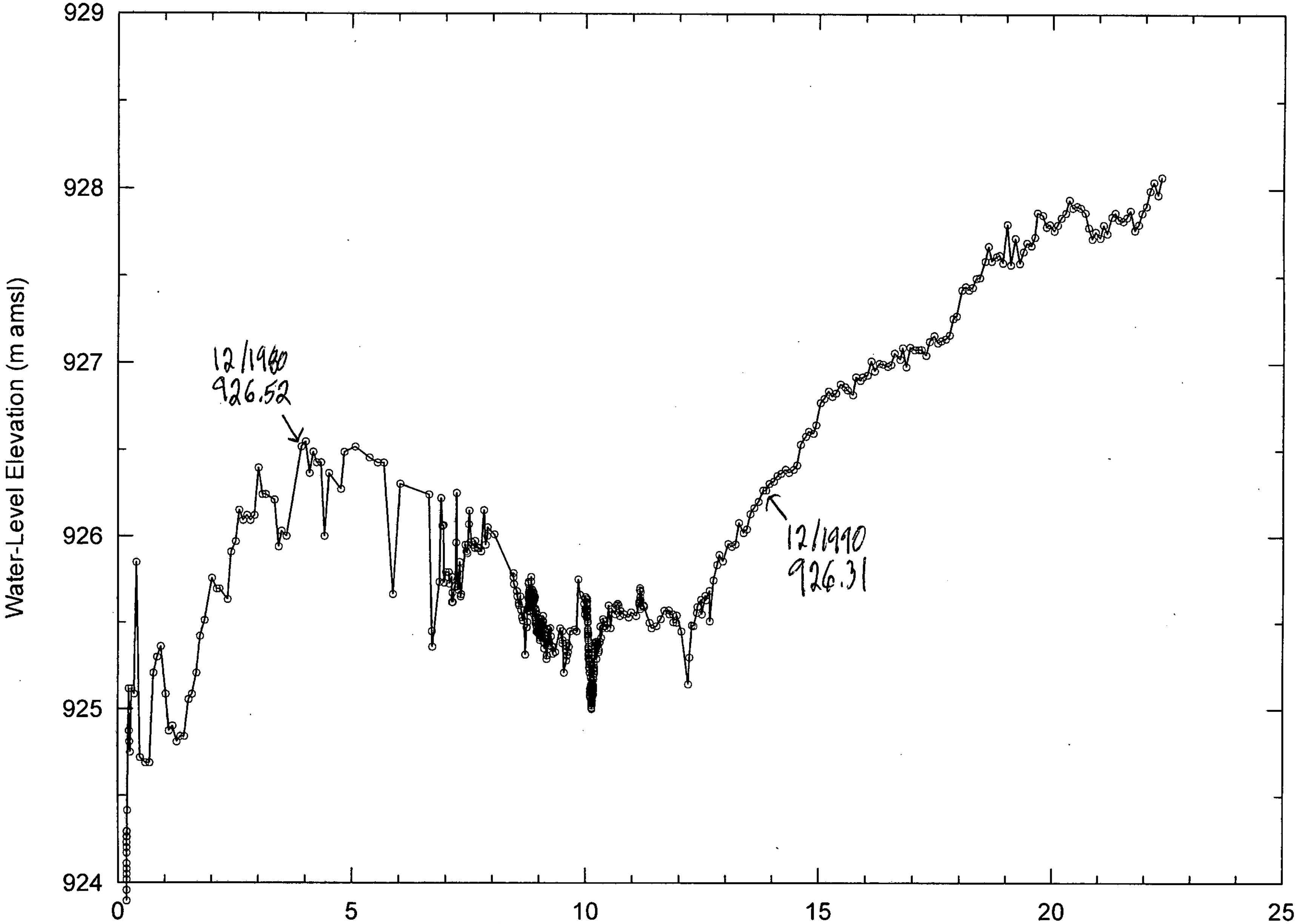
H-18 Culebra Hydrograph, 1988-3/2001



File: H-18-1988.grf


H-19b0 Culebra Hydrograph, 1997-2002
Water-Level Elevation (m amsl)
912
911
910
909
0
1
2
3
4
5
6
Time Since 1/1/97 (yr)
9/2000
911.05
File: H-19b0-1997.grf

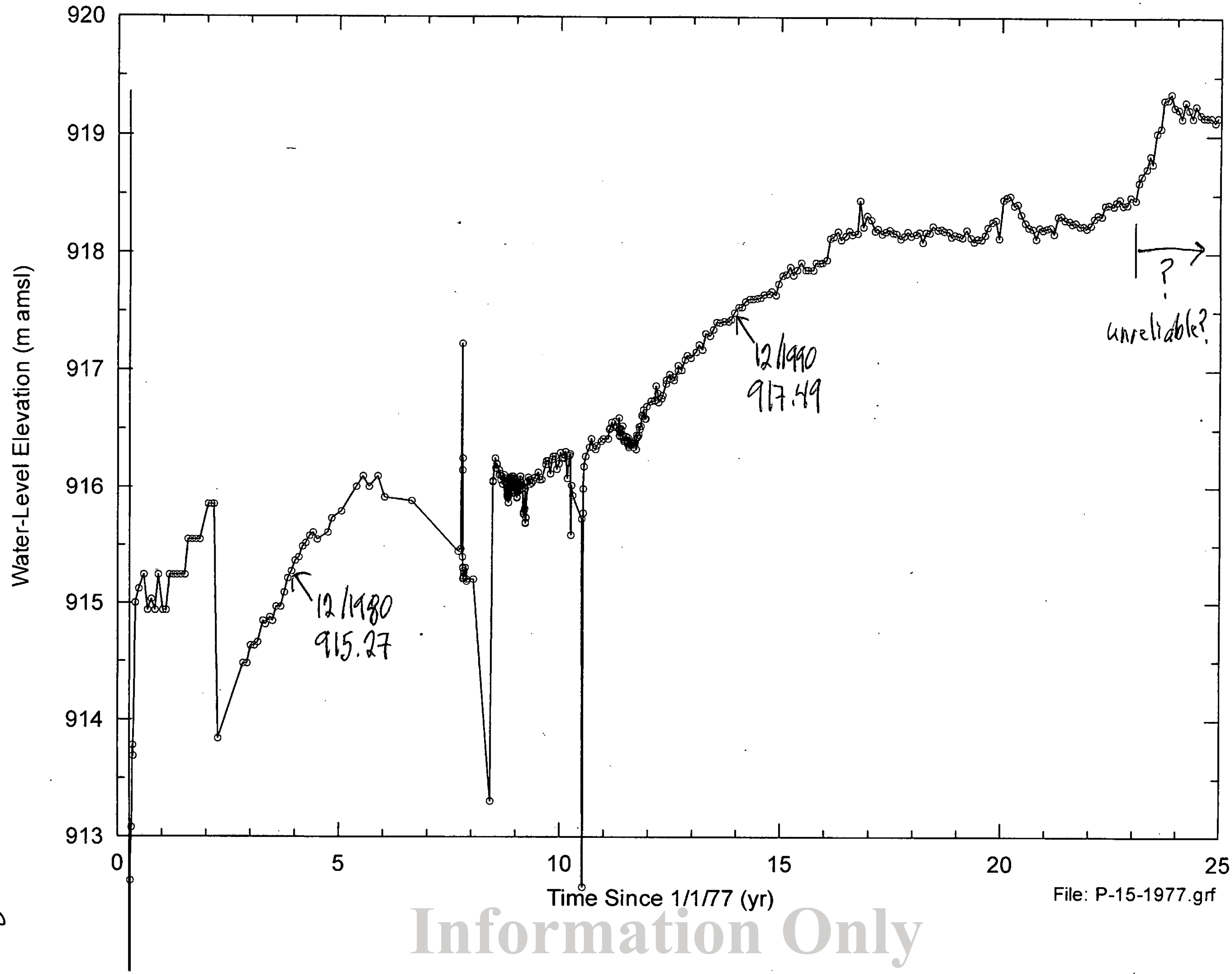
P-14 Culebra Hydrograph, 1977-8/1999



File: P-14-1977.grf

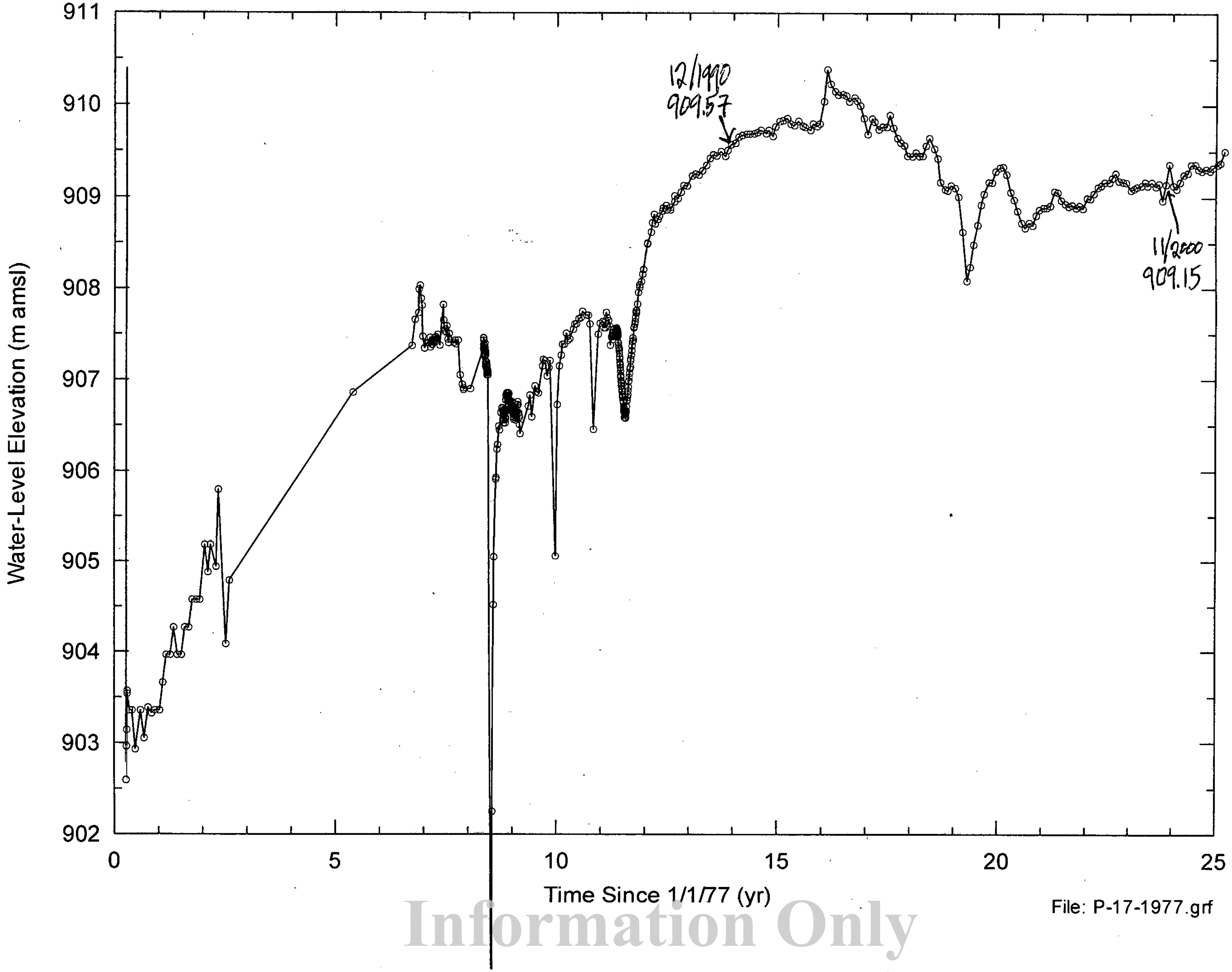
52

P-15 Culebra Hydrograph, 1977-2001



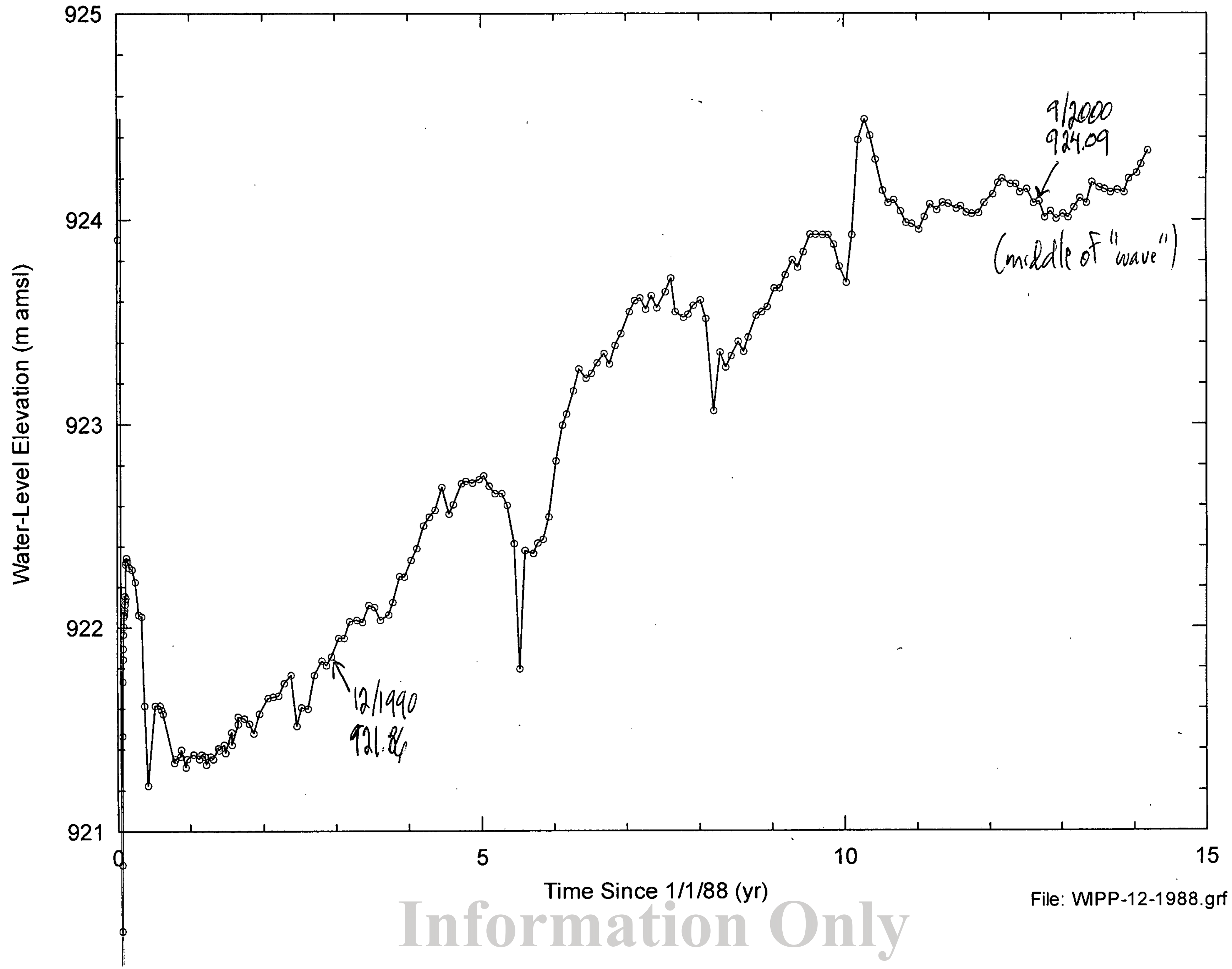
53

P-17 Culebra Hydrograph, 1977-2002



File: P-17-1977.grf

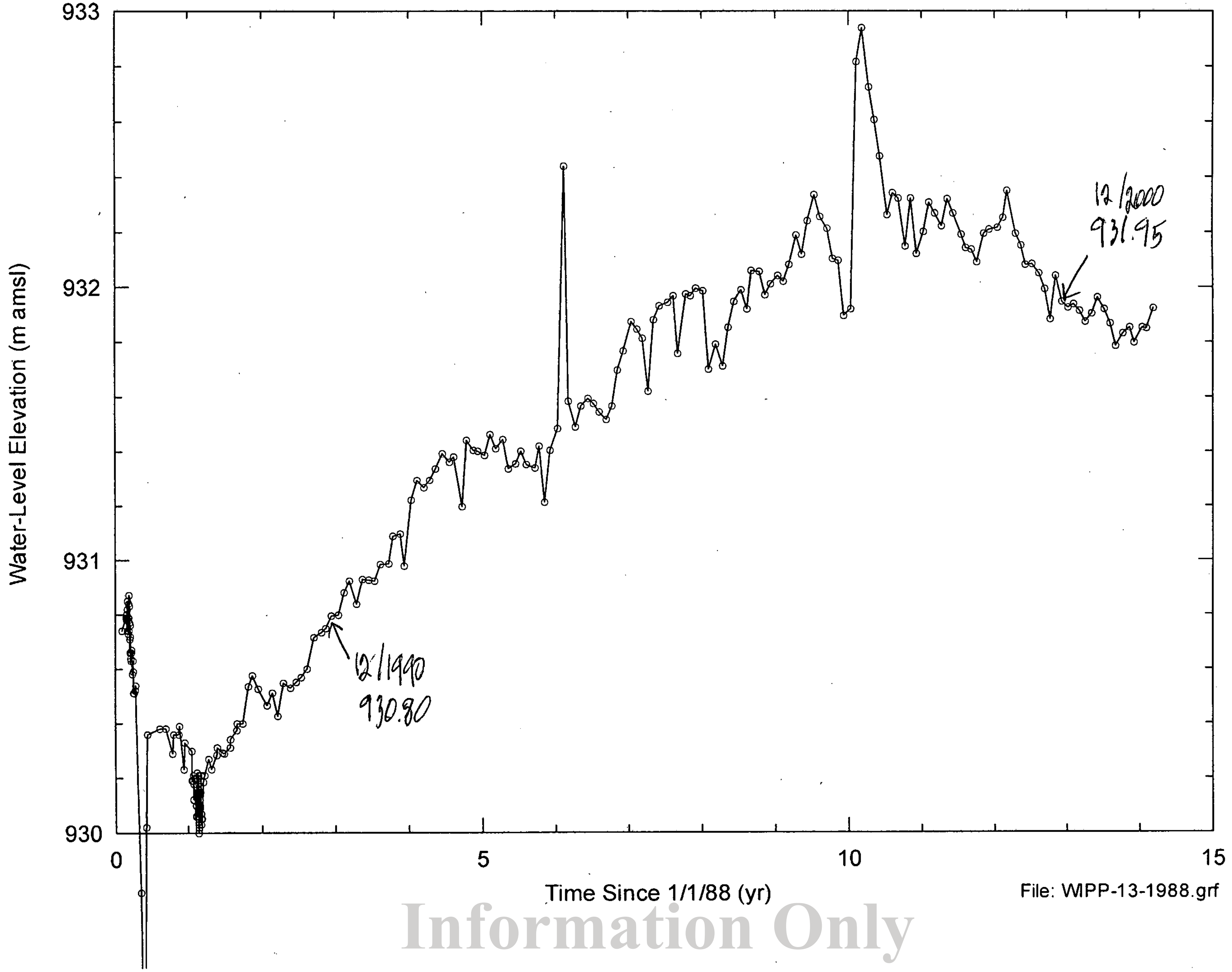
WIPP-12 Culebra Hydrograph, 1988-2002



File: WIPP-12-1988.grf

55

WIPP-13 Culebra Hydrograph, 1988-2002



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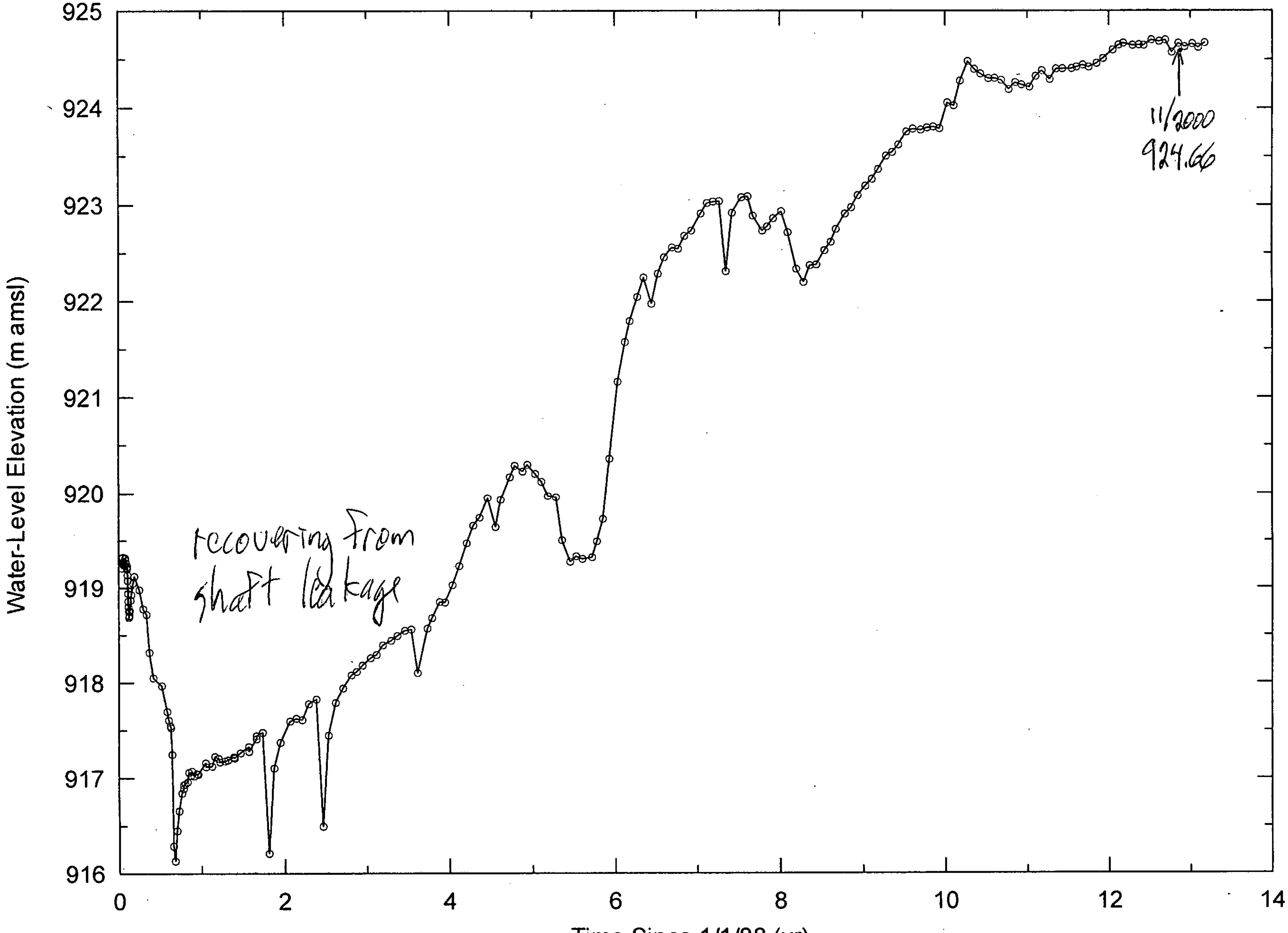
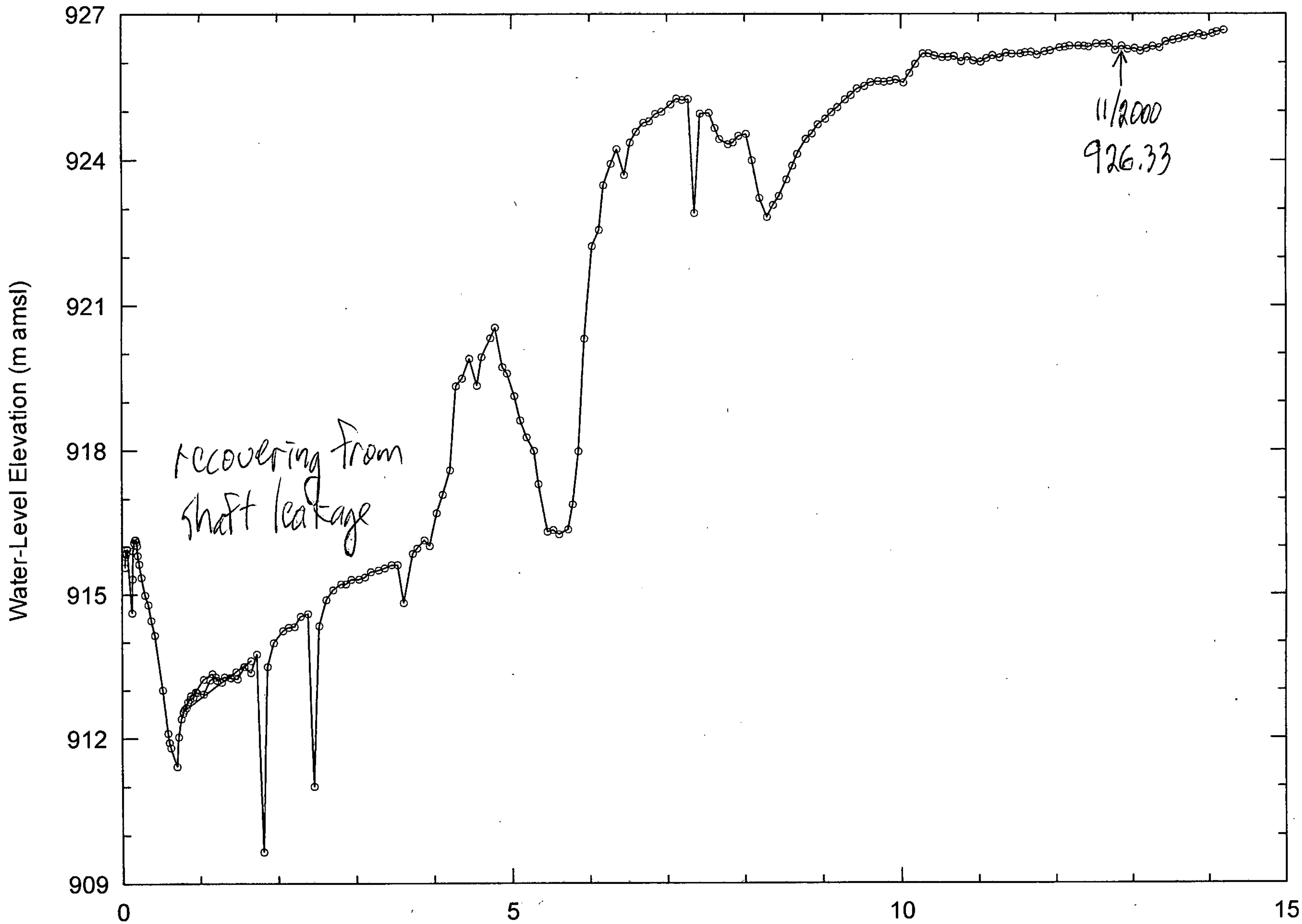
WIPP-18 Culebra Hydrograph, 1988-3/2001



File: WIPP-18-1988.grf

WIPP-19 Culebra Hydrograph, 1988-2002



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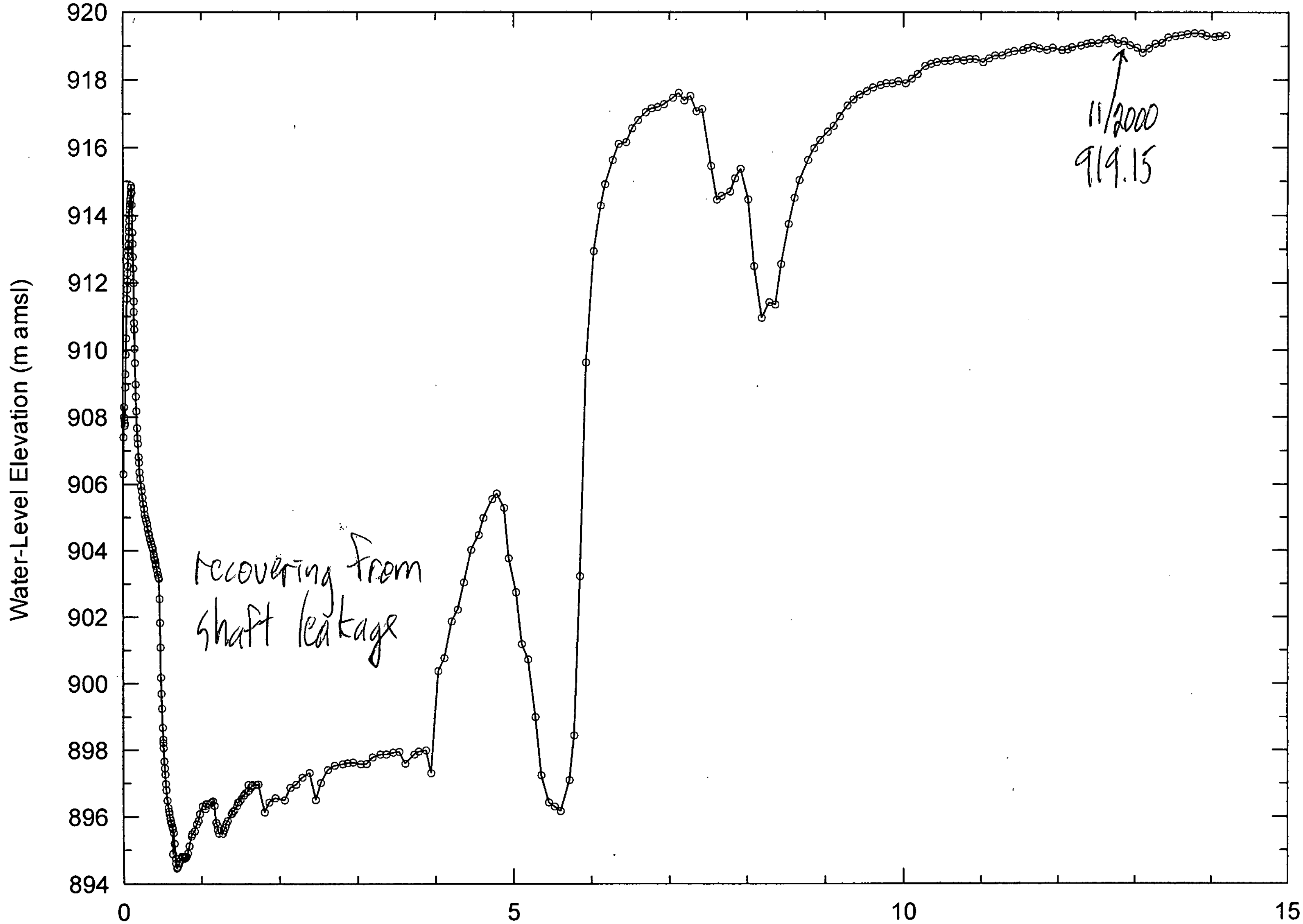
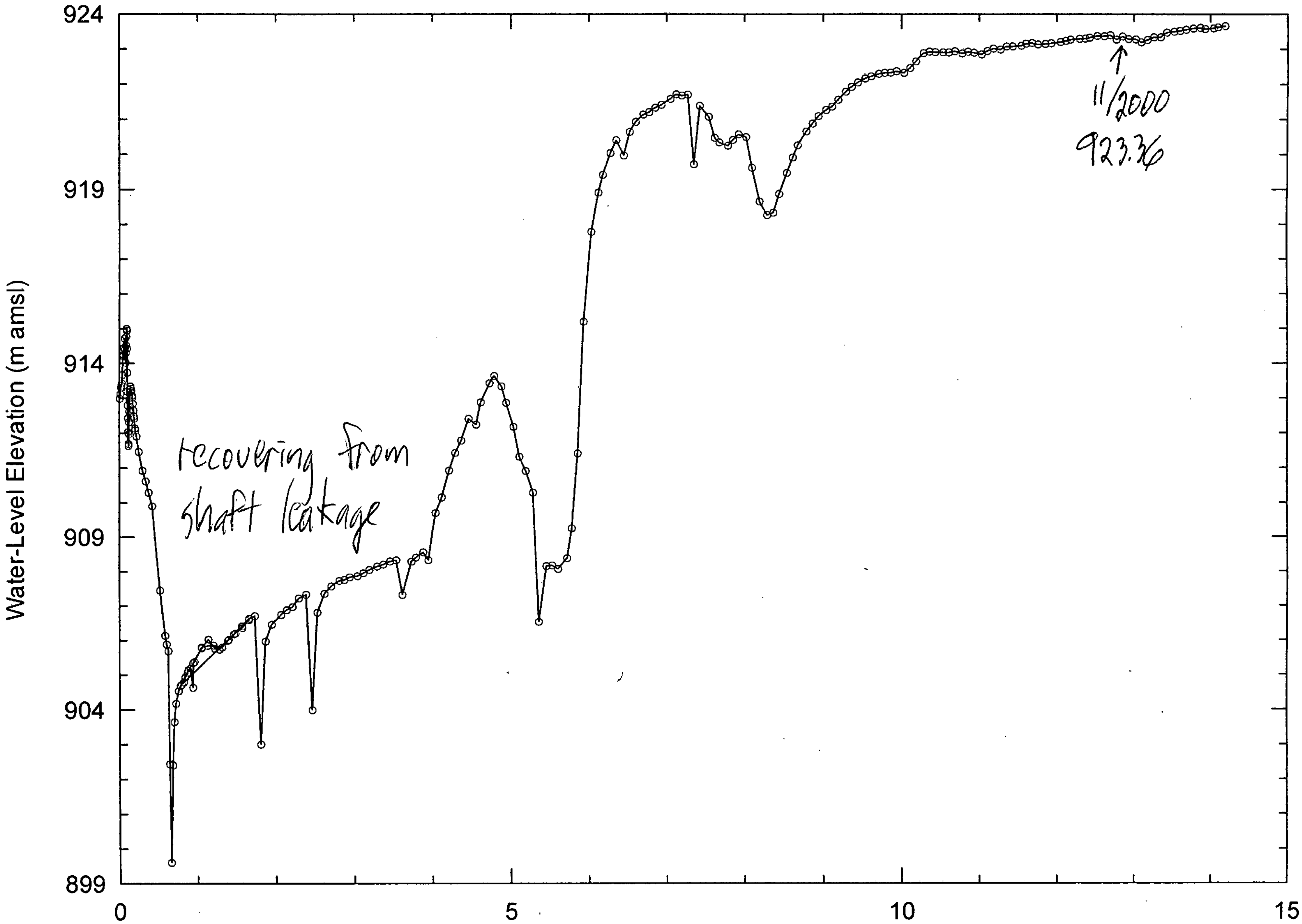
WIPP-21 Culebra Hydrograph, 1988-2002



File: WIPP-21-1988.grf

WIPP-22 Culebra Hydrograph, 1988-2002



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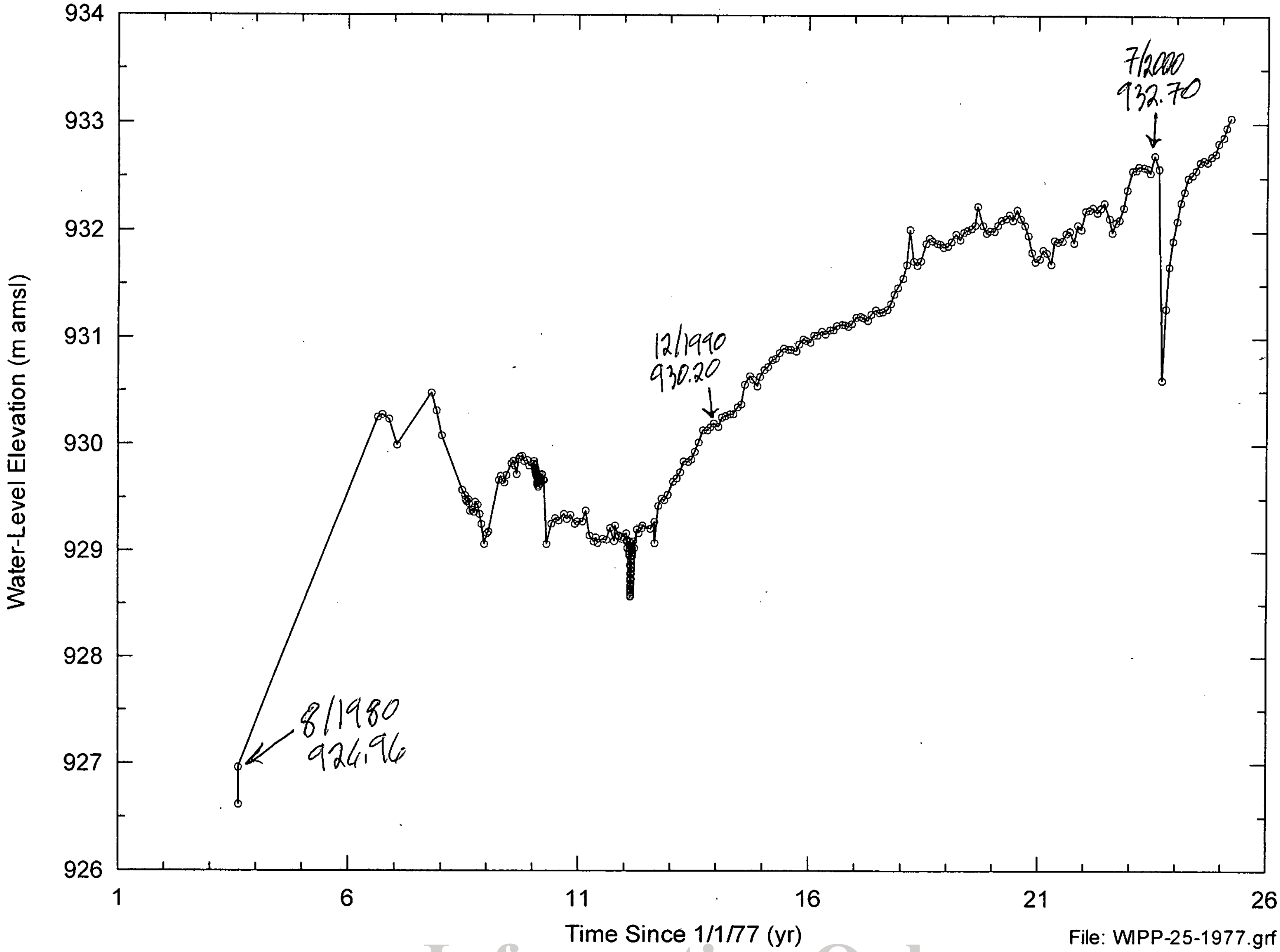
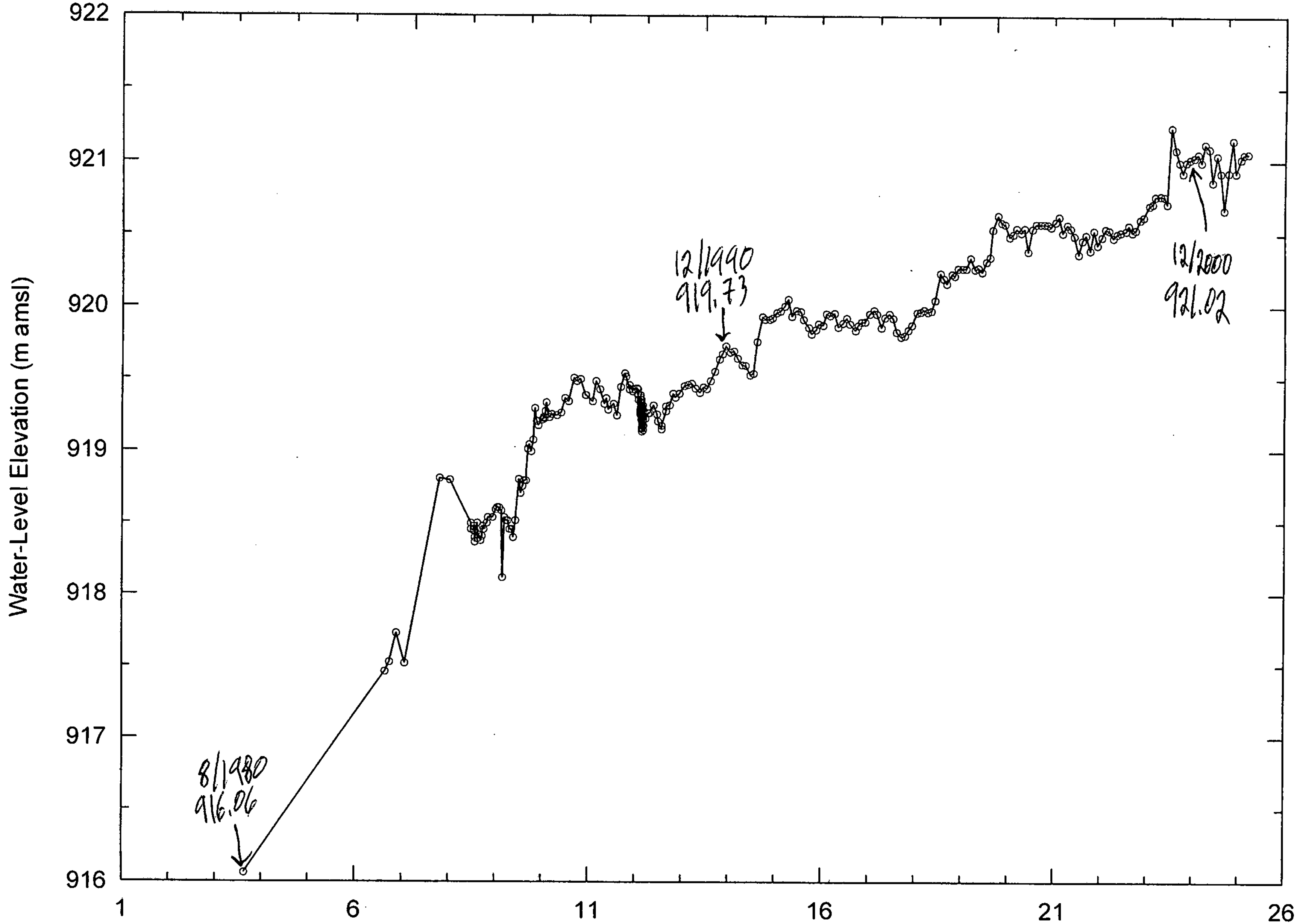
WIPP-25 Culebra Hydrograph, 1978-2002



61

WIPP-26 Culebra Hydrograph, 1978-2002



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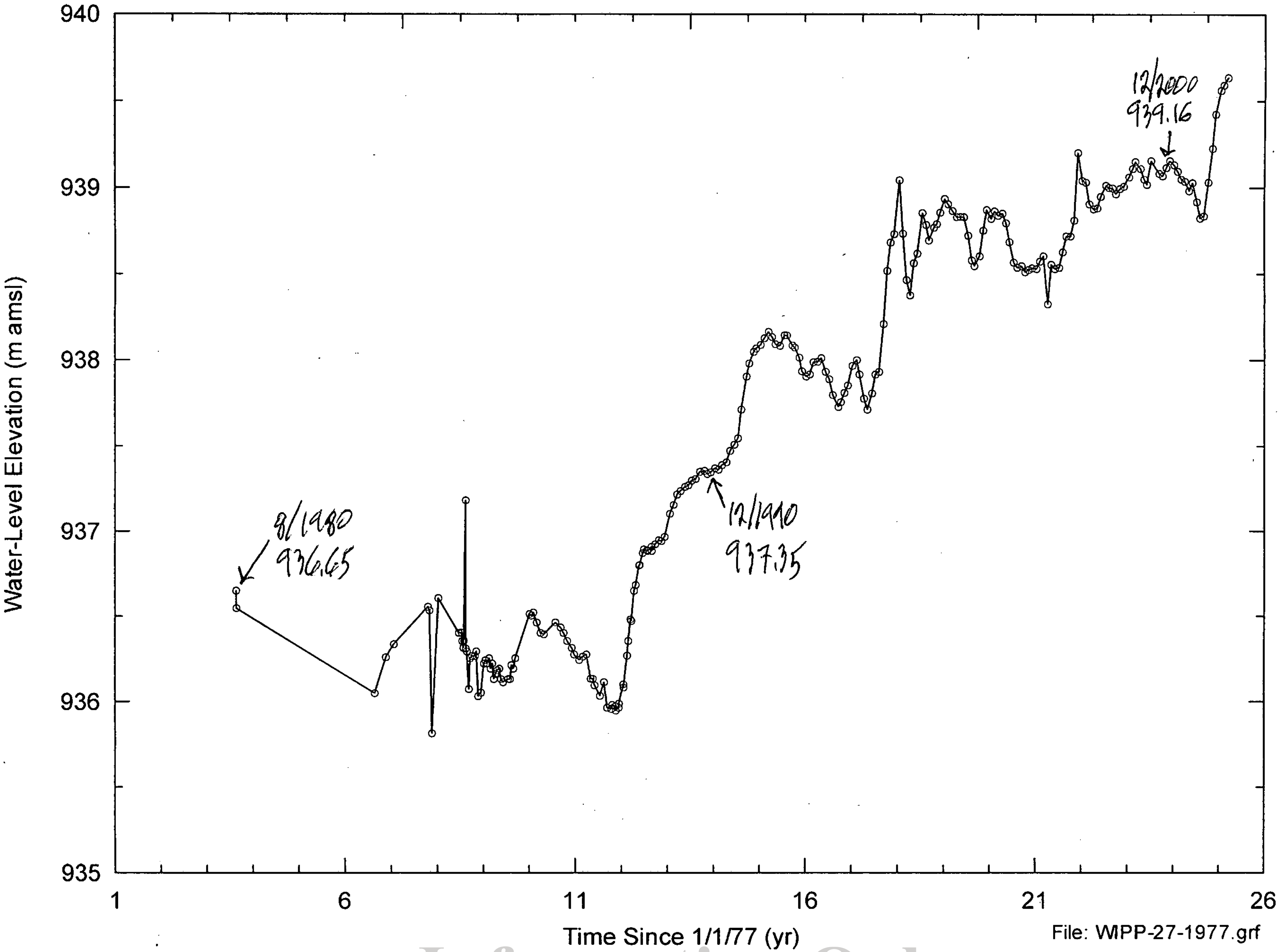
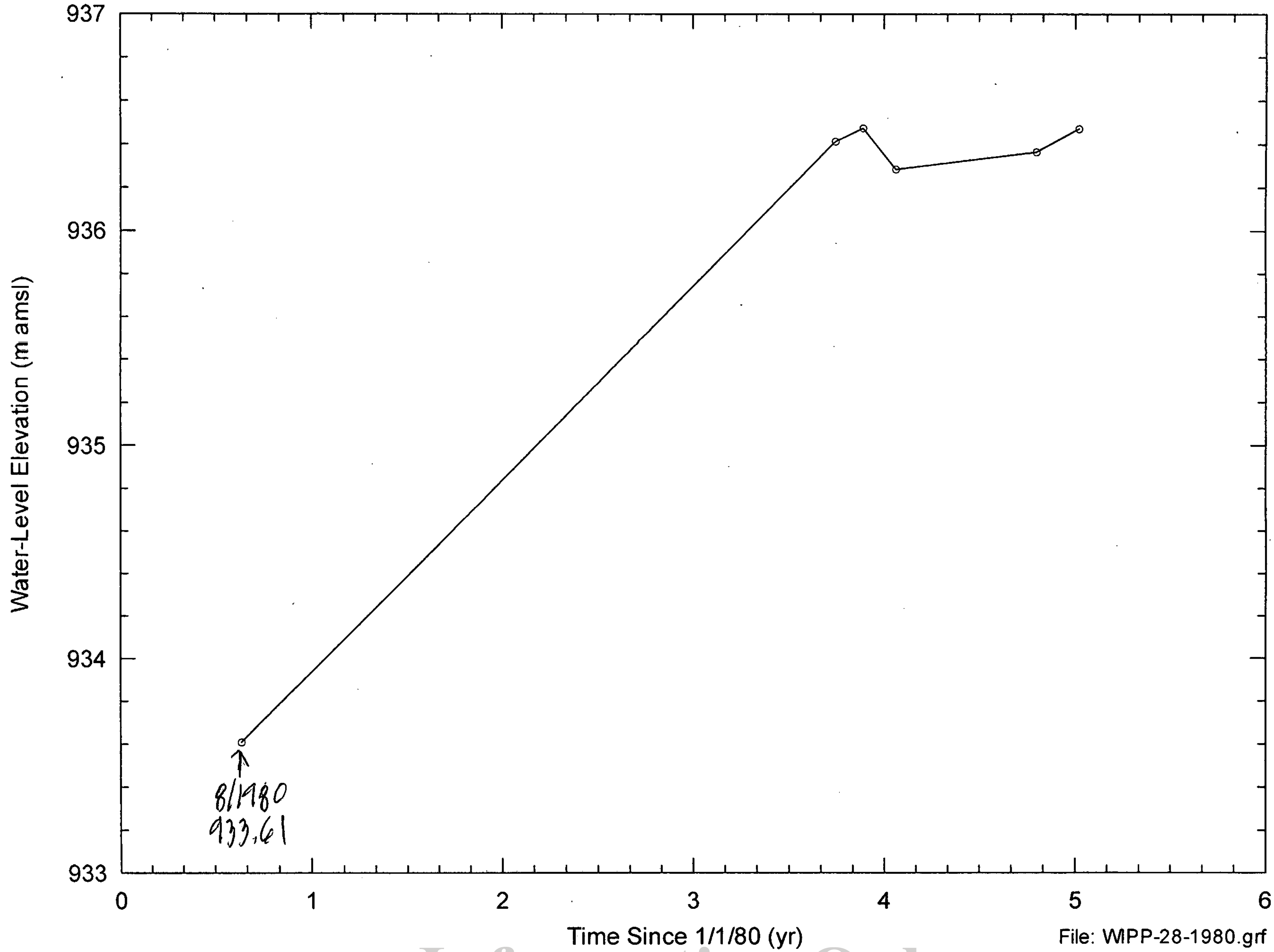
WIPP-27 Culebra Hydrograph, 1978-2002



File: WIPP-27-1977.grf

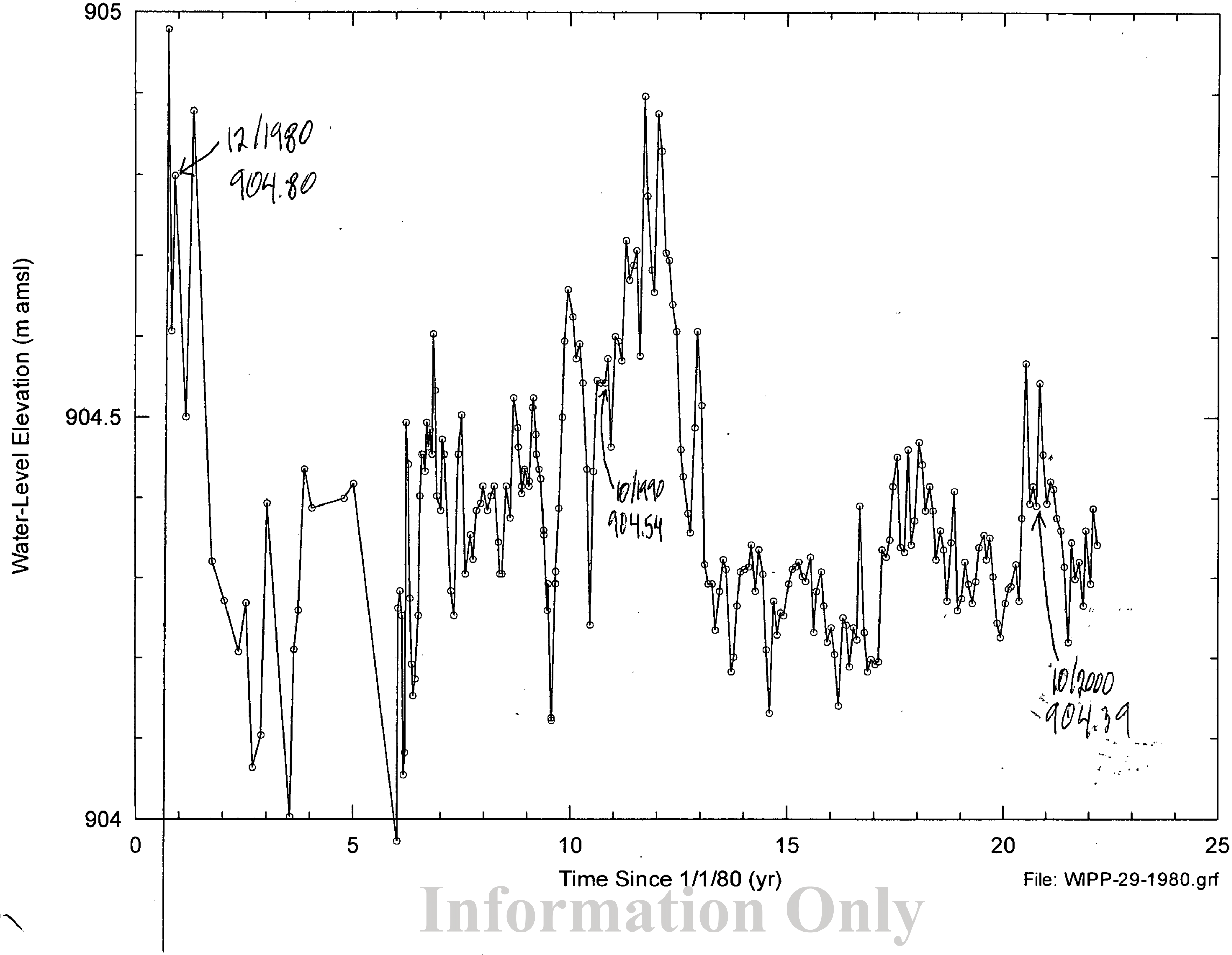
63

WIPP-28 Culebra Hydrograph, 1980-1985



69

WIPP-29 Culebra Hydrograph, 1980-2002



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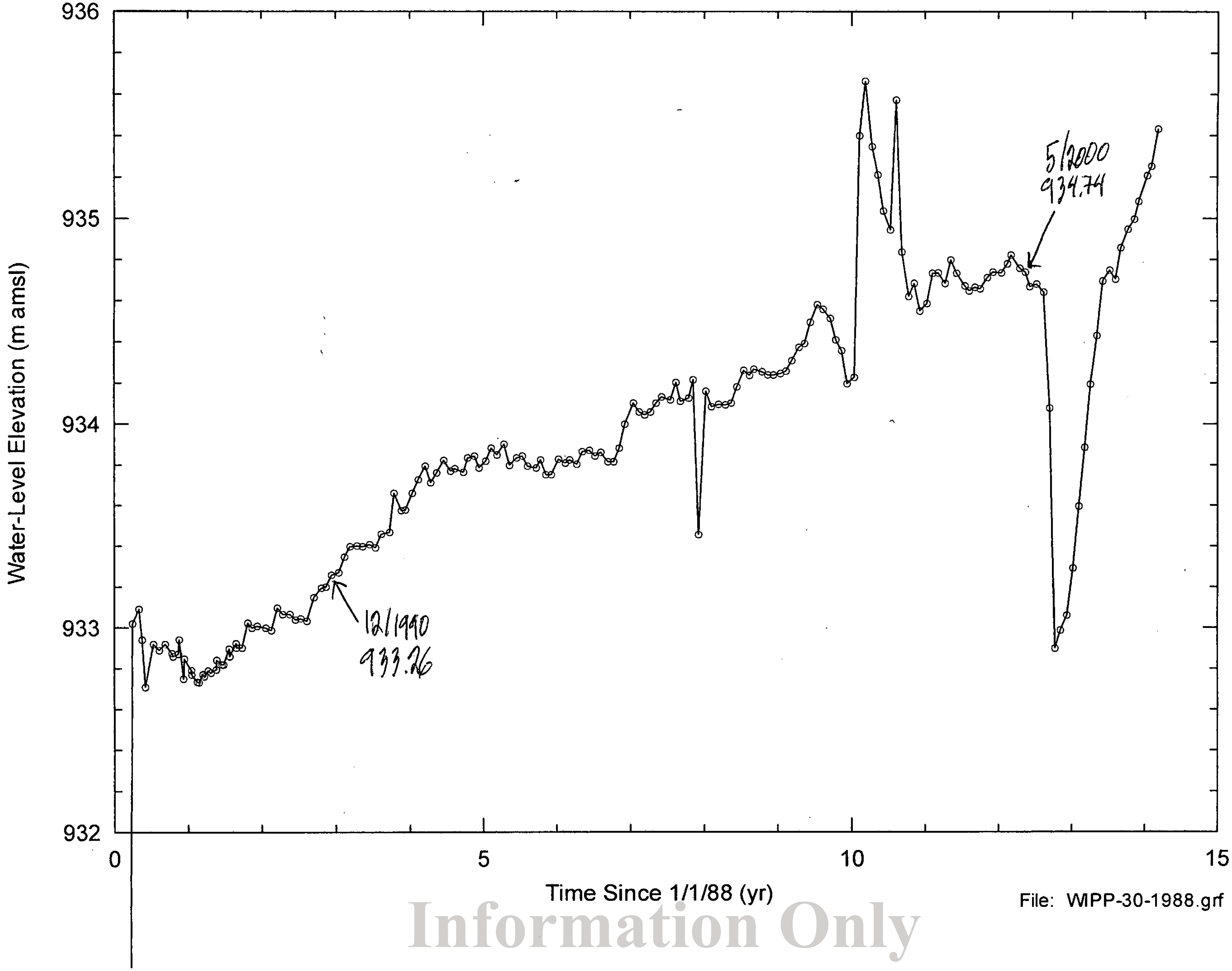
65

WIPP-30 Culebra Hydrograph, 1988-2002



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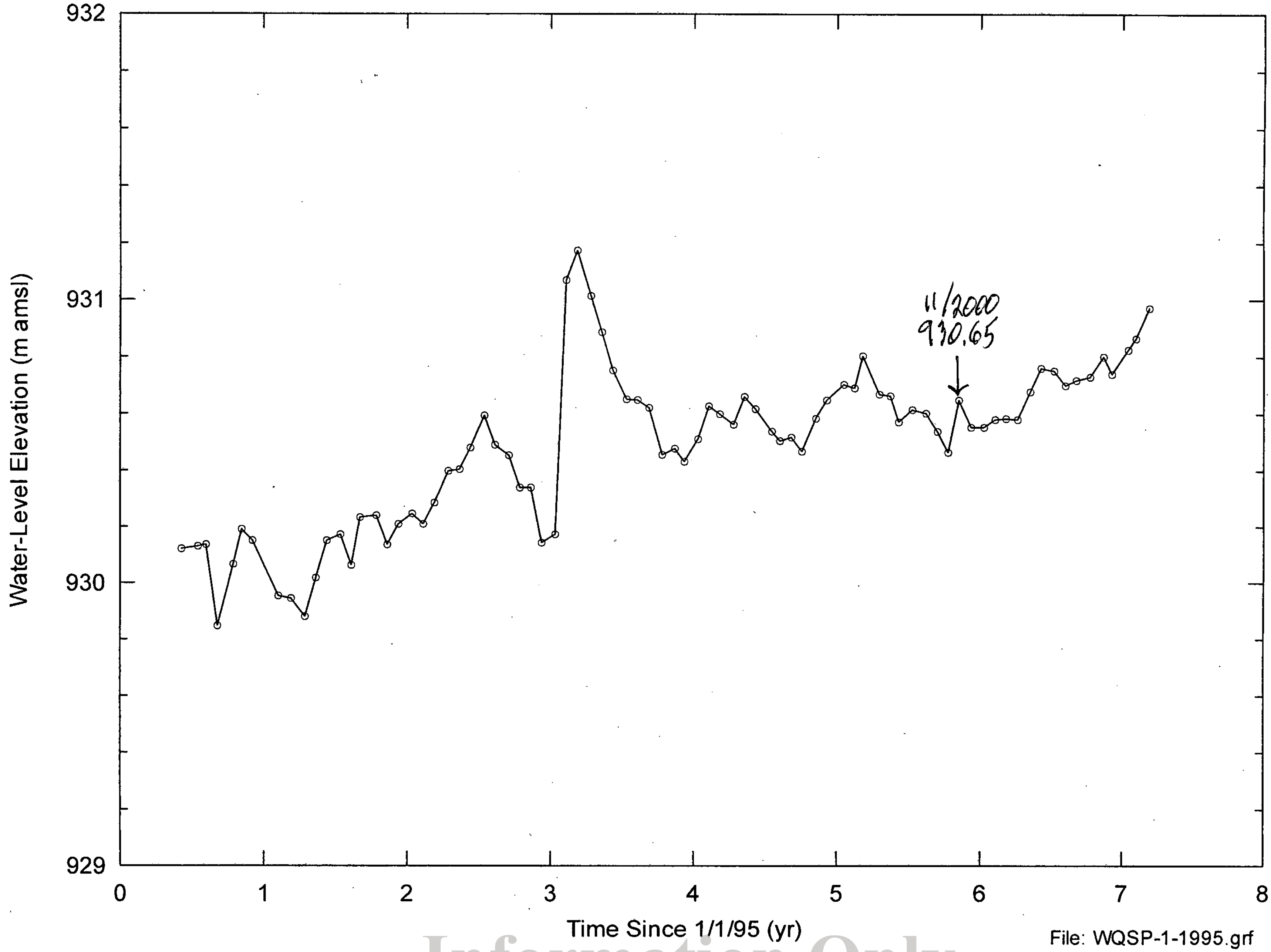
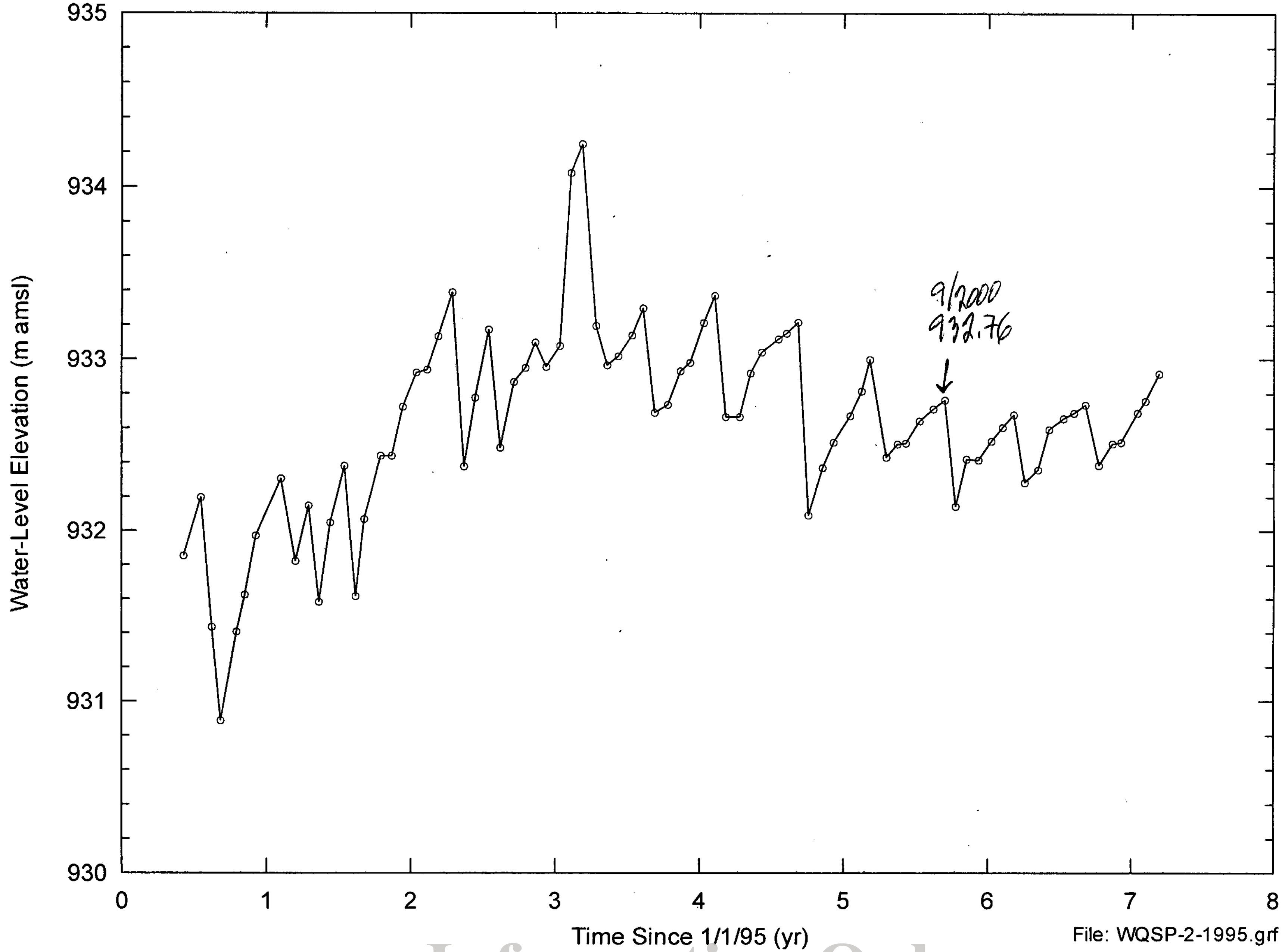
WQSP-1 Culebra Hydrograph, 1995-2002



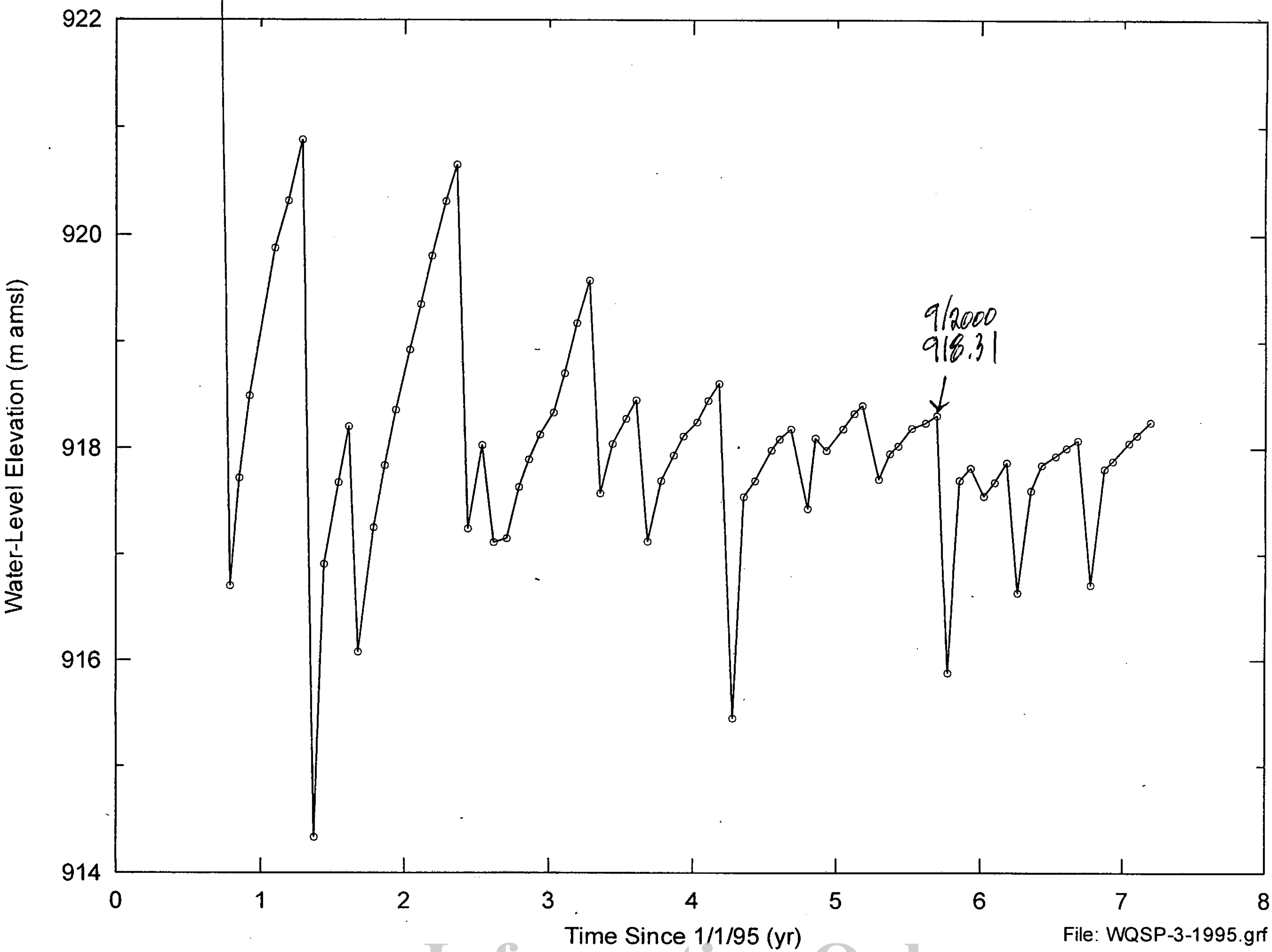
File: WQSP-1-1995.grf

67

WQSP-2 Culebra Hydrograph, 1995-2002



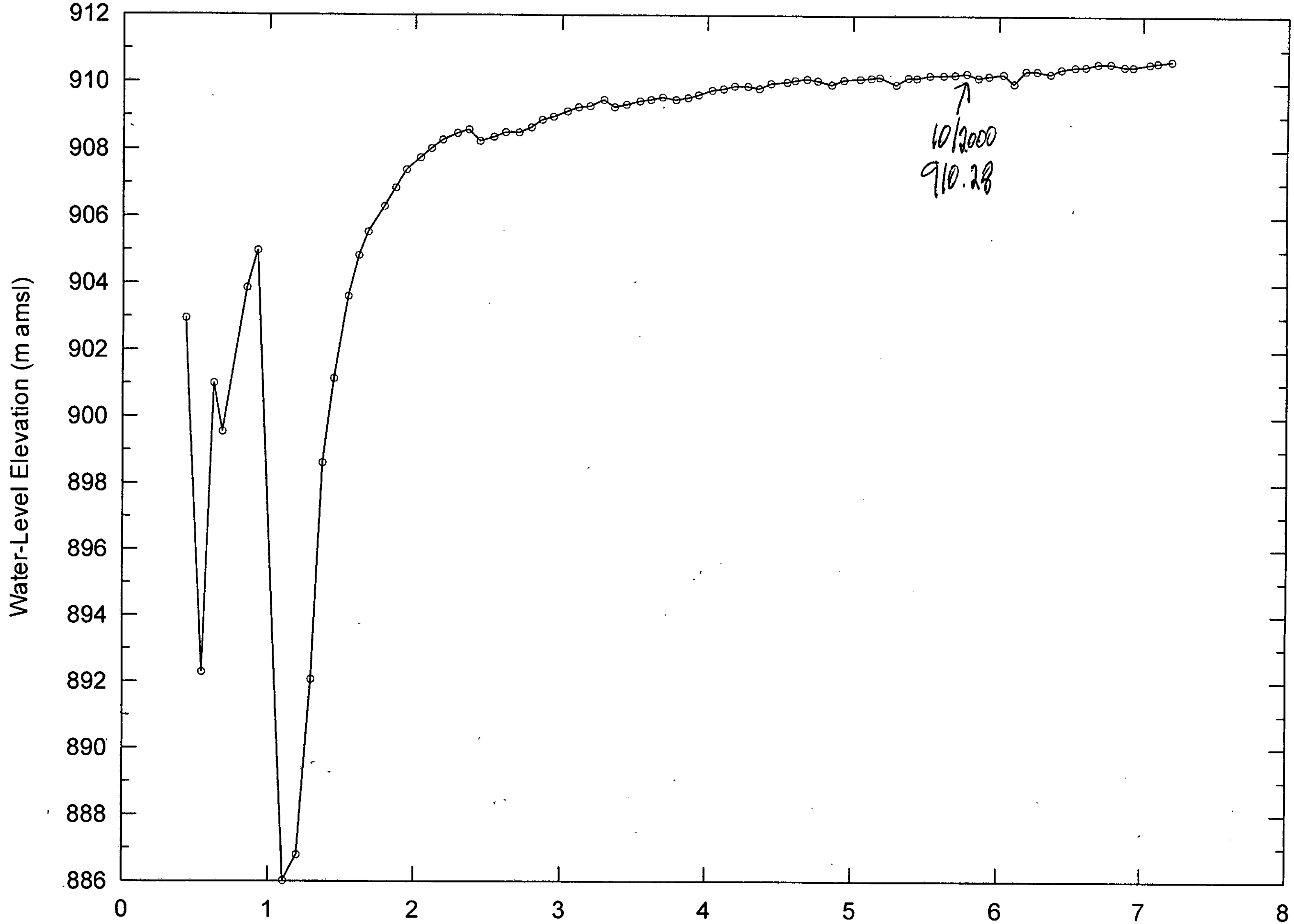
WQSP-3 Culebra Hydrograph, 1995-2002



File: WQSP-3-1995.grf

69

WQSP-4 Culebra Hydrograph, 1995-2002



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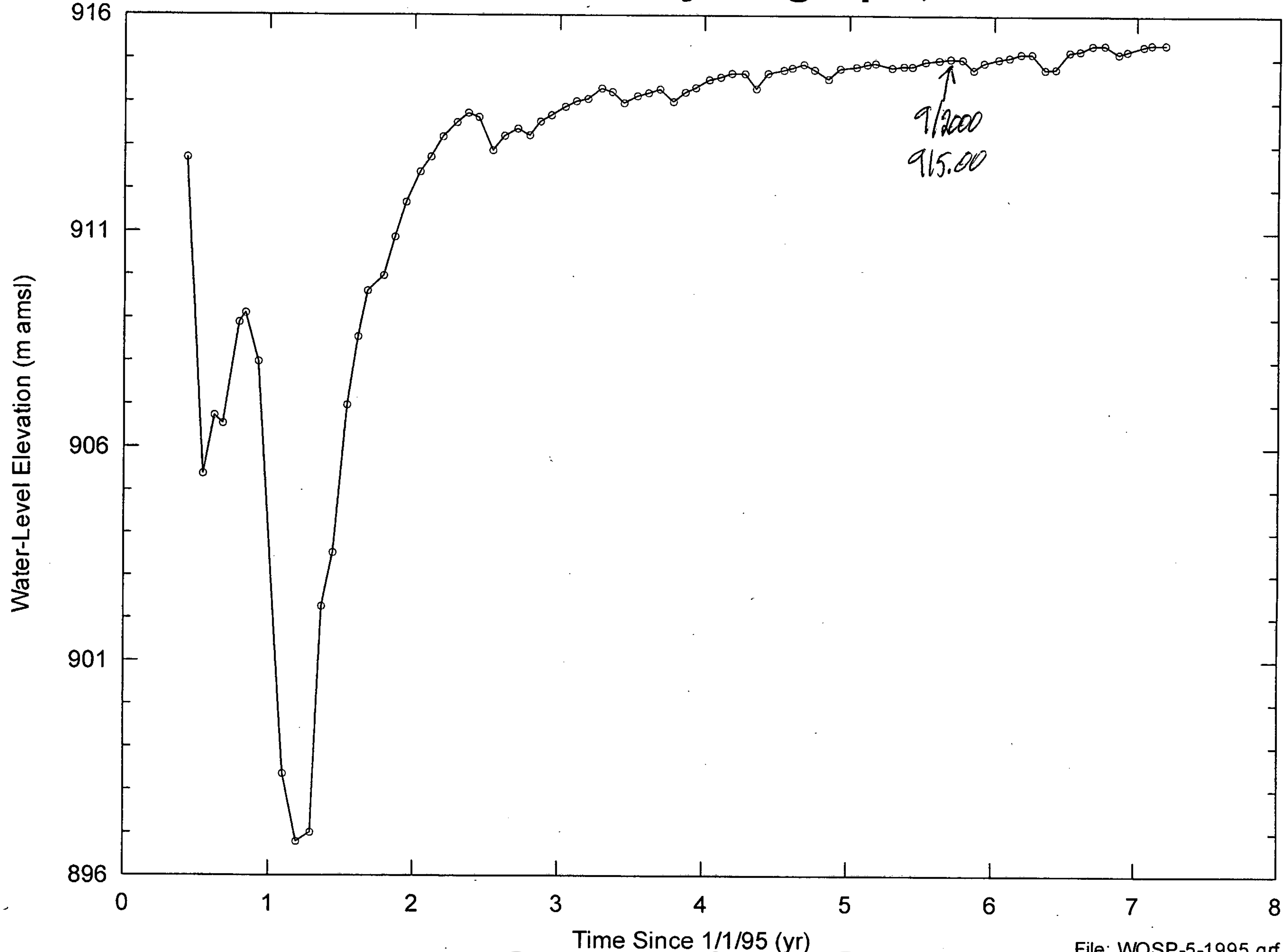
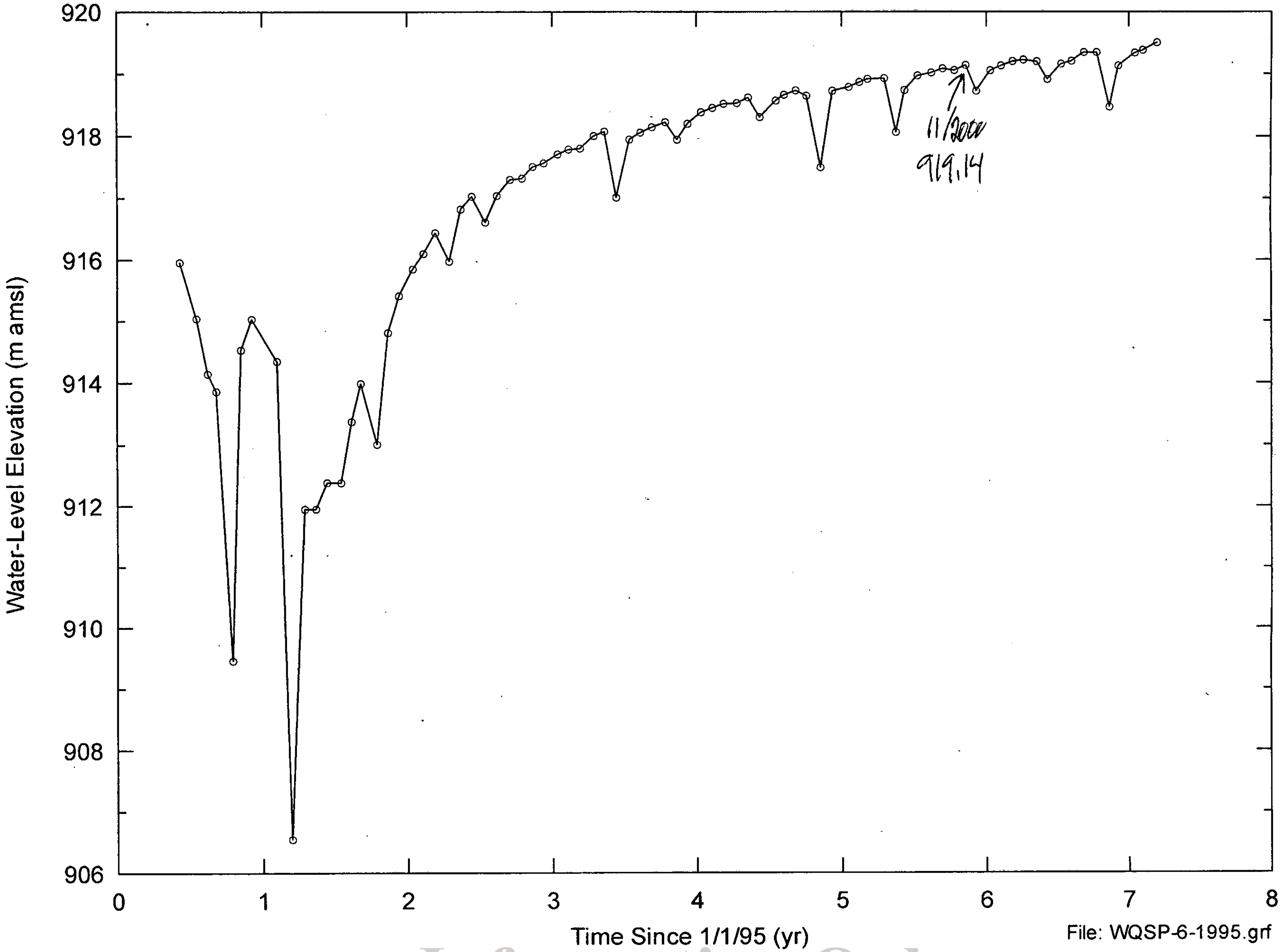
WQSP-5 Culebra Hydrograph, 1995-2002



File: WQSP-5-1995.grf

71

WQSP-6 Culebra Hydrograph, 1995-2002



72