6.0 BACKGROUND WATER QUALITY

This section provides information on the ground water monitoring program at the Grants Project, an assessment of full range of background concentrations for the alluvial and Chinle aquifers and the related mixing zone, and the rationale for identifying background monitoring wells and their related constituent levels.

6.1 WATER QUALITY MONITORING

HMC's Standard Operating Procedure (SOP) for monitoring ground water specifies exact procedures for sample collection, sample handling and shipping, laboratory processing and data review and management. The SOP lists the equipment to be used in collecting samples, procedures for sample collection, and the sample preservation techniques. The procedure requires measurement of the static water level prior to sampling the well. Removal of at least two casing volumes of water from the well is usually produced before final field conductivity measurements are taken and prior to sample collection. Samples are filtered with a 0.45 micron filter, and the appropriate preservative is added to each sample prior to shipment to the laboratory. On an annual basis, ten percent of the regulatory permit related samples collected are split as a quality assurance-quality control measure.

The SOP also dictates the protocols used for the data review and validation. The most recent results are compared to those from previous analyses to determine if laboratory rechecks are necessary. Water quality constituent detection limits that have been customarily used for Grants Project samples by Energy Laboratory and the HMC on-site laboratory are shown in Table 6-1. These two laboratories analyzed a majority of the samples in the database. The New Mexico Environmental Department laboratory and Barringer Laboratory analyzed a few samples. The available detection limits for the NMED and Barringer samples were similar to those presented in Table 6-1 for Energy Laboratory and the HMC laboratory.

For the calculation of background constituent concentrations, wells were selected based on confirmation of acceptable well completion and the appropriateness of the well location for defining background water quality as defined in earlier sections of this report. The water-quality

TABLE 6-1. GRANTS PROJECT WATER QUALITY DETECTION LIMITS

Constituent	Lab	Period	Detection Value
Sulfate	Energy	1992 - 2003	1 mg/l
TDS	Energy	1992 - 2003	10 mg/l
Chloride	Energy	1992 - 2003	0.1 mg/l
Uranium	Energy	1992 - 1995	0.01 mg/l
	Energy	1995 - 2003	0.0003 mg/l
	HMC	1976 - 1993	0.01 mg/l
Selenium	Energy	1992 - 1996	0.01 mg/l
	Energy	1997 - 2003	0.005 mg/l
	HMC	1976 - 1993	0.01 mg/l
Molybdenum	Energy	1992 - 1993	0.01 mg/l
	Energy	1993 - 2003	0.03 mg/l
	HMC	1976 - 1993	0.01 mg/l
Nitrate	Energy	1992 - 2003	0.1 mg/l
	HMC	1976 - 1993	0.1 mg/l
Radium-226	Energy	1992 - 2003	0.2 pCi/l
	HMC	1976 - 1993	0.2 pCi/l
Radium-228	Energy	1992 - 2003	1 pCi/l
Vanadium	Energy	1992 - 2003	0.1 mg/l
	HMC	1976 - 1993	0.1 mg/l
Thorium-230	Energy	1992 - 2003	0.2 pCi/l

data from the selected wells were retrieved from the HMC database and supplied to the statistical evaluation contractor Environmental Restoration Group, Inc (ERG) of Albuquerque, N.M.

6.2 ALLUVIAL AQUIFER BACKGROUND WATER QUALITY

Site standards were set for the alluvial aquifer water-quality constituents at the Grants Project in the 1980's. The standards were established for the Grants Project site by averaging measured constituent concentrations for a limited number of samples. However, the use of an average concentration is not appropriate to represent background concentrations, because, by definition, concentrations in a portion of the samples used to calculate the average would exceed the average. In combination with a limited data set, the average concentration method for establishing a site standard does not produce a representative standard. A representative site standard must consider the range of background concentrations in order to determine when a true exceedance of a background concentration(s) has occurred. Alluvial aquifer background concentrations, which

account for the full natural range in concentrations and include an expanded data set, have been calculated and were presented in the 2001 submittal and are repeated later in this section for comparison with the Chinle aquifer background concentrations.

6.2.1 EXISTING SITE STANDARDS

Water-quality standards for constituents U, Se, Mo, Ra226 + Ra228, Th230 and V were set for the alluvial aquifer at the Grants Project by the NRC in 1989. These site standards are applicable at three Point of Compliance (POC) wells, S4, D1 and X (see Figure 6-1 for locations) and are specified in the site NRC license SUA-1471 - Condition 35. The six site standards, shown in Table 6-2, were set by averaging three data values from one of five background wells available at the time. The NMED standards for uranium, selenium, molybdenum, radium-226 plus radium-228, sulfate, chloride, TDS and nitrate for this site were established in 1984 and also are shown in Table 6-2. The State standards were set during the initial Groundwater Discharge Permit (DP-200) approval process, also by averaging concentrations. As stated previously, the use of average values is not appropriate for setting background concentration limits. NRC alluvial aquifer site standards need to be established for sulfate, chloride, TDS and nitrate based on the appropriate range of background concentrations.

TABLE 6-2. GRANTS PROJECT ALLUVIAL WATER-QUALITY STANDARDS

Constituents	Current Standards	
	NRC	NEW MEXICO
Uranium	0.04	5
Selenium	0.10	0.12
Molybdenum	0.03	1.0@
Sulfate	----	976
Chloride	----	250
TDS	----	1770
Nitrate	----	12.4
Vanadium	0.02	----
RA-226 + Ra228	5	30
Thorium-230	0.3	----
NOTE: All concentrations are in mg/l except; Ra-226 + Ra-228 and Th-230, which are in pCi/l @ = Irrigation Standard		

6.2.2 ALLUVIAL AQUIFER BACKGROUND WATER QUALITY

Background hydrologic conditions at the Grants site are, by definition, those that exist up-gradient or north of the Large Tailings Pile. Water quality and water levels have been monitored in up-gradient site wells since 1976. Alluvial wells DD, P, P1, P2, P3, P4, Q, R and ND (near up-gradient wells), located on the HMC property just north of the Large Tailings Pile have been used for monitoring alluvial background water quality. Wells P1, P2 and P3 were not sampled in 2002. Additional up-gradient wells, located farther north, were sampled in 2002 (wells 914, 916, 920, 921, 922 and 950, see Figure 6-1 for locations). Information gathered from these far up-gradient wells has been used to further define the piezometric surface and water-quality conditions in the up-gradient alluvial aquifer. However, these far up-gradient wells were not used in establishing the 95th percentile alluvial background values in ERG's statistical evaluation (ERG 1999).

The period of record and normal sampling frequency for the near up-gradient background wells and far up-gradient wells are presented in Table 6-3. Wells DD, P, Q and R were first sampled in 1976. Monitoring of up-gradient alluvial well ND started in 1983. Monitoring of wells P1 and P2 was initiated in 1992, and monitoring of wells P3 and P4 began in 1998.

TABLE 6-3. BACKGROUND MONITORING PERIOD AND FREQUENCY

WELL NAME	PERIOD OF RECORD	TYPICAL SAMPLING FREQUENCY
NEAR UP-GRADIENT BACKGROUND ALLUVIAL WELLS		
DD	1976 - 2000	Annually
ND	1983 - 2000	Annually
P	1976 - 2001	Quarterly
P1	1992 - 1999	Quarterly
P2	1992 - 2000	Quarterly
P3	1998 - 2001	Annually
P4	1998 - 2001	Annually
Q	1976 - 2000	Quarterly
R	1976 - 2000	Quarterly
FAR UP-GRADIENT WELLS		
914	1983 - 2001	Variable
916	1994 - 2001	Annually
920	1981 - 2001	Annually
921	1994 - 2001	Annually
922	1981 - 2001	Annually
950	1994 - 2001	Variable

All water-level and water-quality monitoring in the far up-gradient wells had commenced by 1994. Background water-quality data have been acquired from the alluvial aquifer at this site for as many as 25 years, with quarterly measurements for some wells over that entire period.

The latest water-quality data for the alluvial background wells for six constituents: sulfate, uranium, selenium, chloride, TDS and nitrate are shown on Figure 6-1. Sulfate concentrations in water collected from the nine near up-gradient wells vary from 664 to 1500 mg/l. The sulfate concentrations for the far up-gradient wells vary from 55 to 1460 mg/l.

Uranium concentrations range from 0.02 to 0.18 mg/l in the near up-gradient wells. The uranium concentrations in the far up-gradient wells vary over a similar range, from 0.001 to 0.21 mg/l.

Selenium concentrations range from 0.04 to 0.50 mg/l in the near up-gradient background wells. A slightly larger range in selenium concentrations from 0.007 to 0.63 mg/l was observed in the far up-gradient wells.

Molybdenum concentrations are not presented on Figure 6-1 but all molybdenum concentrations in these up-gradient wells are less than 0.03 mg/l except for one anomalous value of 0.09 mg/l from well 920 on August 15, 2002.

Chloride concentrations in water sampled from the near up-gradient alluvial background wells ranged from 48 to 83 mg/l. The chloride concentrations in the far up-gradient wells ranged from a low of 26 mg/l to a high of 135 mg/l.

The TDS concentrations ranged from 1480 to 2680 mg/l and 370 to 2700 mg/l for the near up-gradient wells and far up-gradient wells, respectively.

Nitrate concentrations in the alluvial aquifer also vary naturally over a broad range (from 1.4 to 14.7 mg/l) for the near up-gradient wells north of the Large Tailings area. The nitrate concentrations in the far upgradient wells ranged from less than 0.1 to 16.9 mg/l.

The 95th percentile of the historical near up-gradient background data for this site was defined by ERG (1999). The 95th percentile is used to quantify the upper limit of background concentrations of the constituents of interest. The 95th percentile is appropriate because only a small percentage (approximately 5%) of concentration measurements will exceed the respective background value. For a site-specific background concentration to be appropriate, exceedance of the concentration must be reliably indicative of a change in the water quality. The 95th percentile background levels for the site constituents at the Grants Project site are presented on Figure 6-1 and listed in the following tabulation:

ALLUVIAL AQUIFER 95th PERCENTILE CONCENTRATION, in mg/l

Selenium	Uranium	Molybdenum	TDS	Sulfate	Chloride	Nitrate
0.27	0.15	0.05	3060	1870	112	23

The 95th percentile level was selected to define the full range of background concentrations (see ERG 1999 for a detailed discussion of the statistical analysis). As discussed earlier, 5% of the natural concentrations would be expected to exceed the site background concentration established in this manner. One of the most recent uranium concentrations in the nine near up-gradient background wells slightly exceeds the 95th percentile concentration of 0.15 mg/l. A minor and infrequent exceedance may serve as a reminder that the 95th percentile is not the absolute upper limit of plausible background concentrations. One recent background selenium concentration also exceeded the selenium 95th percentile. None of the recently measured sulfate or TDS concentrations exceed the 95th percentile.

The 1999 ERG report presented the statistical theory used in developing the 95th percentile background concentrations for the alluvial aquifer. Tables 73 through 94 in the Statistical Evaluation (ERG 1999) report present the calculation of 95th percentile uranium concentration in water samples from the nine near up-gradient background wells. Tables 95 through 113 present similar calculations for the far up-gradient wells, but were <u>not</u> used in selecting the 95th percentile. Only the nine near up-gradient background wells were used in developing the 95th percentile concentrations presented in this report.

6.3 CHINLE AQUIFER BACKGROUND WATER QUALITY

6.3.1 INTRODUCTION

Background water quality in the Chinle aquifers has been evaluated using available data from 1982 through mid-2003 from 30 Chinle wells. In addition, two Upper Chinle wells were recently installed north of the Large Tailings Pile to improve the spatial distribution of background wells.

Alluvial aquifer water has entered the Chinle aquifers in their respective subcrop areas and has affected the water quality in the mixing zone. Water quality data from those wells completed within the mixing zone are used to evaluate the background water quality in the mixing zone. Wells located outside of the mixing zone are used to define the background concentrations in each of the three Chinle aquifers.

In the following subsections, the Chinle aquifers non-mixing zones are discussed individually. The mixing zone areas of all three Chinle aquifers with the alluvial aquifer, however, are discussed as a single water quality unit for purposes of establishing background water quality. Prior to consideration of any well for inclusion in the background water-quality analysis, the drilling and completion records for each well were reviewed to ensure adequate documentation of the well completion for the particular aquifer. The following tabulation lists the wells selected for statistical analysis:

1) **Chinle Mixing**
   CW9, CW10, CW50, CW52, CW15, CW17, CW24, CW35, WR25, CW36, CW37, CW39 & CW43
2) **Upper Chinle Non-mixing**
   931, 934, CW3, CW13 & CW18
3) **Middle Chinle Non-mixing**
   ACW, CW1, CW2, CW14, CW28 & WCW
4) **Lower Chinle Non-mixing**
   CW26, CW29, CW31, CW32, CW33 & CW41

Available geophysical logs for the Chinle wells are presented in Appendix A. Appendix B presents a well-completion schematic for each of the Chinle wells used to define background water-quality. The geophysical logs were used to identify the aquifer in which the wells are

completed. Proper completion of a well is critical for the Chinle aquifer wells, because the majority of these wells are not completed in the uppermost aquifer, and a connection within the annulus of the well can facilitate an exchange of water between aquifers.

The location of a well is also an important factor, because some areas within each Chinle aquifer have been influenced by seepage from the tailings. Any well impacted by seepage cannot be used to define the background concentrations. Wells located in areas that have been affected by the tailings seepage were not used, nor that portion of their data collected after the time when seepage impacts were observed was not used. Water-quality data from the Chinle wells were closely reviewed and evaluated for indicators of tailings seepage impacts. The water-quality data were not included in the statistical analysis if there was indication of seepage from the tailings.

Trend analysis for selected constituents in the Chinle wells included in the background water-quality analysis is presented in Appendix C. The analysis does not indicate any long-term trends in the Chinle wells that are not considered naturally occurring.

6.3.2 UPPER CHINLE AQUIFER - NON-MIXING ZONE WELLS

The locations of Upper Chinle wells used to define background concentrations are presented on Figure 6-2. Wells shown on Figure 6-2 with a blue rectangular box around the well name are completed in the Upper Chinle aquifer and have been used to define the background concentrations in the non-mixing zone. Water samples collected from wells 931, 934, CW3, CW13 and CW18 contain natural constituent concentrations that represent the background water quality for the Upper Chinle aquifer in the non-mixing zone. The water quality in well CW3 has been affected in 2002 and 2003 due to the pumping of this well. Therefore, only pre-2002 water-quality data from well CW3 were used for evaluating background water quality. Well CW13 has been used as an injection well for ground water restoration, so only data collected prior to injection into well CW13 were used for this well.

6.3.3 MIDDLE CHINLE AQUIFER - NON-MIXING ZONE WELLS

In the Middle Chinle aquifer, the mixing zone exists over the entire aquifer west of the West Fault and adjacent to the subcrop area east of the West Fault. Calcium concentrations less than 30 mg/l distinguish those Middle Chinle wells that are not in the mixing zone. Calcium concentrations in

water collected from wells ACW, CW1, CW2, CW14, CW28 and WCW are less than 30 mg/l. and, therefore, these wells are deemed to be representative of the natural (background) Middle Chinle non-mixing zone (see wells with blue rectangle around well name on Figure 6-3).

6.3.4 LOWER CHINLE AQUIFER - NON-MIXING ZONE WELLS

The interval comprising the Lower Chinle aquifer is characterized by secondary permeability in the lower portion of the Chinle shale. The rate of ground water flow in this aquifer is very low. The calcium concentration generally increases with greater distance from the subcrop area due to the slow movement of ground water and subsequent leaching of calcium from the host rock. Due to the naturally poor water quality of the Lower Chinle, distinction of non-mixing zone water based primarily on calcium concentrations is not reliable. For example, only one Lower Chinle well, CW41, has a calcium concentration of less than 30 mg/l. Using all parameters and other known information concerning the Lower Chinle, water quality in Lower Chinle aquifer wells CW26, CW29, CW31, CW32, CW33 and CW41 is considered representative of background conditions of the non-mixing zone (see Figure 6-4).

6.3.5 CHINLE - MIXING ZONE WELLS

The mixing zone in the Upper Chinle aquifer is shown in the yellow pattern on Figure 6-2. Wells with the red rectangle around the well name are completed in the Upper Chinle aquifer and are useful in evaluating the background water quality of the mixing zone. As stated previously, the primary water quality indicator of the mixing zone is a relatively high calcium concentration. Wells CW50 and CW52 have recently been installed. Water samples collected from both wells contain elevated calcium concentrations that, in combination with their proximity to the Upper Chinle subcrop, clearly indicate that these wells are completed within the mixing zone. Wells CW9 and abandoned well CW10 are also within the mixing zone. All calcium concentrations in water samples from well CW10 have been elevated, indicating that this well was within the mixing zone. The calcium concentrations in samples from well CW9 have varied from 17 to 56 mg/l, suggesting that this well is on the fringe of the mixing zone. The transmissivity of the Upper Chinle at well CW9 is very low, and therefore the effects of the alluvial water on this well are less pronounced than in the majority of the wells in the mixing zone.

In the Middle Chinle aquifer west of the West Fault, four wells (CW17, CW24, CW35 and WR25) are useful in defining the background water quality of the mixing zone. Middle Chinle well CW15 is also useful in defining natural concentrations in the mixing zone (see wells with red rectangle around the well name on Figure 6-3).

Without a clear distinction for the Lower Chinle mixing zone based on calcium concentrations, the mixing zone for the Lower Chinle aquifer was identified as a zone adjacent to the subcrop (see Figure 6-4). However, the mixing zone does not extend as far as the area of well CW41 in the southern subcrop area. Wells CW36, CW37, CW39 and CW43 are Lower Chinle wells suitable for defining the background water quality in the mixing zone.

6.4 CHINLE BACKGROUND WATER-QUALITY CONCENTRATIONS

6.4.1 NON-MIXING ZONE CONCENTRATIONS

The 95th percentile concentrations calculated by ERG (2003) for the water-quality data are presented in Table 6-4. The background concentrations for selenium and uranium in the Upper Chinle non-mixing zone are 0.06 and 0.09 mg/l, respectively. The background TDS, sulfate, nitrate and vanadium concentrations are significantly lower in the Upper Chinle non-mixing zone than in the mixing zone.

The water-quality data from Middle Chinle wells defined the full range of background concentrations for the Middle Chinle aquifer, with 95th percentile concentrations of 0.07 and 0.07 mg/l for selenium and uranium, respectively. A 95th percentile molybdenum concentration of 0.05 mg/l was calculated from water-quality data from these wells. The TDS, sulfate, nitrate and vanadium concentrations from the Middle Chinle non-mixing zone are lower than the respective Chinle mixing zone concentrations.

A 95th percentile selenium concentration of 0.32 mg/l for the Lower Chinle non-mixing zone is shown in Table 6-4. Corresponding uranium and molybdenum concentrations of 0.02 and 0.03 mg/l, respectively, were obtained from the analysis for the non-mixing zone wells in the Lower Chinle. These values are significantly lower than those in the Chinle mixing zone. TDS and

sulfate concentrations are higher in the Lower Chinle aquifer non-mixing zone due to the increase of these constituent concentrations as the ground water slowly moves down-gradient in this low permeability aquifer. Nitrate and vanadium concentrations are lower in the Lower Chinle non-mixing zone than those in the Chinle mixing zone.

6.4.2 MIXING ZONE CONCENTRATIONS

The 95th percentile values as calculated by ERG (2003) for the Chinle background concentrations in the mixing zone are presented in Table 6-4. The background selenium concentration is 0.14 mg/l, and the background uranium concentration is 0.18 mg/l for the Chinle mixing zone. The 95th percentile (or upper range of background concentration) is also presented for molybdenum, TDS, sulfate, chloride, nitrate, vanadium, thorium-230 and radium-226 plus radium-228 for the Chinle mixing zone.

TABLE 6-4. GRANTS PROJECT - CHINLE BACKGROUND CONCENTRATIONS

	CONSTITUENT, in mg/l except Thorium-230 and Ra226+Ra228 in pCi/l									
Aquifer Zone	Selenium	Uranium	Molybdenum	TDS	Sulfate	Chloride	Nitrate	Vanadium	Thorium-230	Ra-226+ Ra-228
MIXING ZONE										
Chinle Mixing	0.14	0.18	0.10	3140	1750	96	15	0.08	0.97	3.5
NON-MIXING ZONE										
Upper Chinle	0.06	0.09	0.08	2010	914	412	4.9	0.02	0.55	3.7
Middle Chinle	0.07	0.07	0.05	1560	857	63	4.0	0.02	0.86	2.2
Lower Chinle	0.32	0.02	0.03	4140	2000	634	3.0	0.01	0.72	3.2

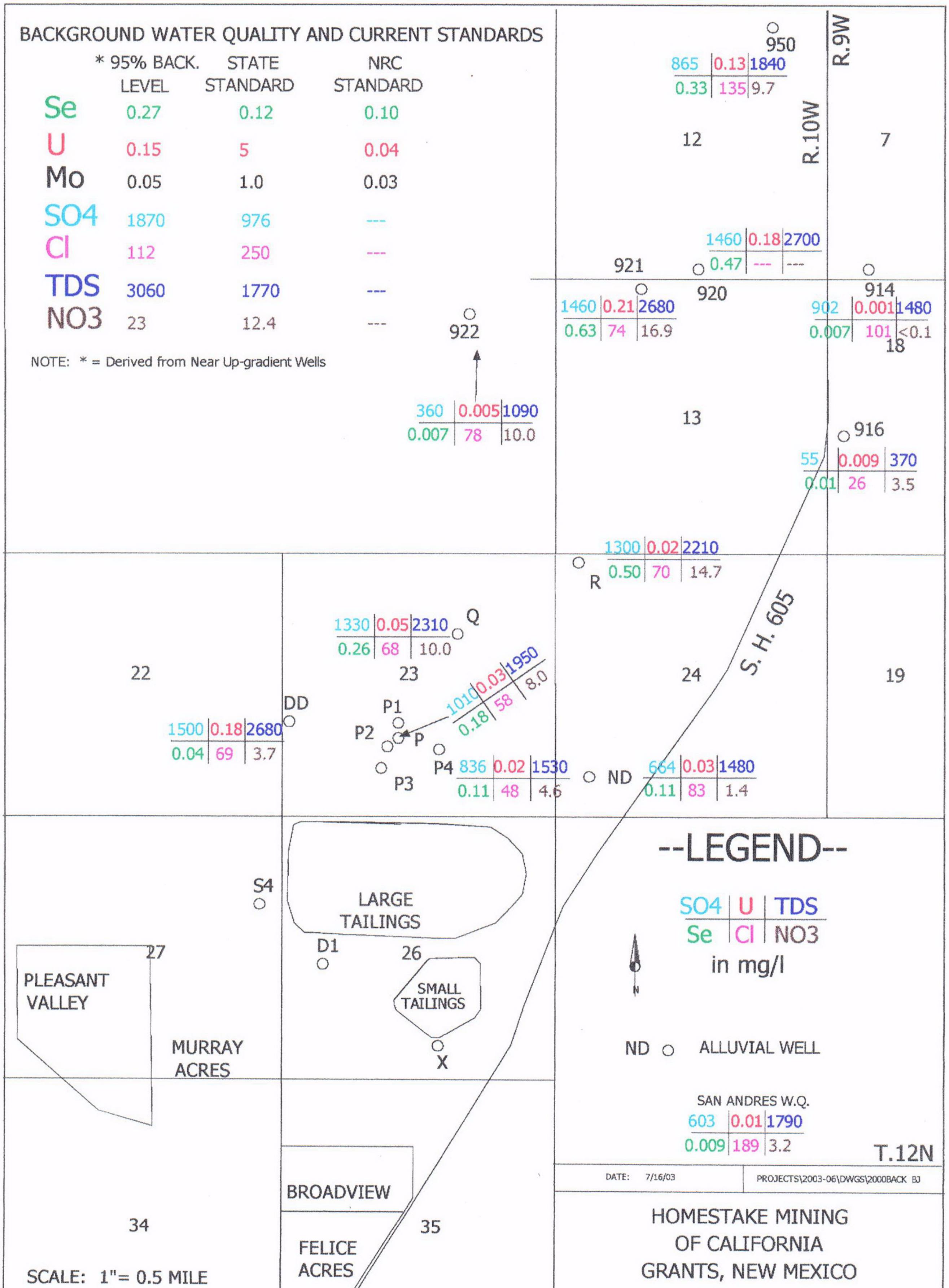
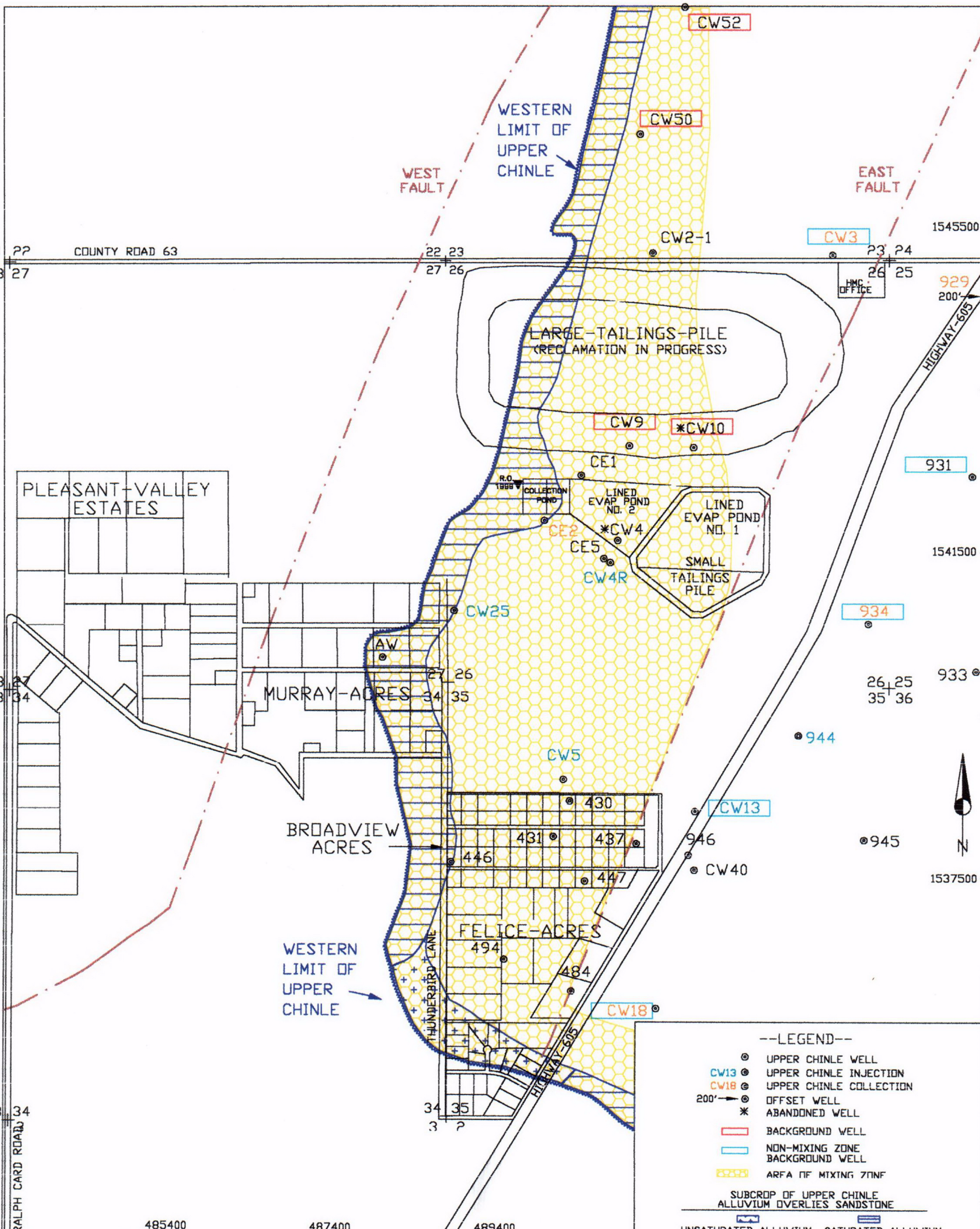


FIGURE 6-1. 2002 BACKGROUND GROUND WATER QUALITY

C01



SCALE: 1"=1600'	HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W	DATE: 10/04/03

FIGURE 6-2. UPPER CHINLE MIXING ZONE AND BACKGROUND WELLS

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C02

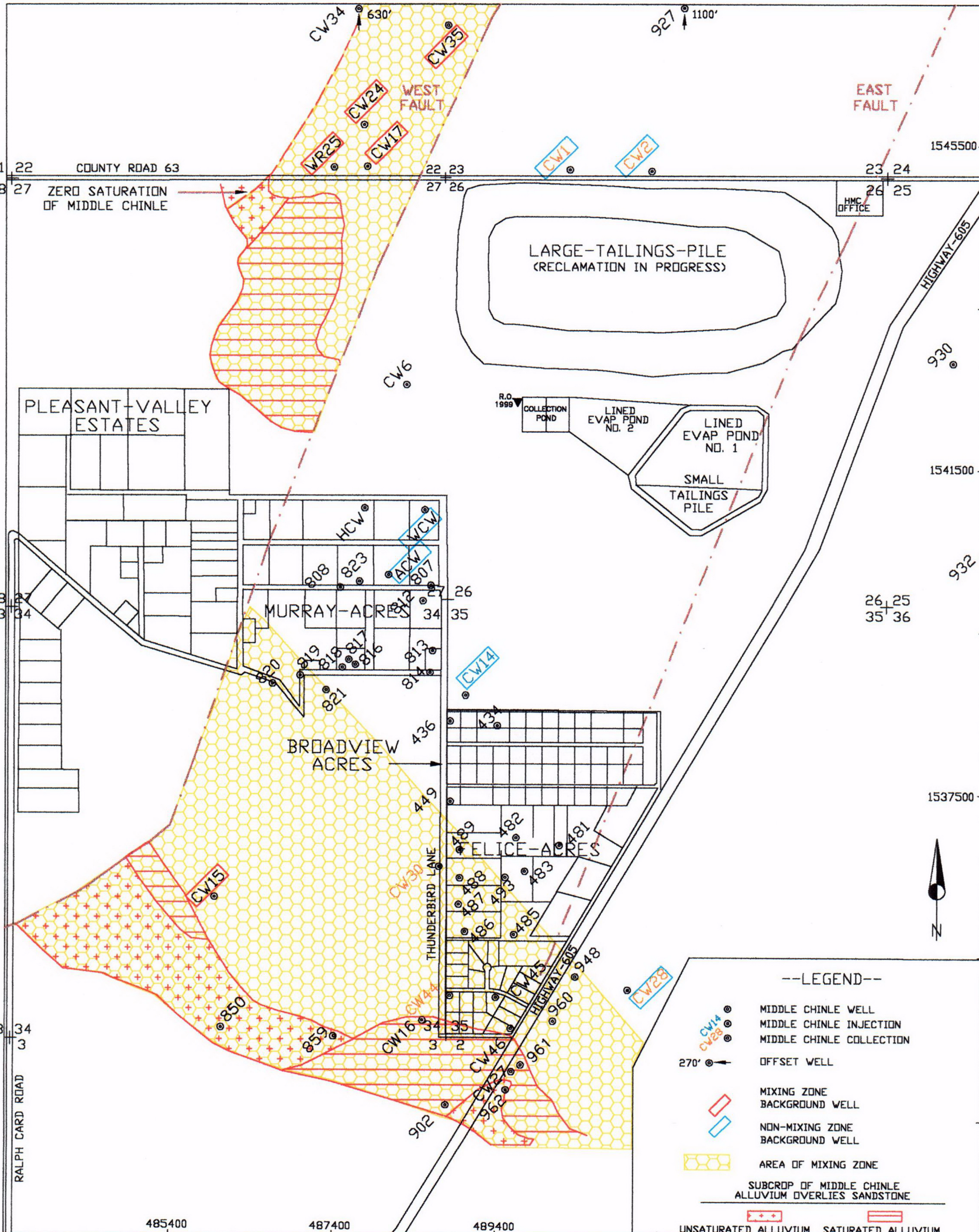

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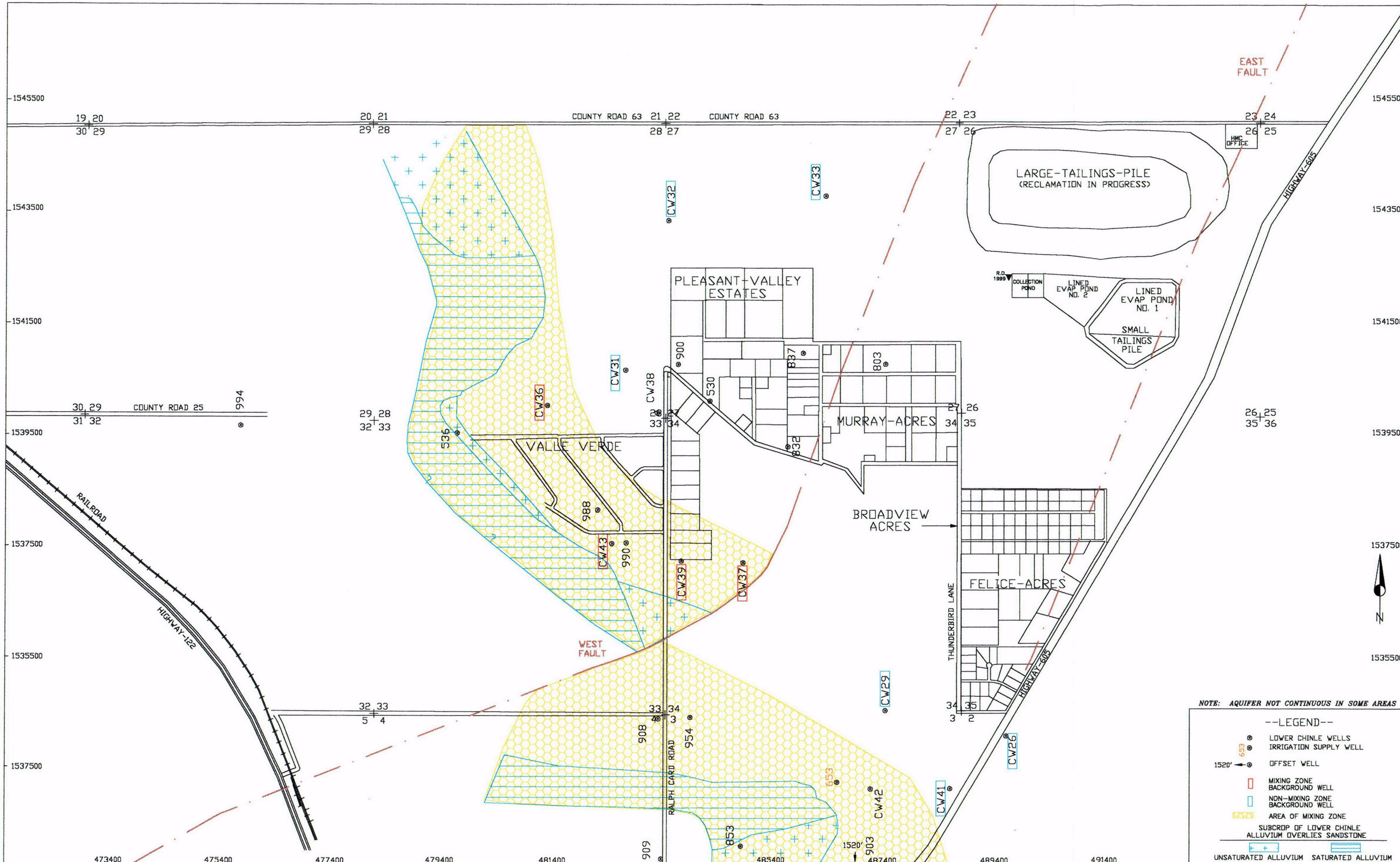
FIGURE 6-3. MIDDLE CHINLE MIXING ZONE AND BACKGROUND WELLS

c:\dd\projects\2003-06\MID1600

C03



SCALE: 1"=1600'

c:\dd\projects\2003-06\C-LOW03

DATE: 10/16/03

HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 6-4. LOWER CHINLE MIXING ZONE AND BACKGROUND WELLS

C04

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APPENDIX A

WELL LOGS

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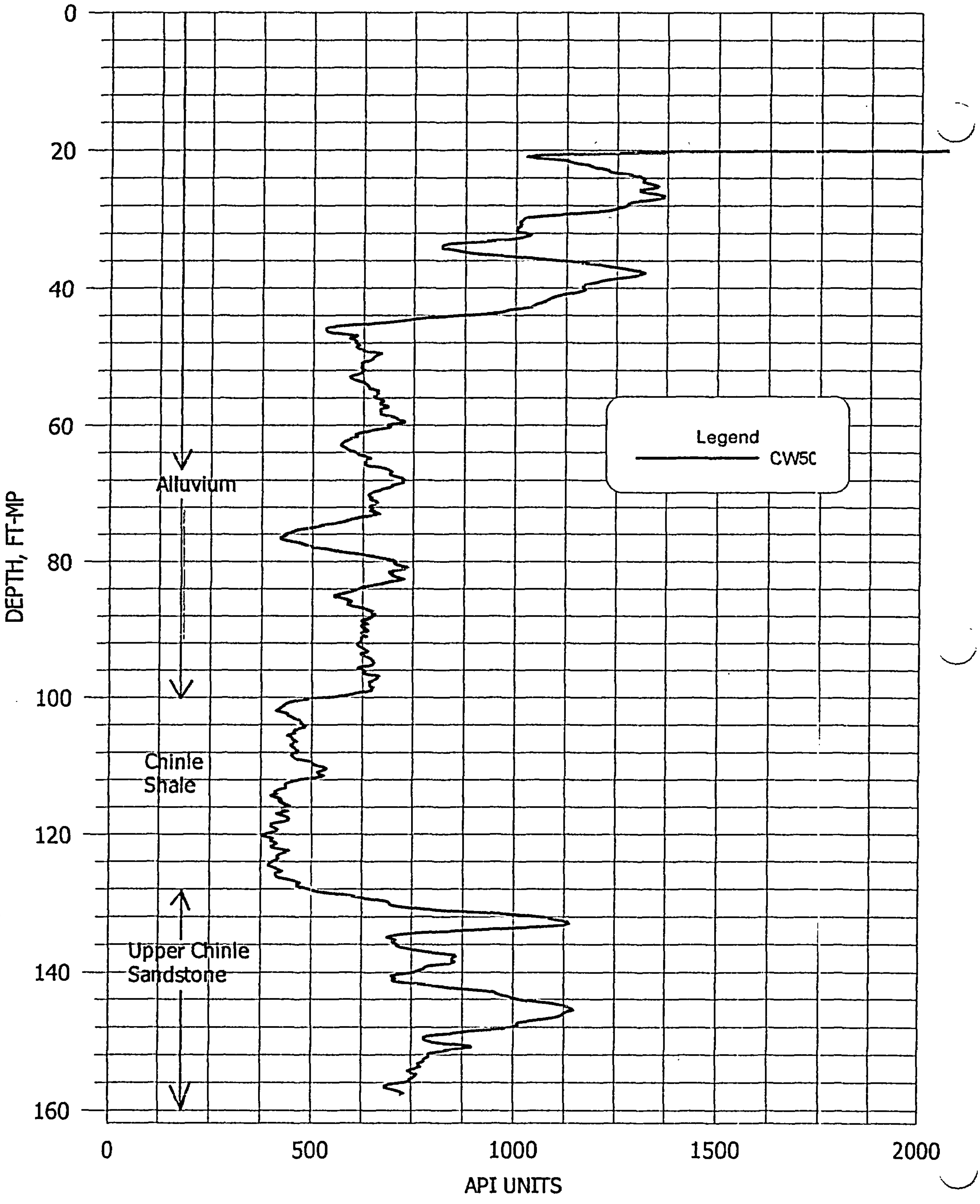

FIGURE A.1-1. NEUTRON LOG FOR UPPER CHINLE WELL CW50.

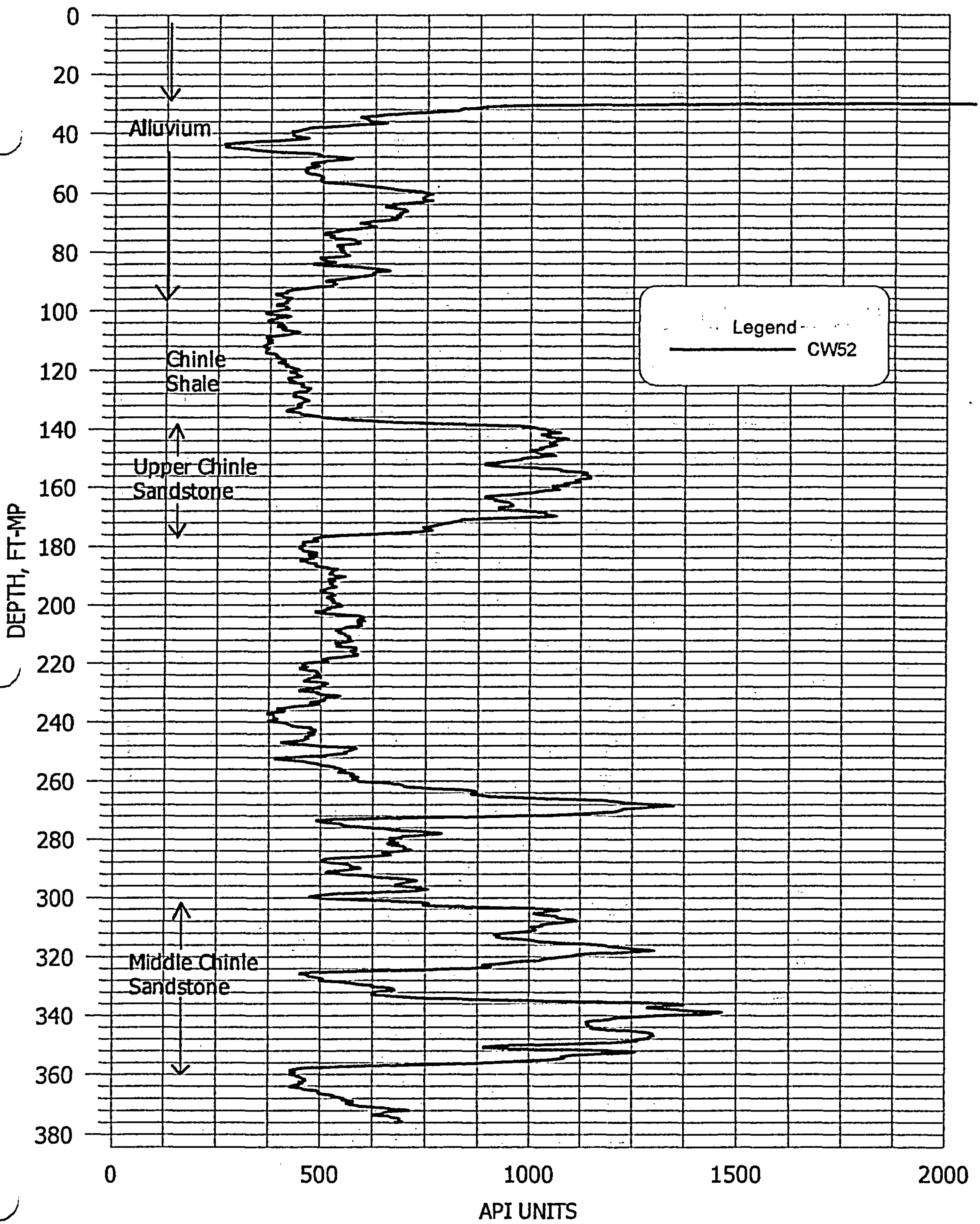

FIGURE A.1-2. NEUTRON LOG FOR UPPER CHINLE WELL CW52.

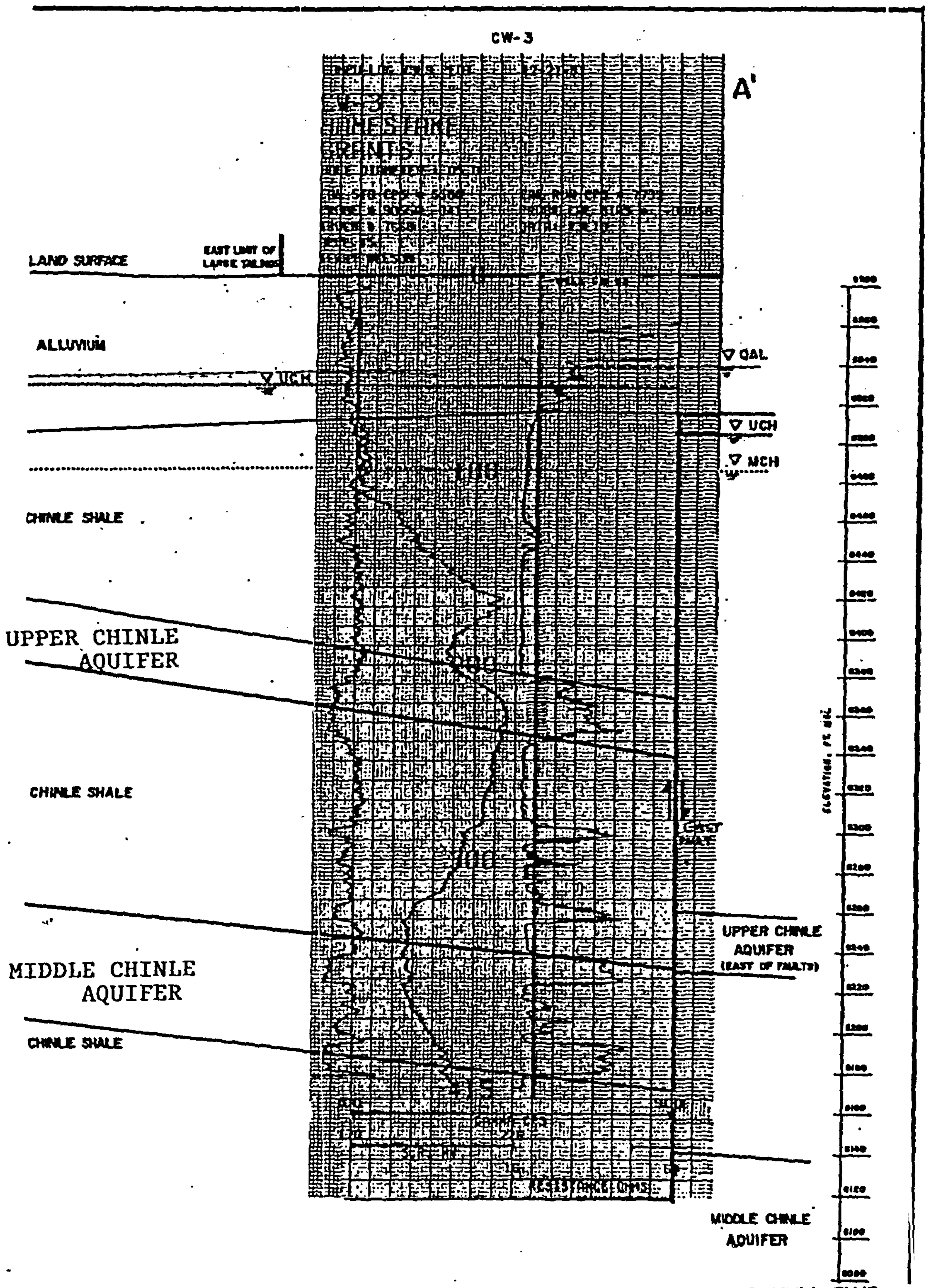

FIGURE A.1-3. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL CW3.

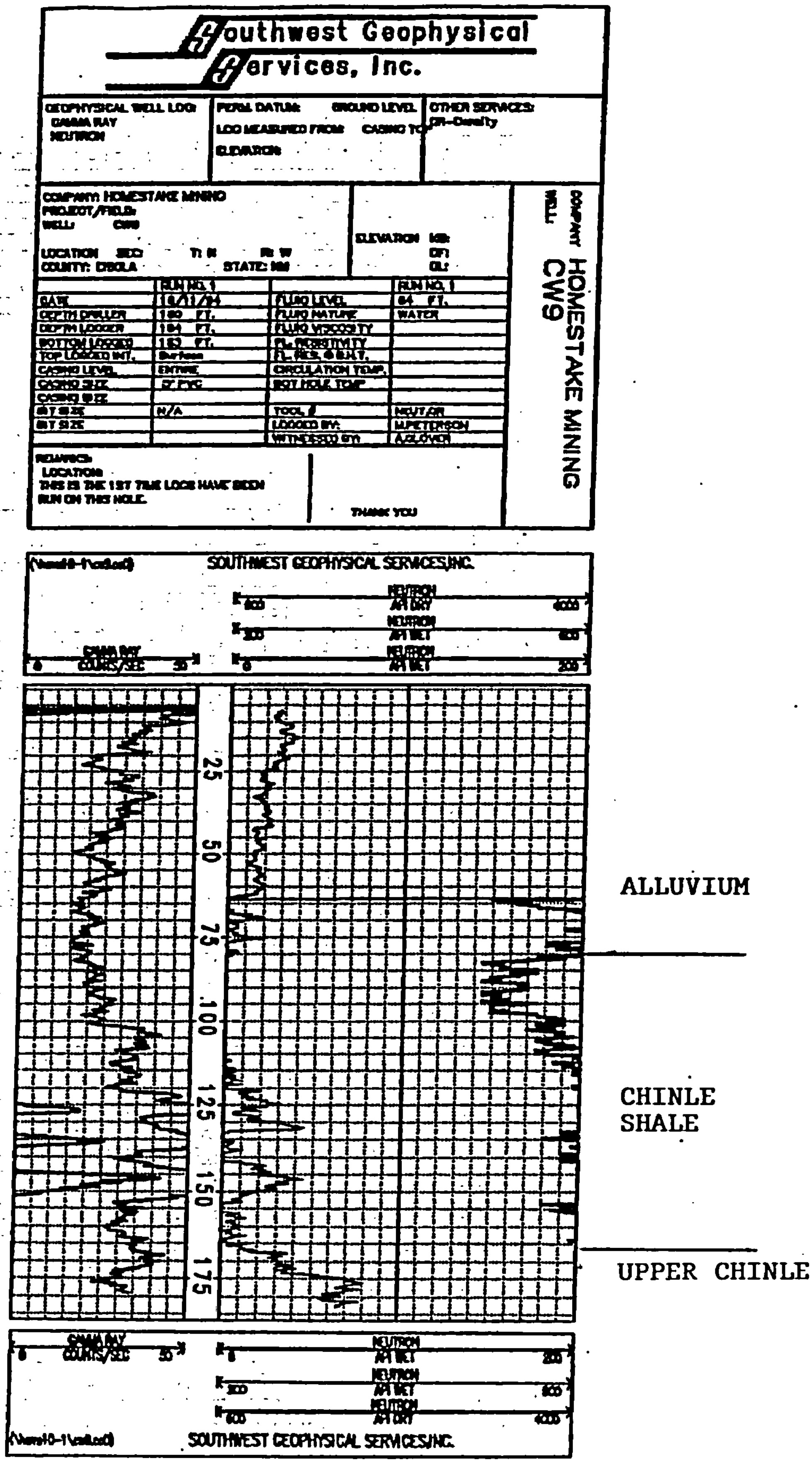

FIGURE A.1-4. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL CW9.

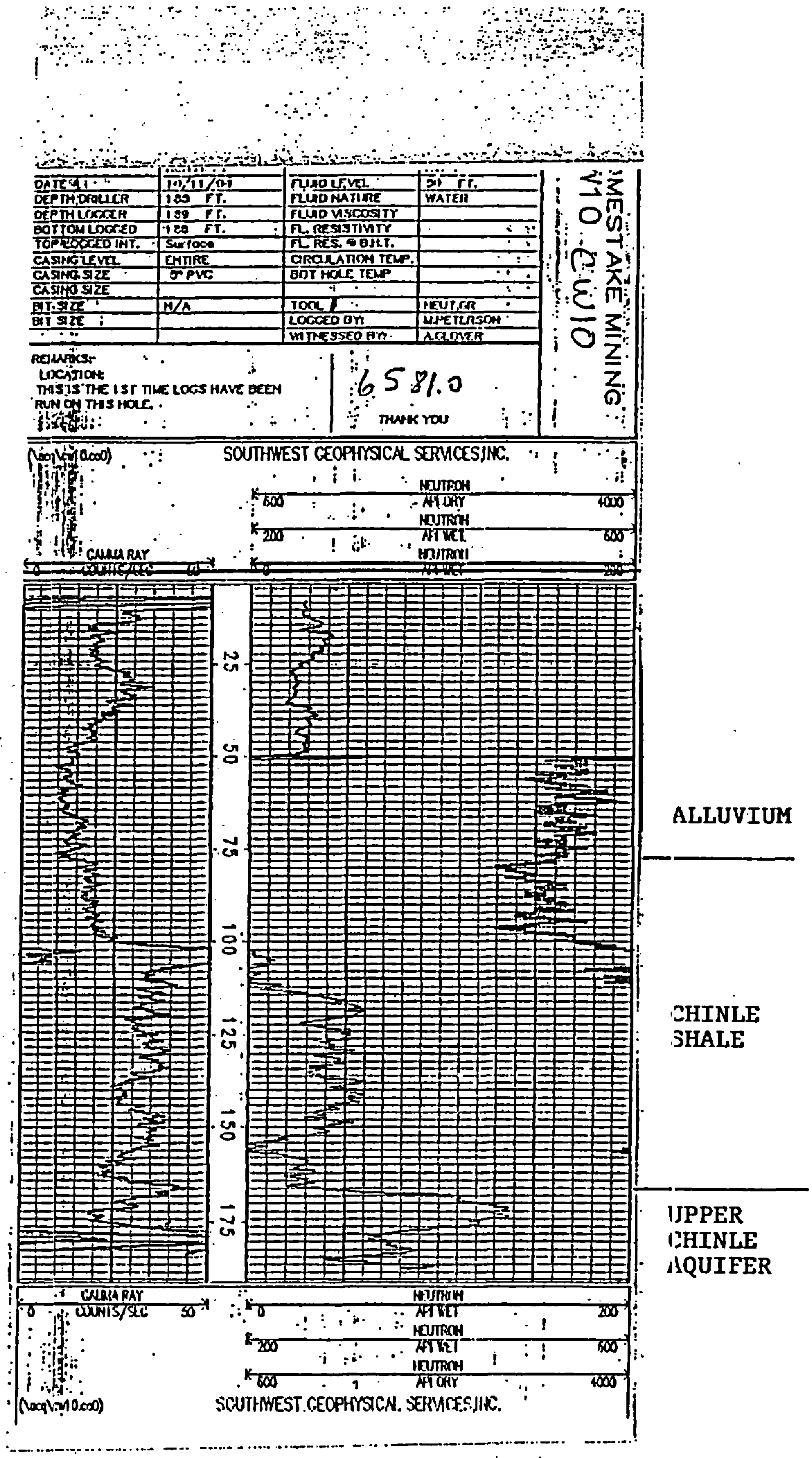

FIGURE A.1-5. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL CW10.

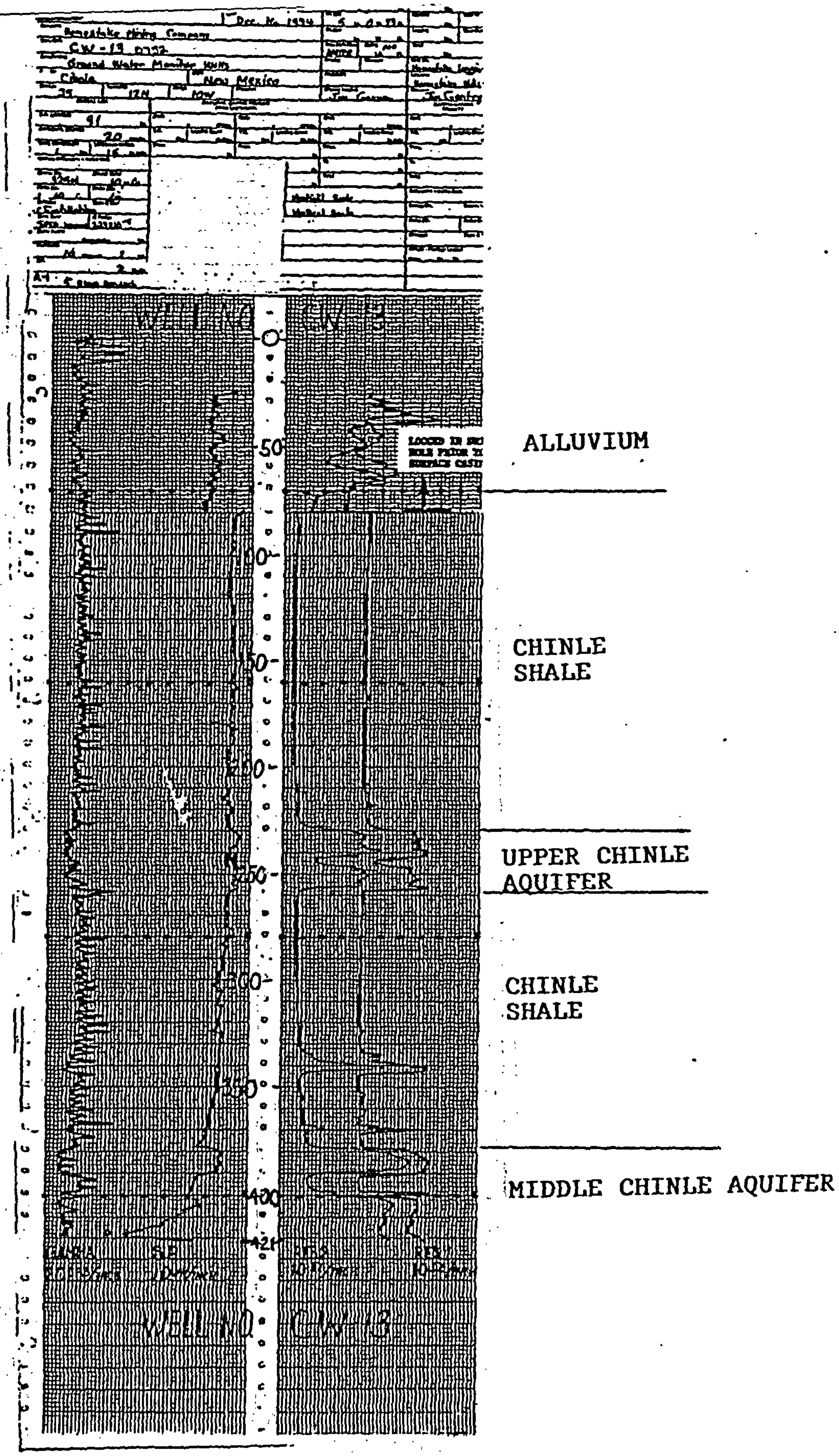

FIGURE A.1-6. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL CW13.

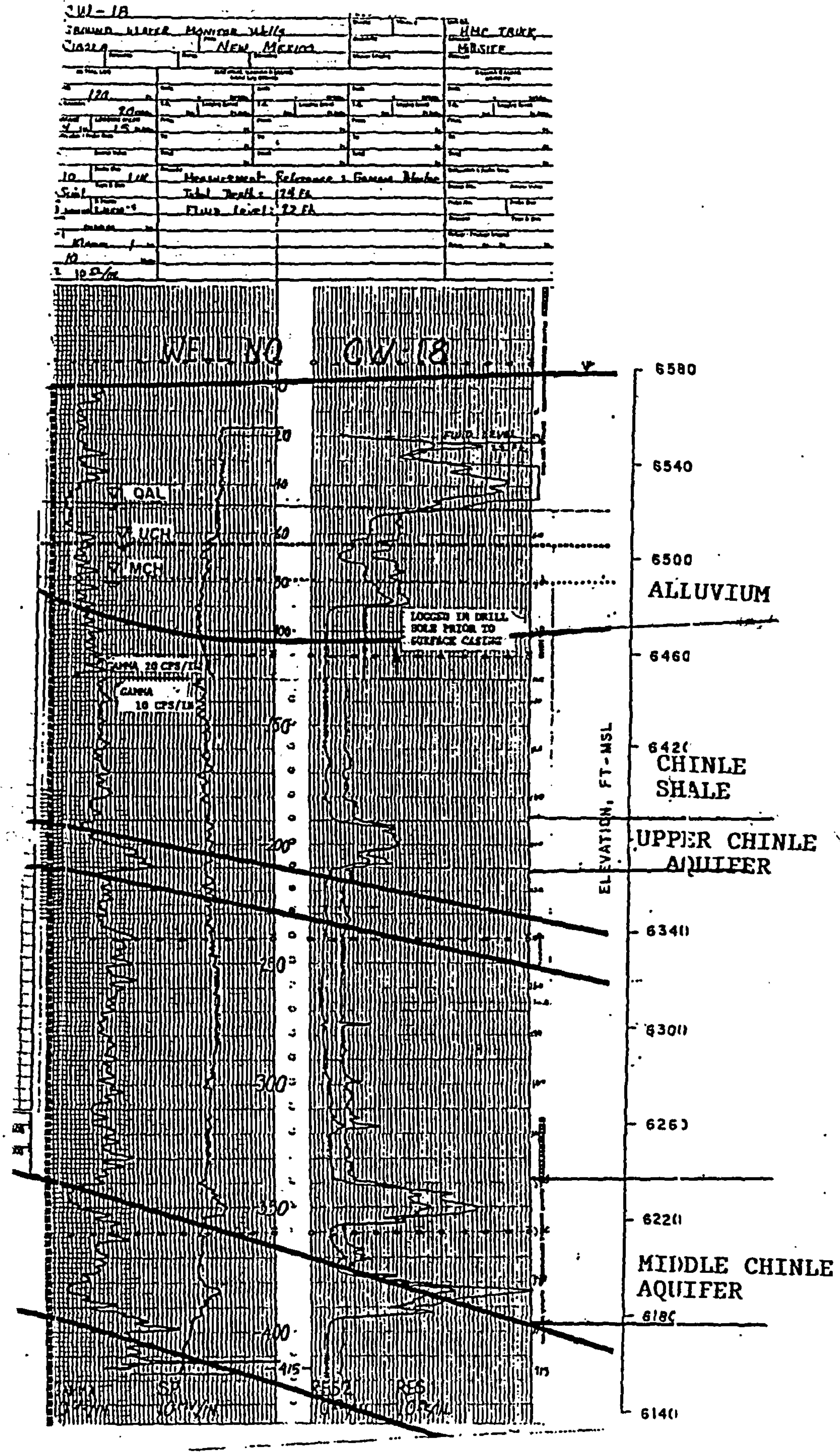

FIGURE A.1-7. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL CW18.

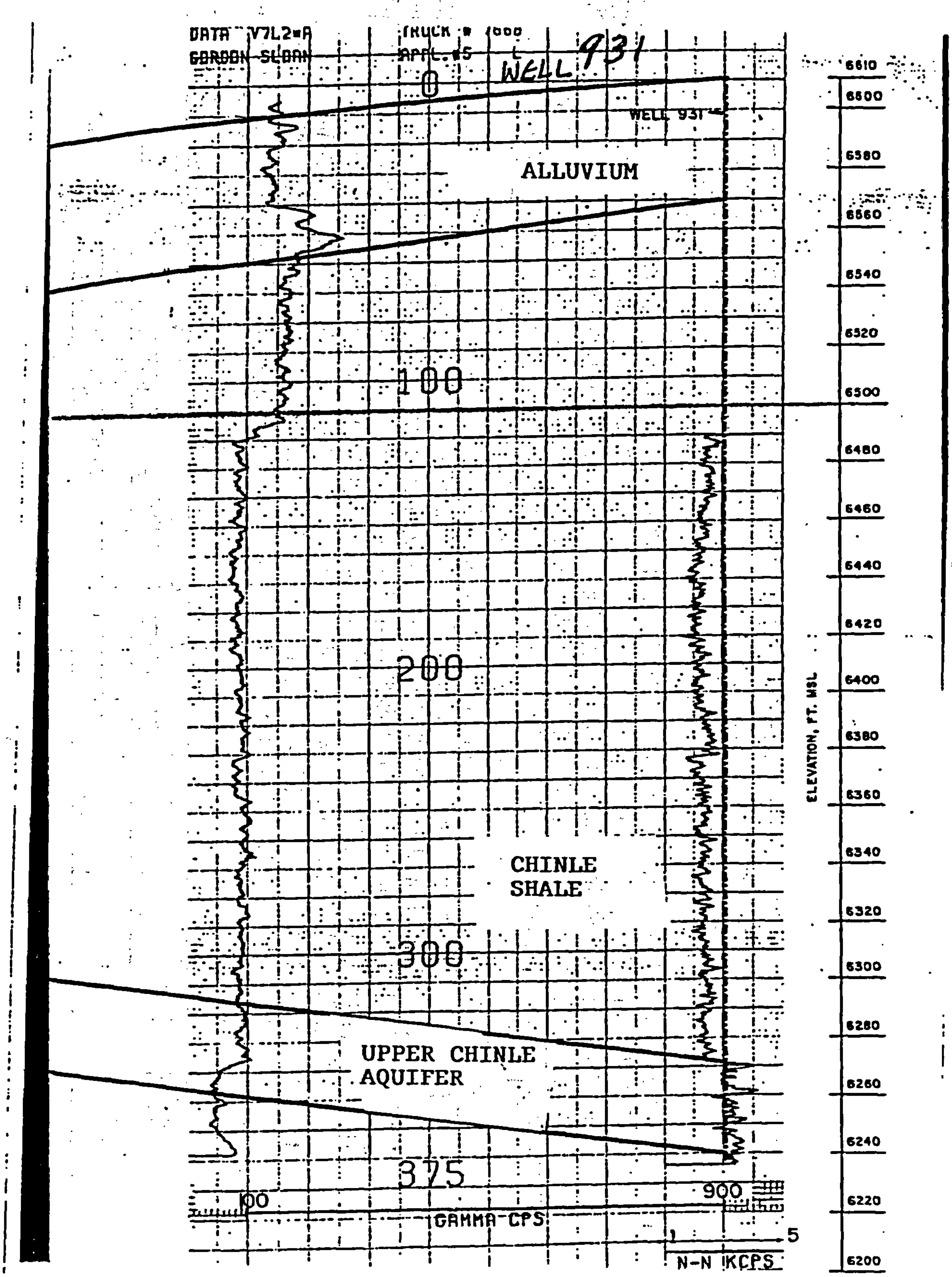

FIGURE A.1-8. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL 931.

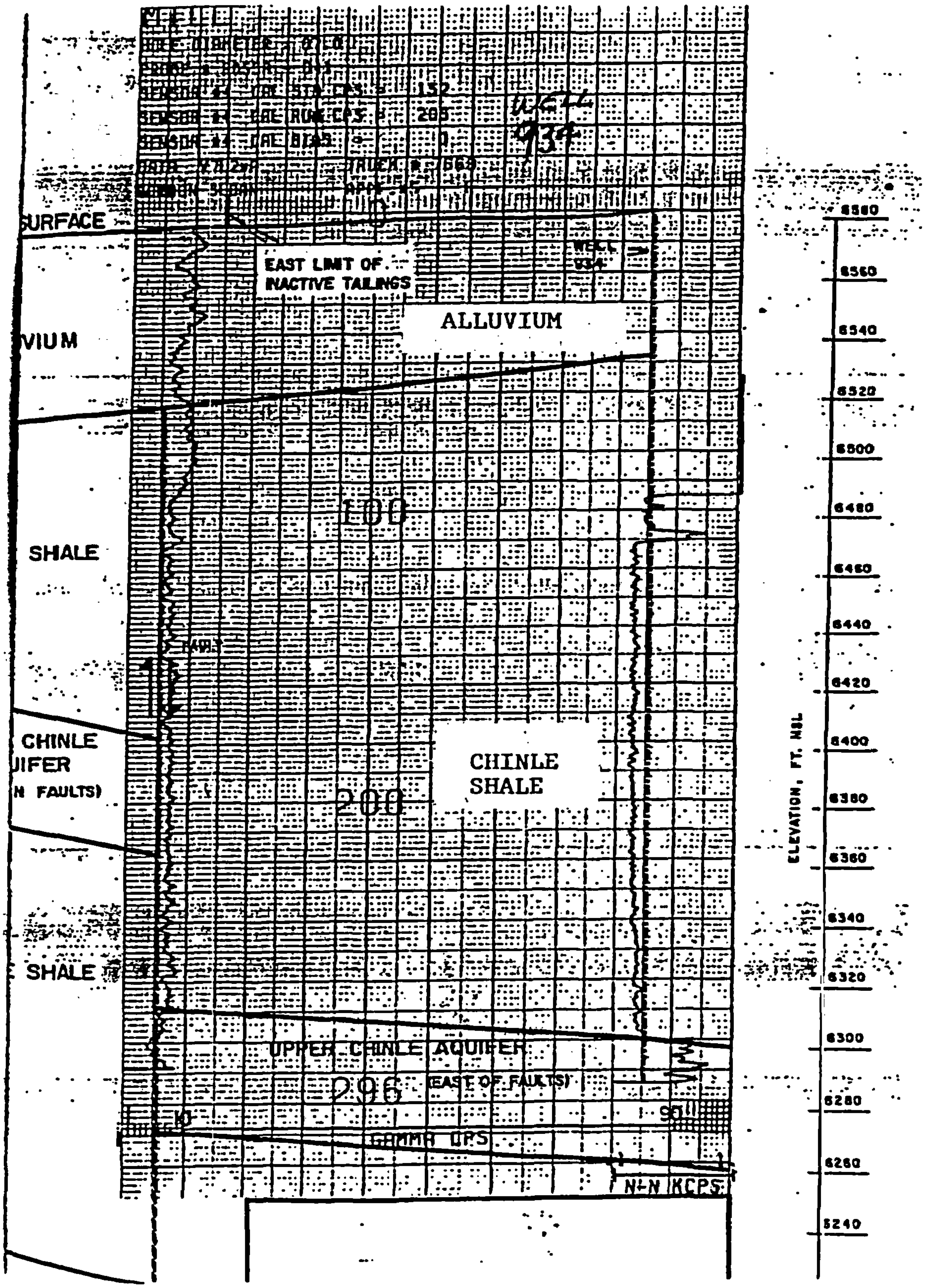

FIGURE A.1-9. GEOPHYSICAL LOGS FOR UPPER CHINLE WELL 934.

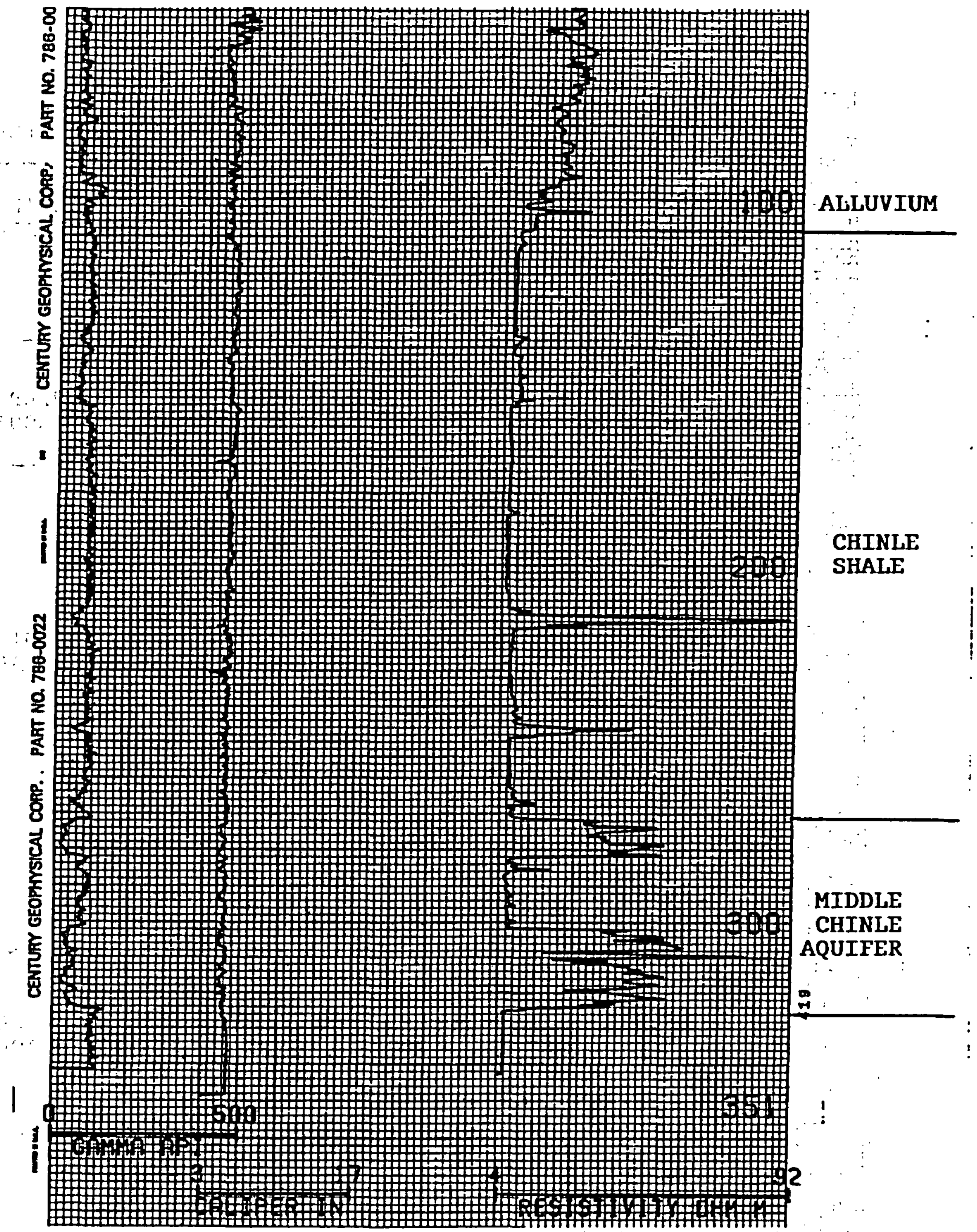

FIGURE A.2-1. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW1.

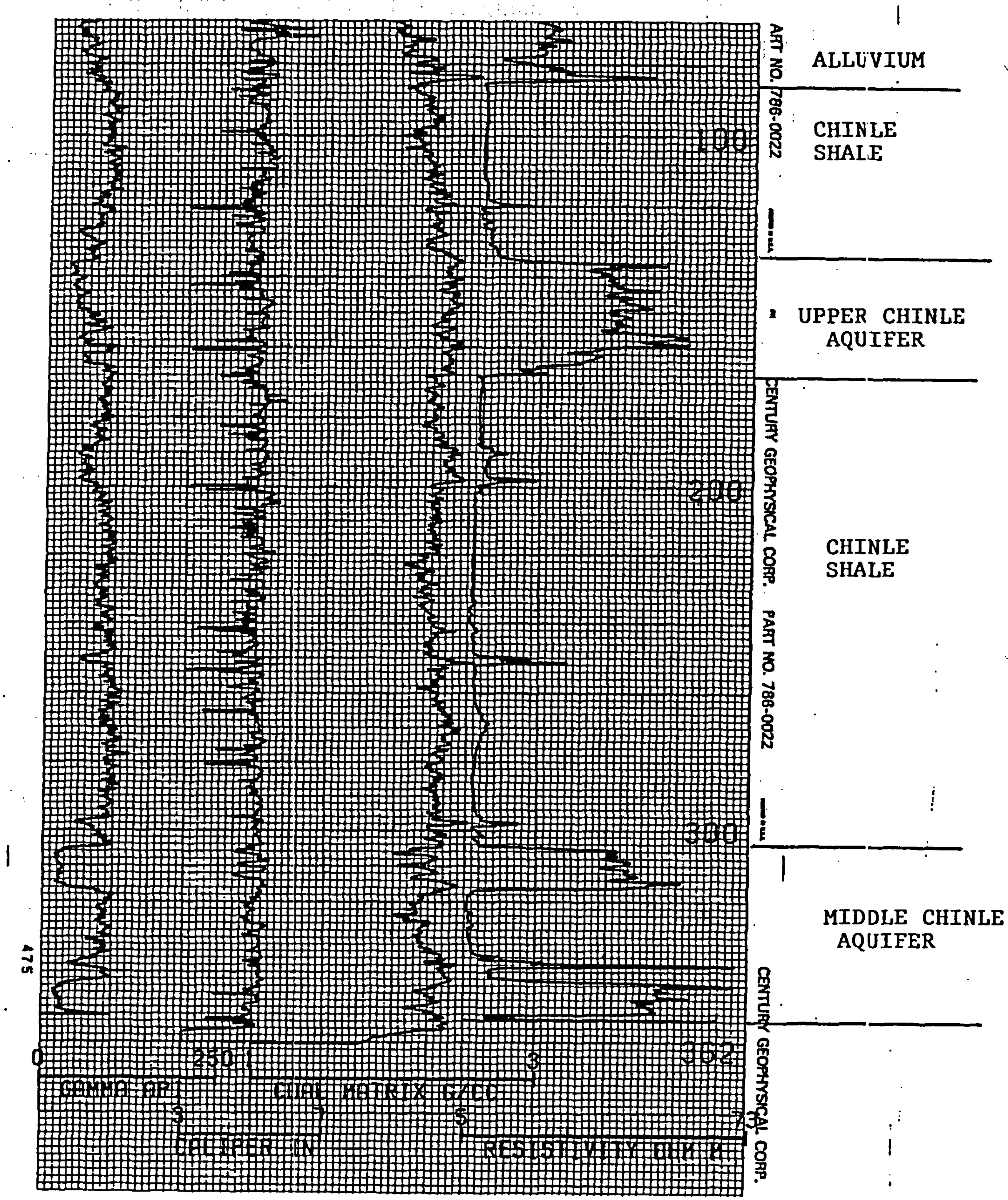

FIGURE A.2-2. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW2.

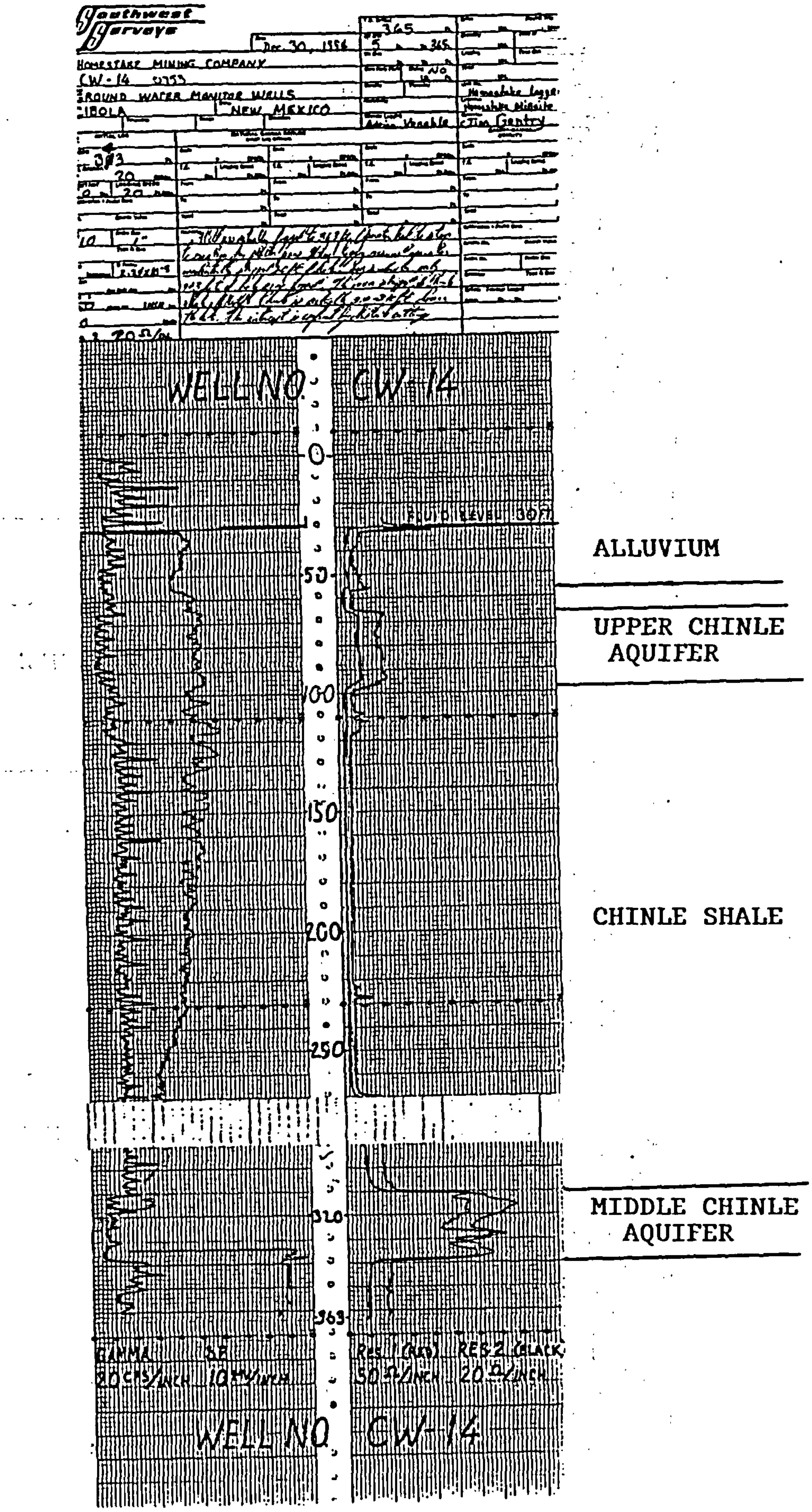

FIGURE A.2-3. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW14.

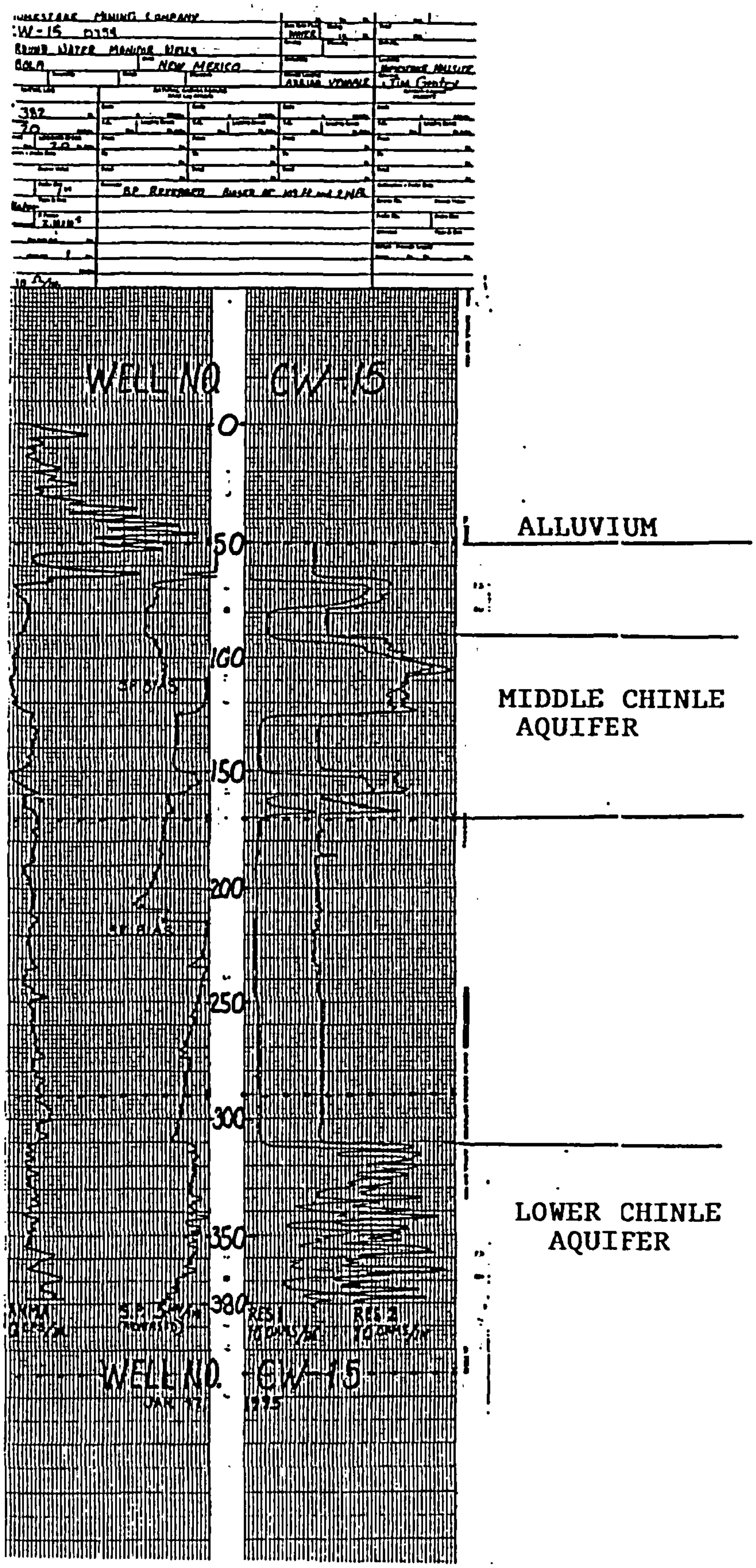

FIGURE A.2-4. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW15.

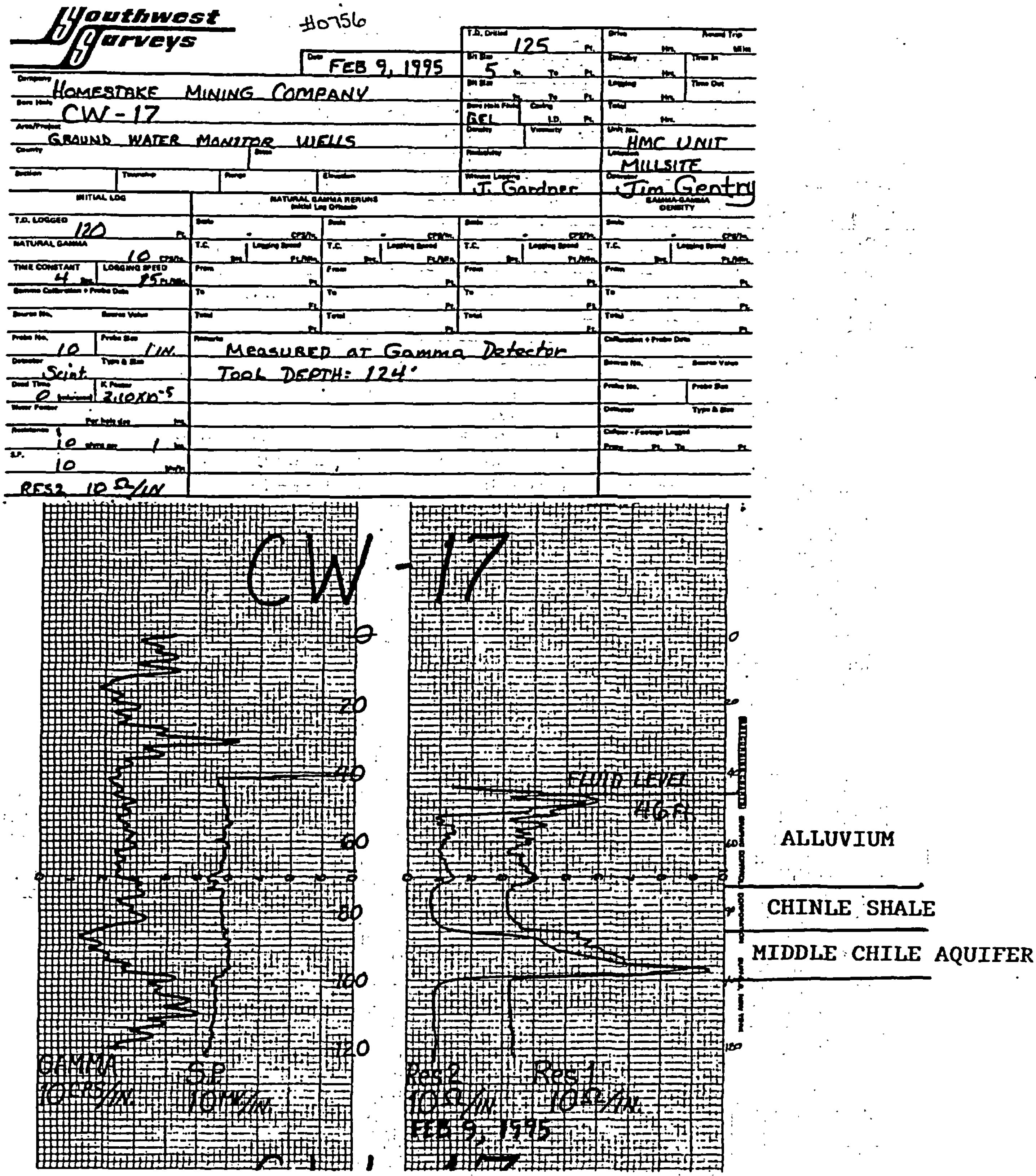

FIGURE A.2-5. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW17.

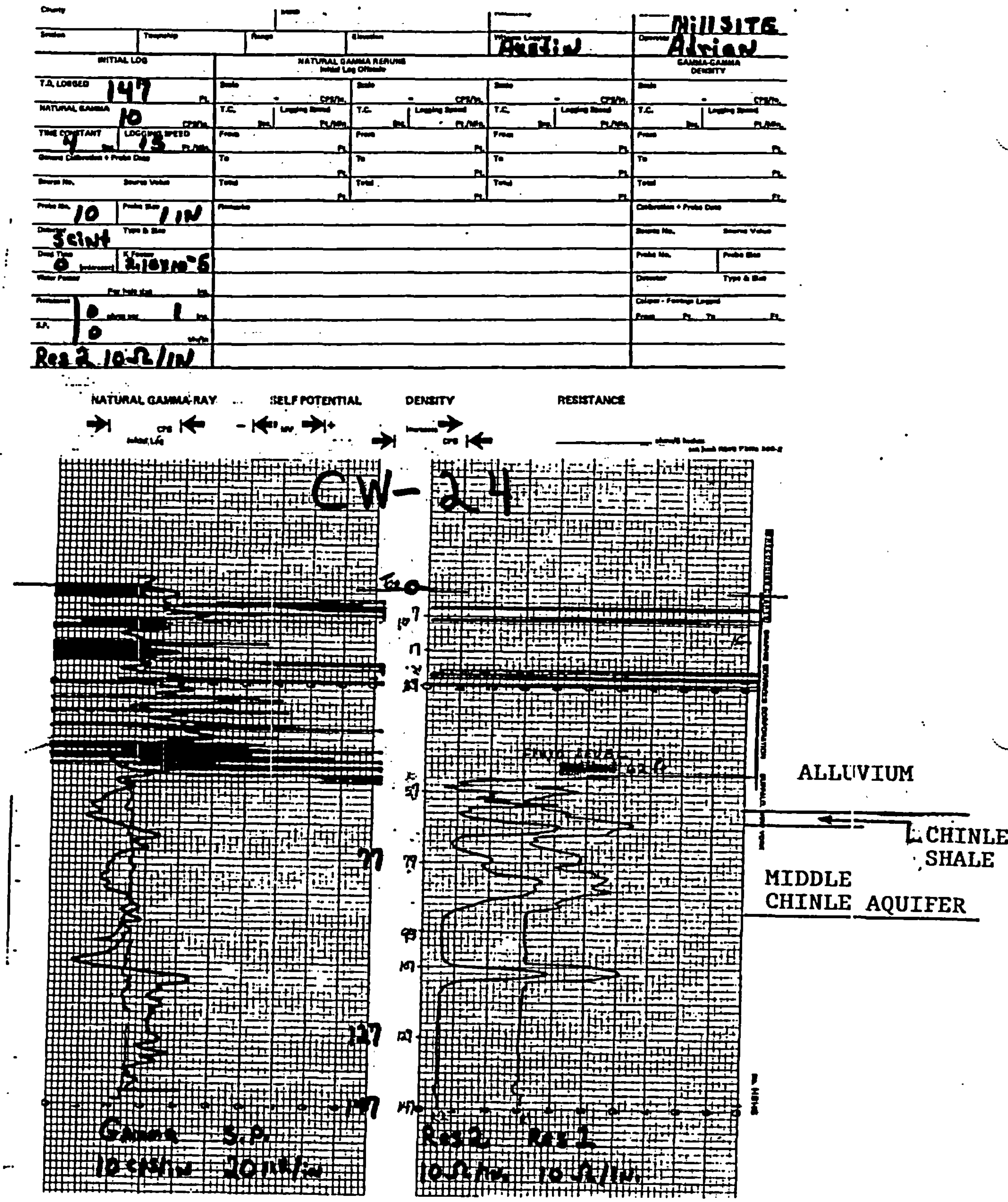

FIGURE A.2-6. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW24.

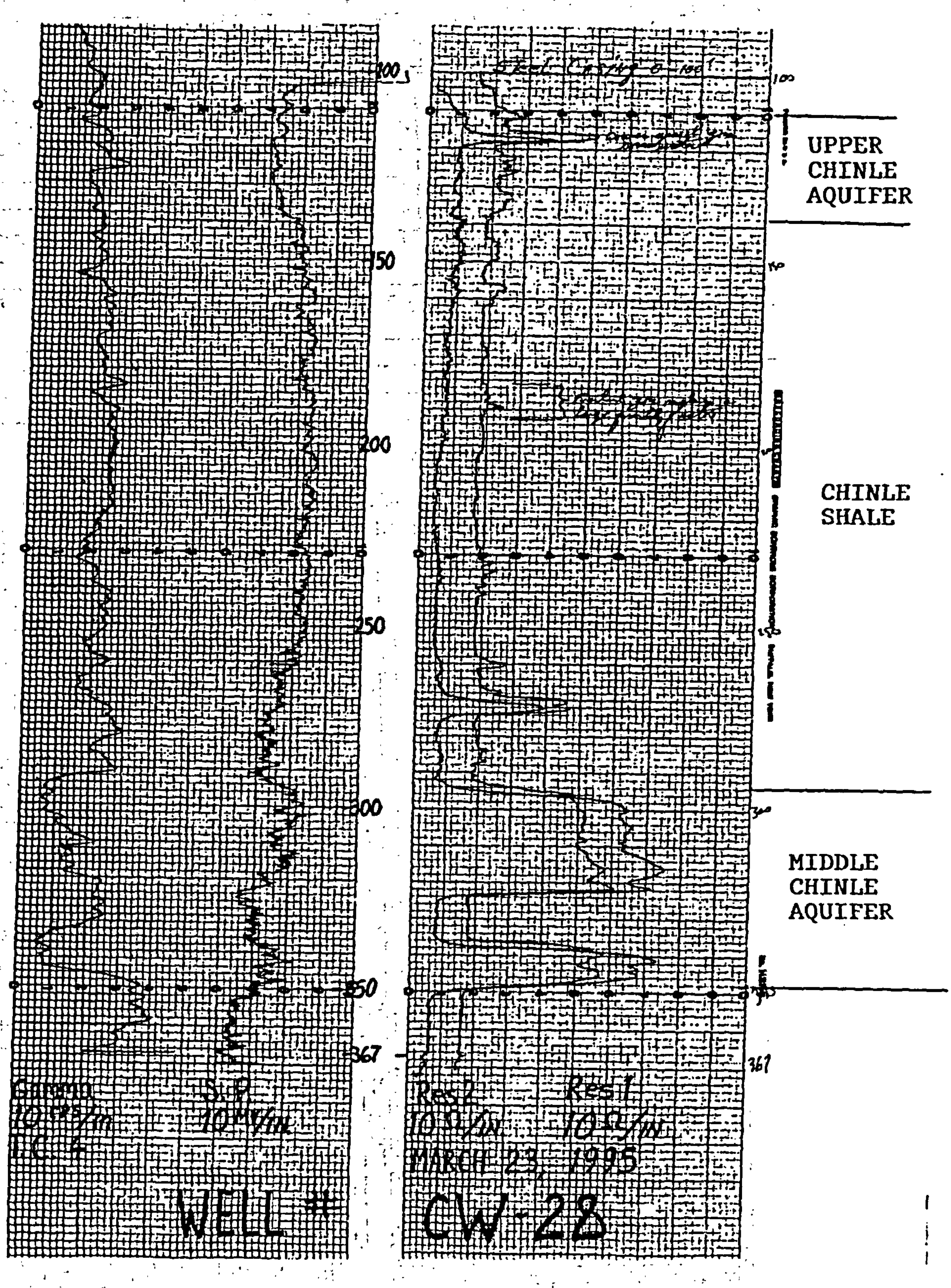

FIGURE A.2-7. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW28.

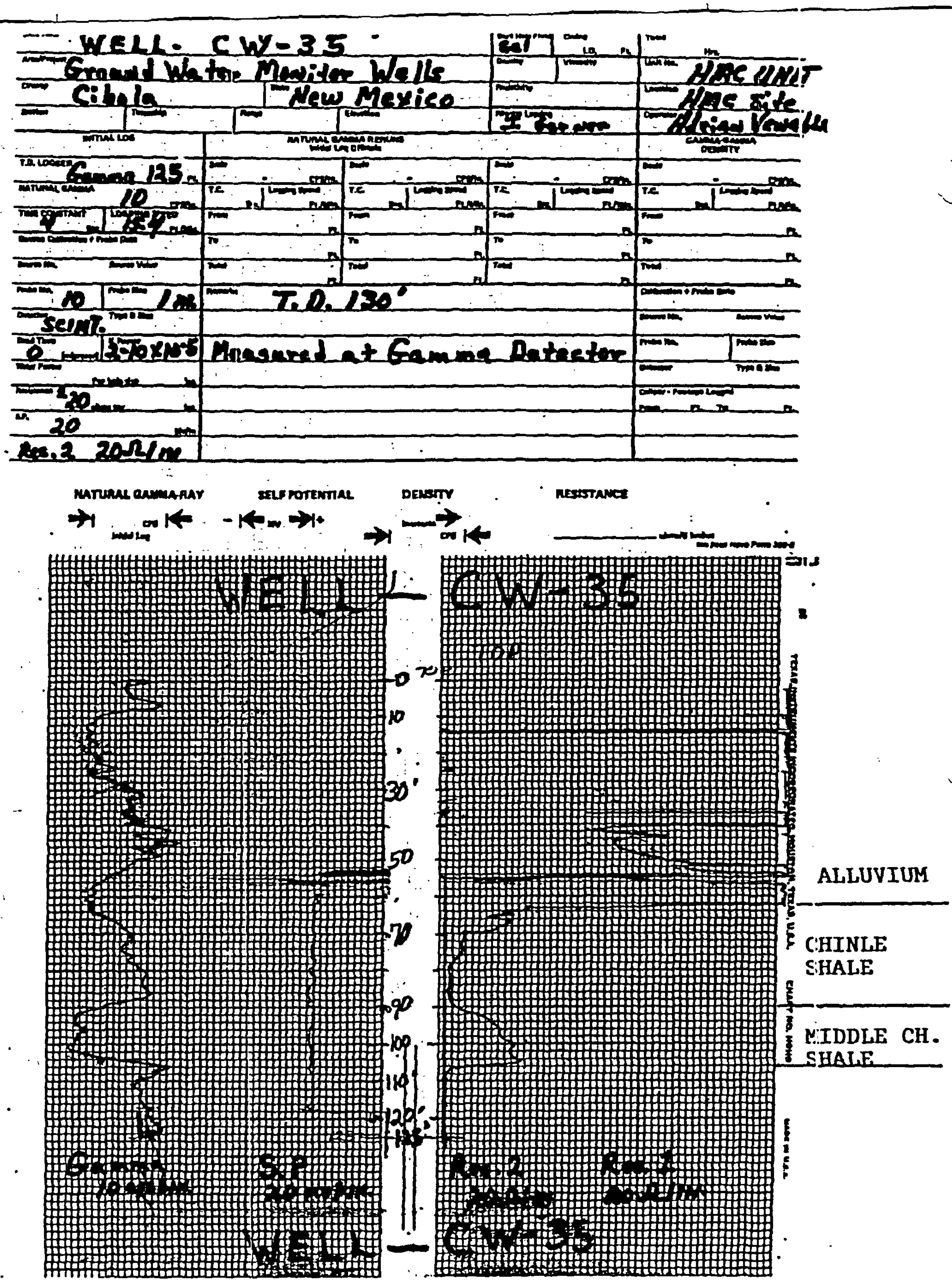

FIGURE A.2-8. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL CW35.

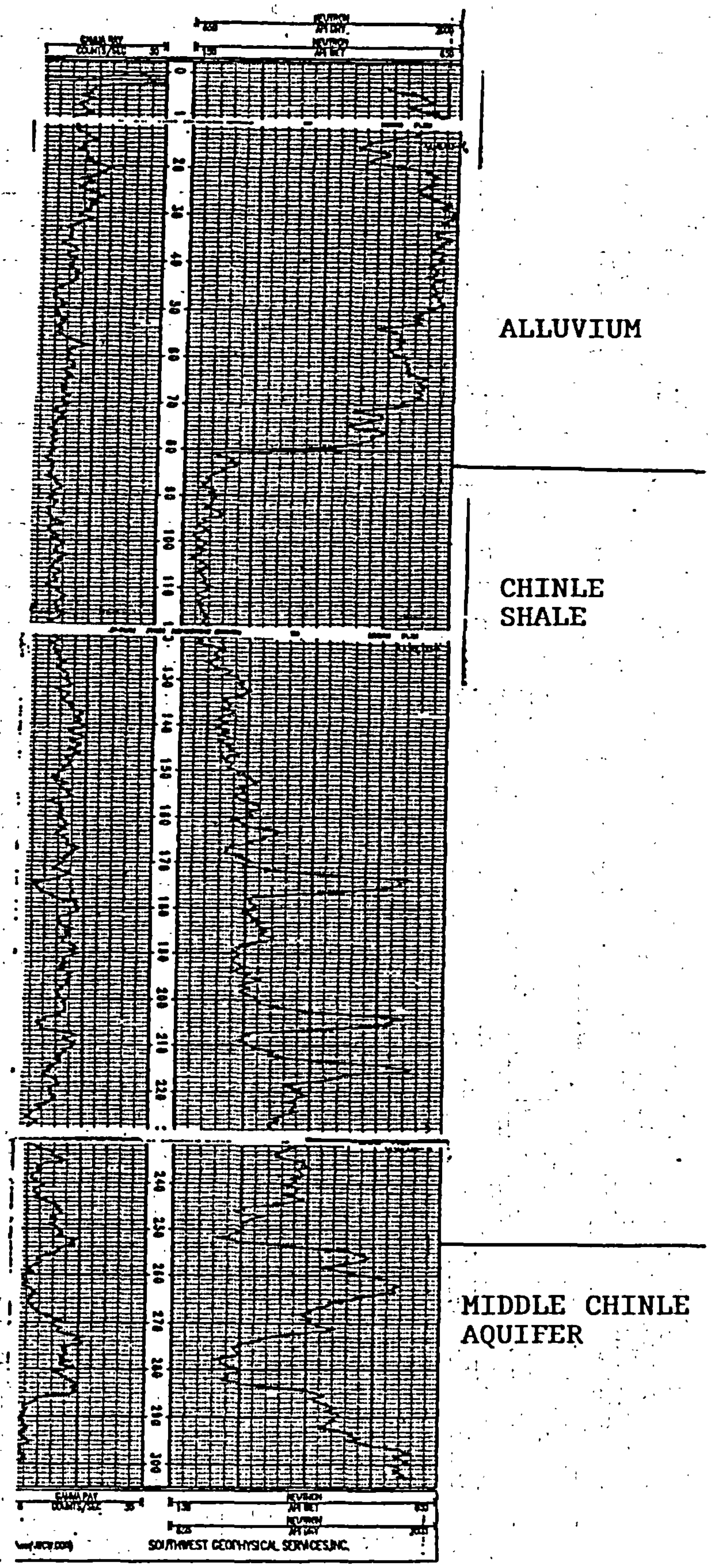

FIGURE A.2-9. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL WCW.

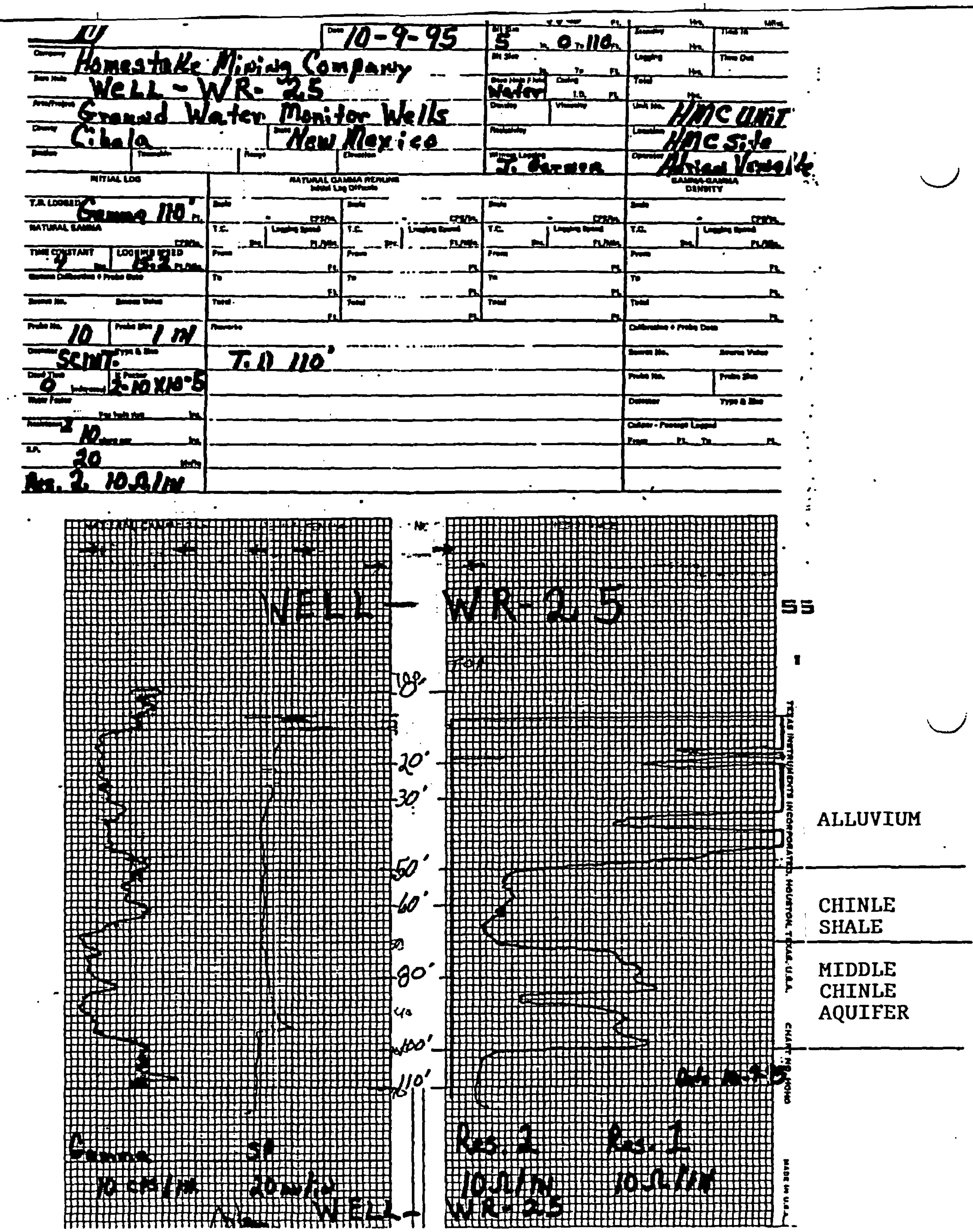

FIGURE A.2-10. GEOPHYSICAL LOGS FOR MIDDLE CHINLE WELL WR25.

TABLE A.2-1. LITHOLOGIC LOG FOR MIDDLE CHINLE WELL ACW.				
Depth in feet		Thickness in Feet	Color and Type of Material Encountered	
From	To			
0	20	20	tan shale	ALLUVIUM
20	40	20	tan sandy shale & gravel	
40	57	17	red shale	CHINLE SHALE
57	72	15	frac. Red & gray sandstone	UPPER CHINLE AQUIFER
72	154	82	chinle	CHINLE SHALE
154	175	21	red shale	
175	264	89	chinle	
264	278	14	tan sandstone	MIDDLE CHILE AQUIFER
278	291	13	gray sandy shale	
291	300	9	sandstone	
300	305	5	red shale	
305	320	15	frac. Tan sandstone	
320	340	20	chinle	

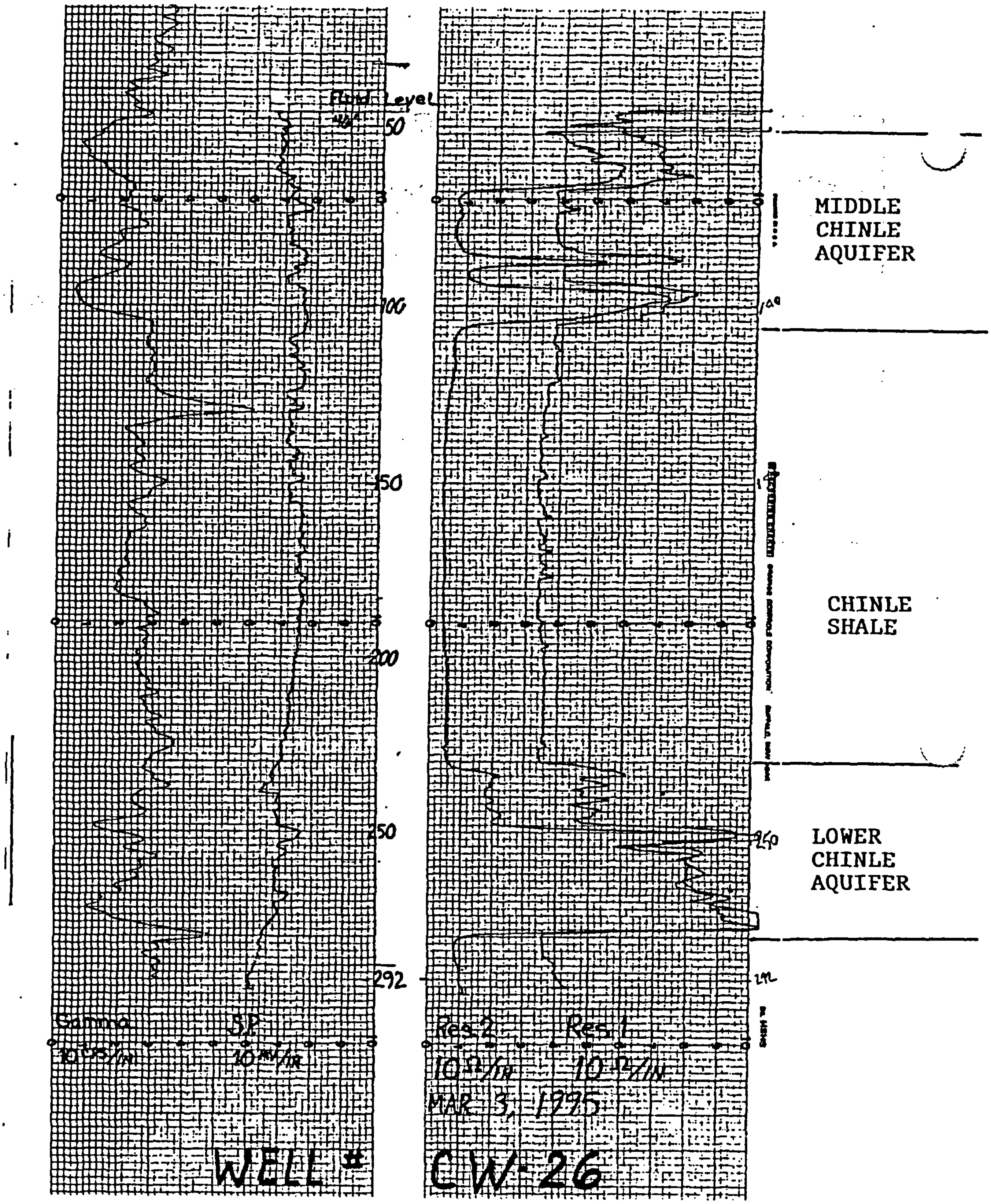

FIGURE A.3-1. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW26.

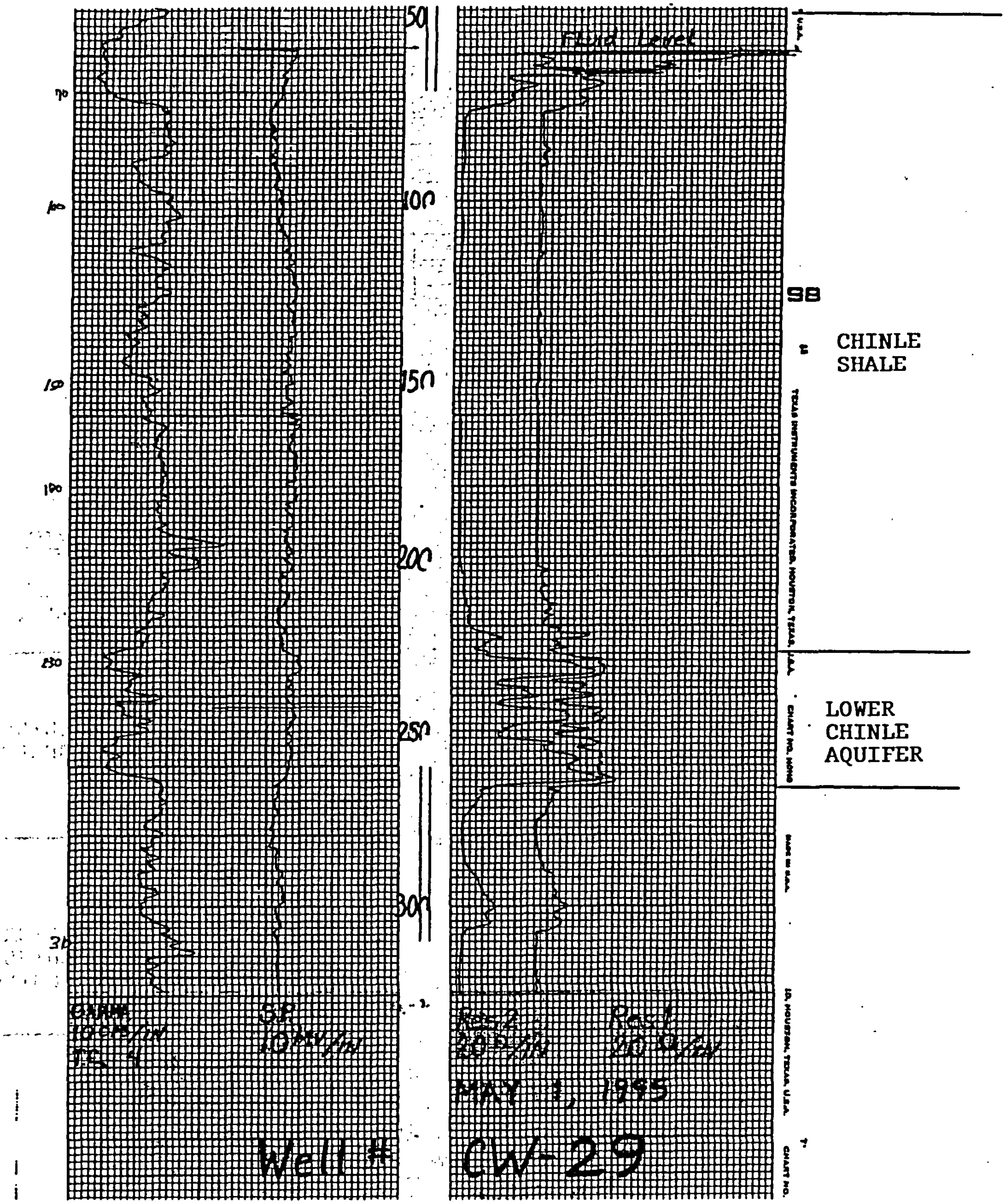

FIGURE A.3-2. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW29.

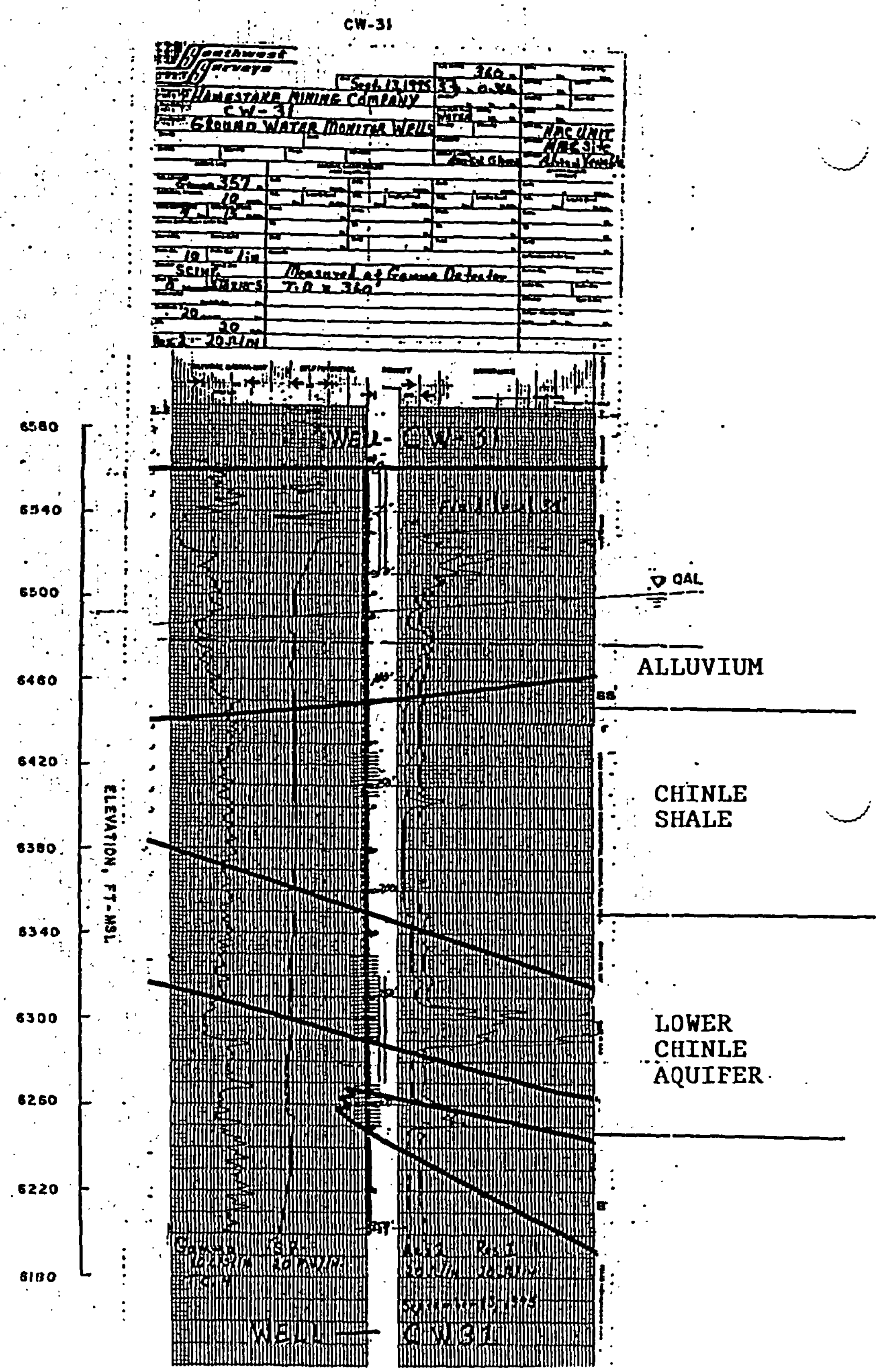

FIGURE A.3-3. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW31.

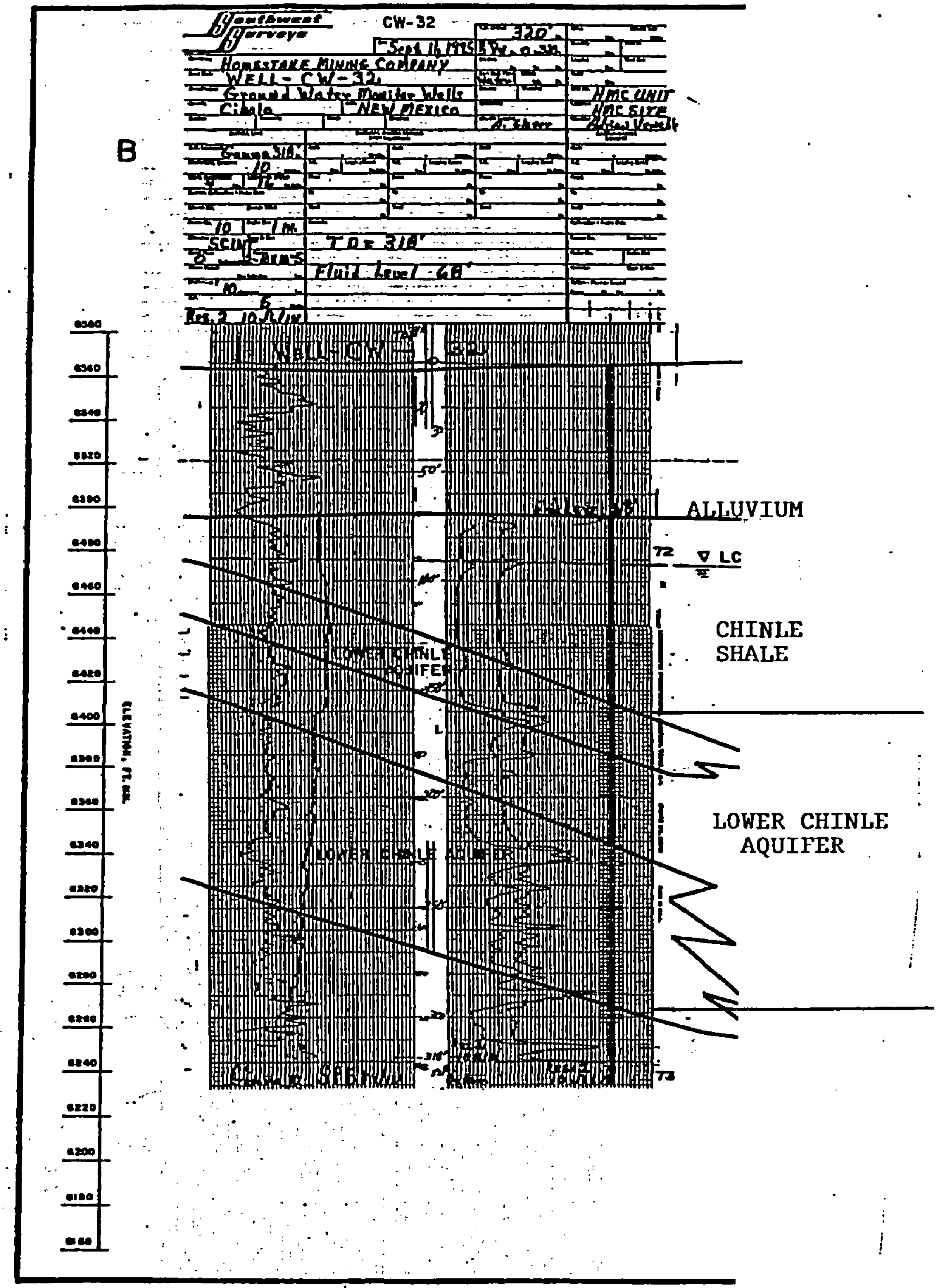

FIGURE A.3-4. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW32.

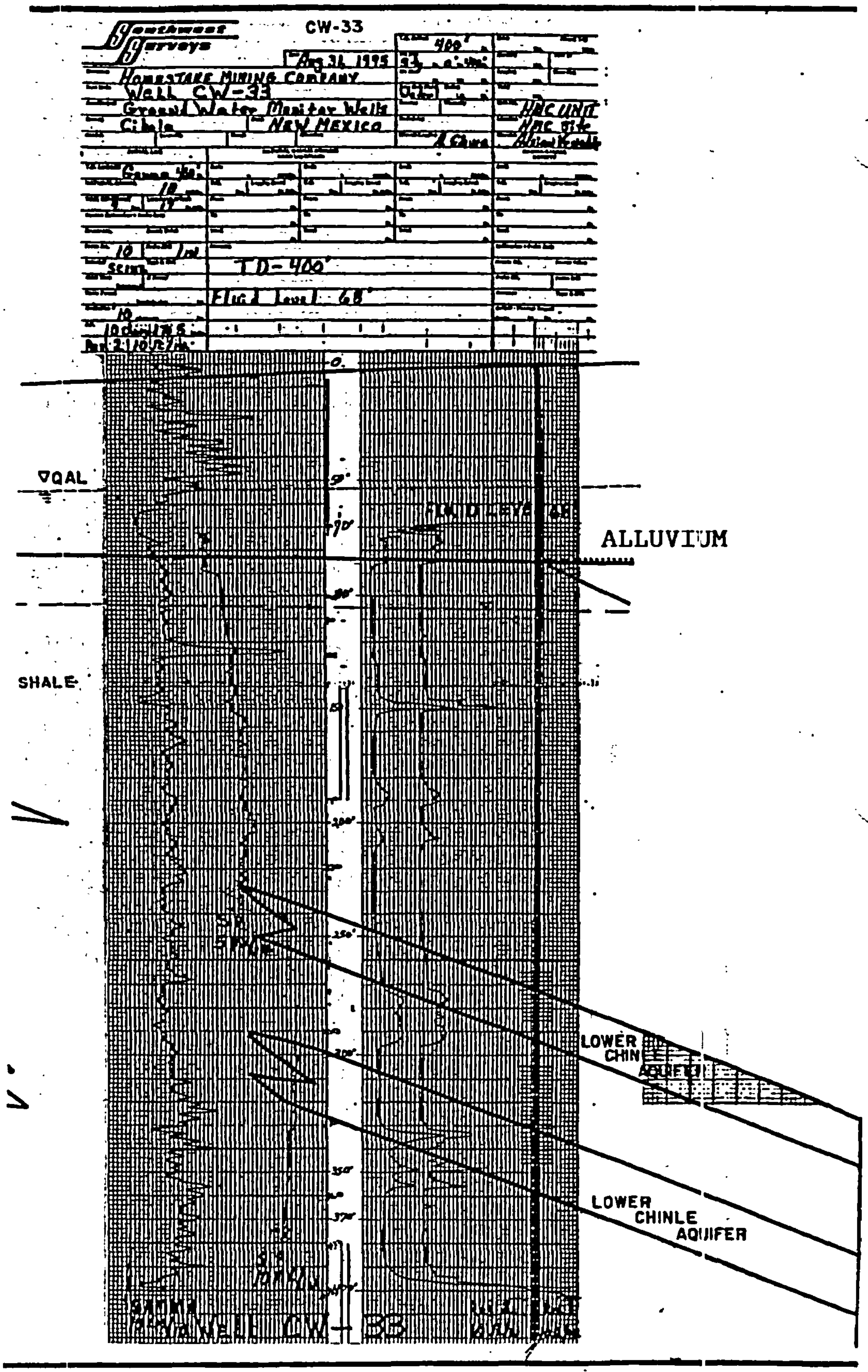

FIGURE A.3-5. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW33.

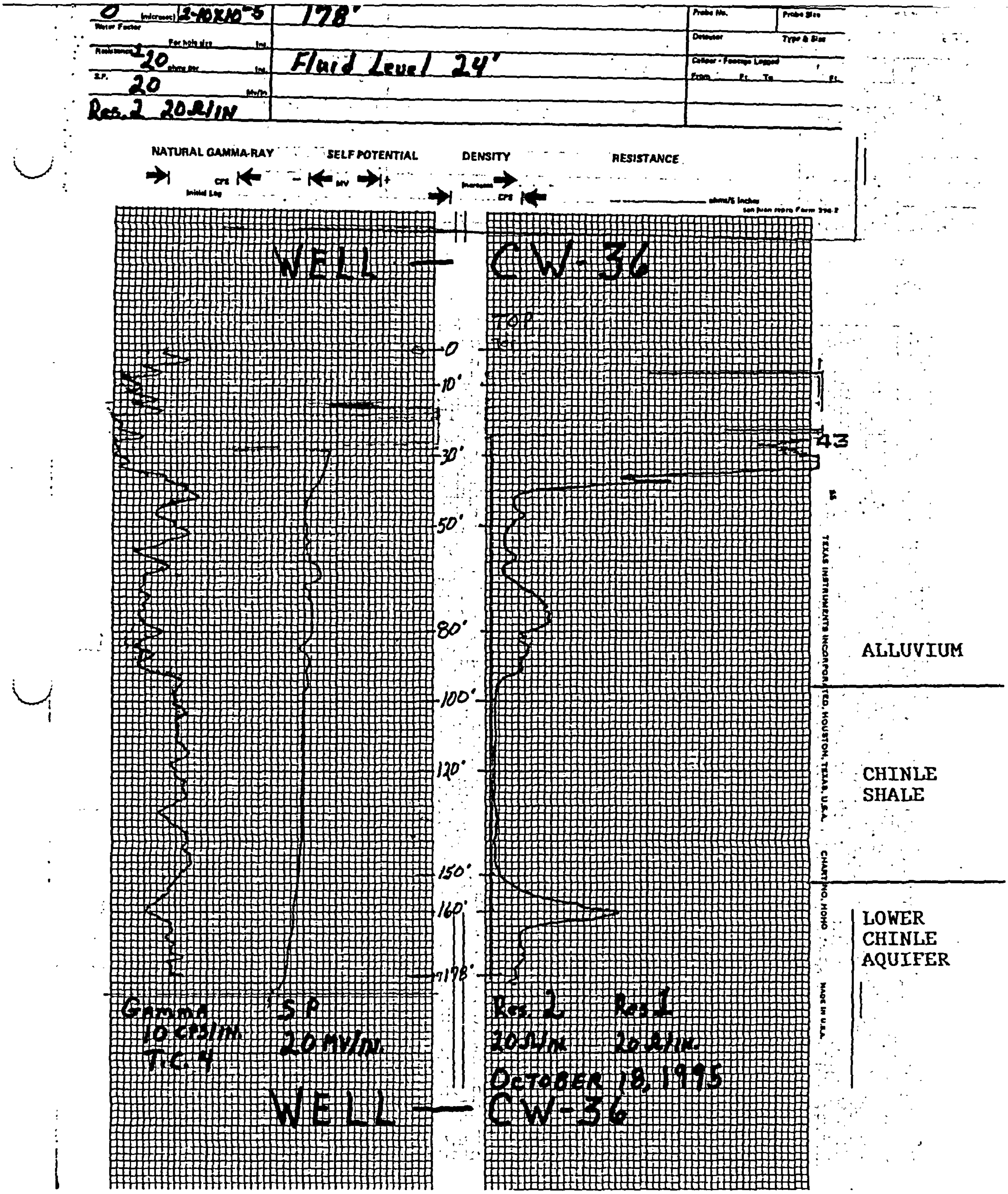

FIGURE A.3-6. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW36.

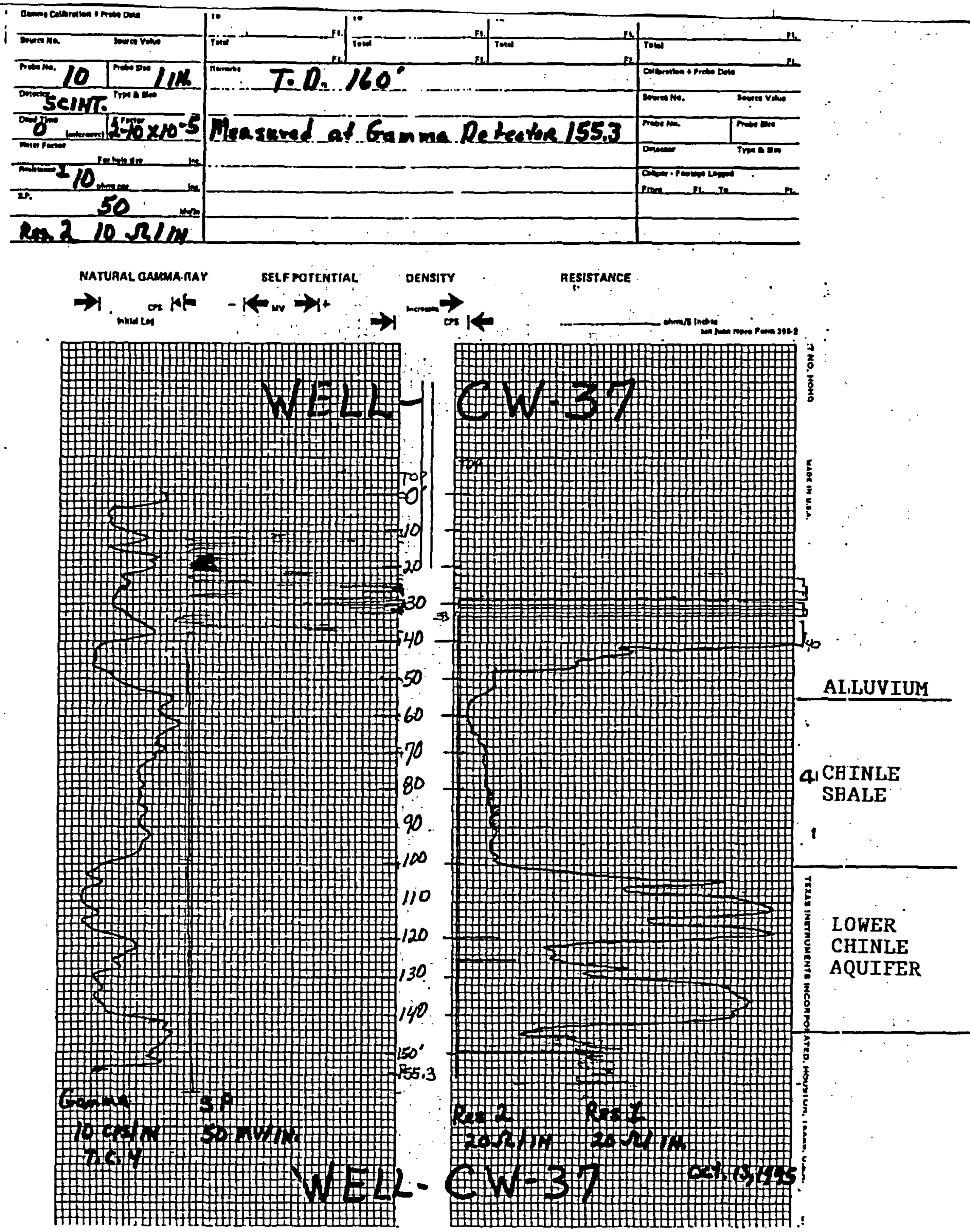

FIGURE A.3-7. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW37.

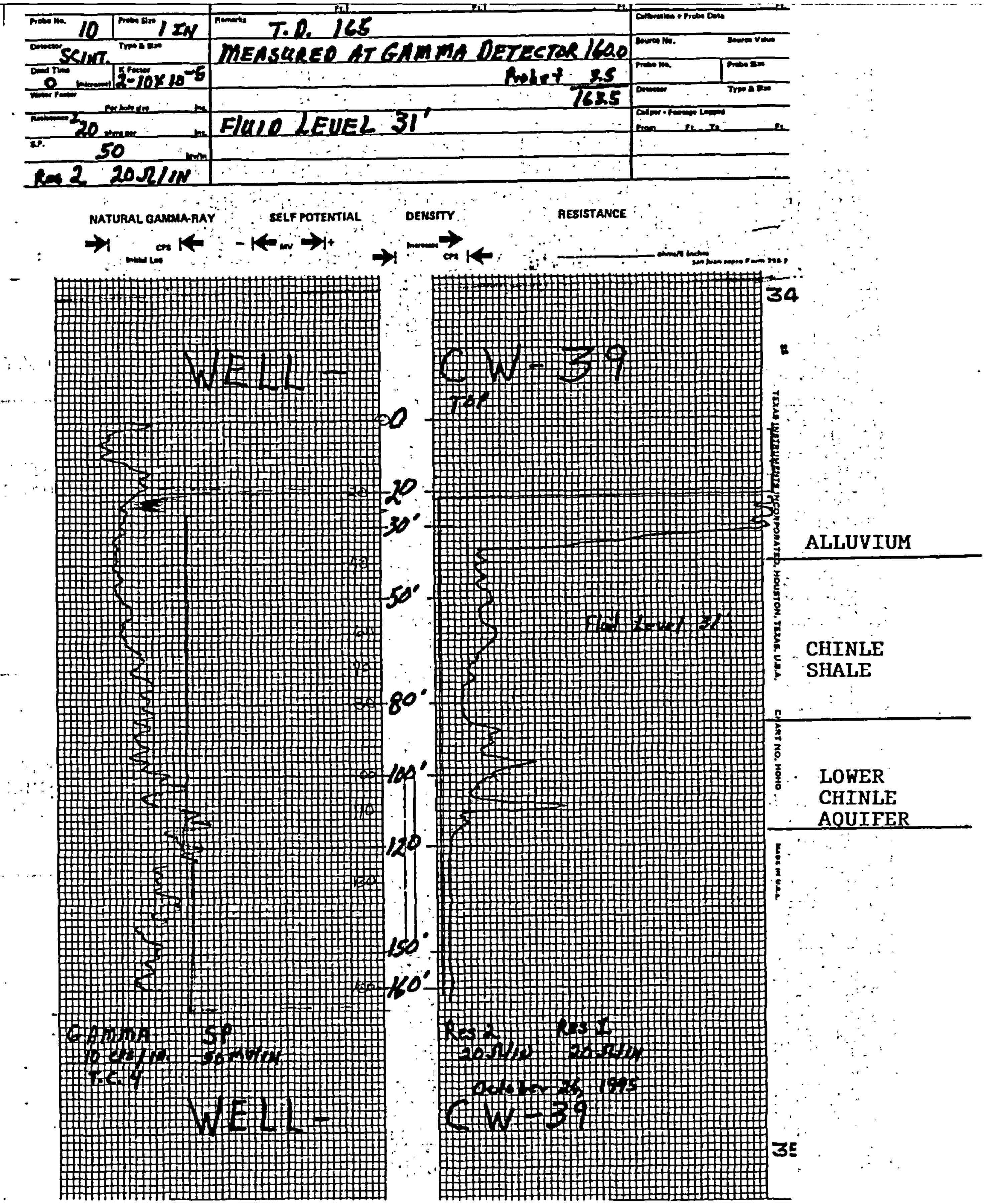

FIGURE A.3-8. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW39.

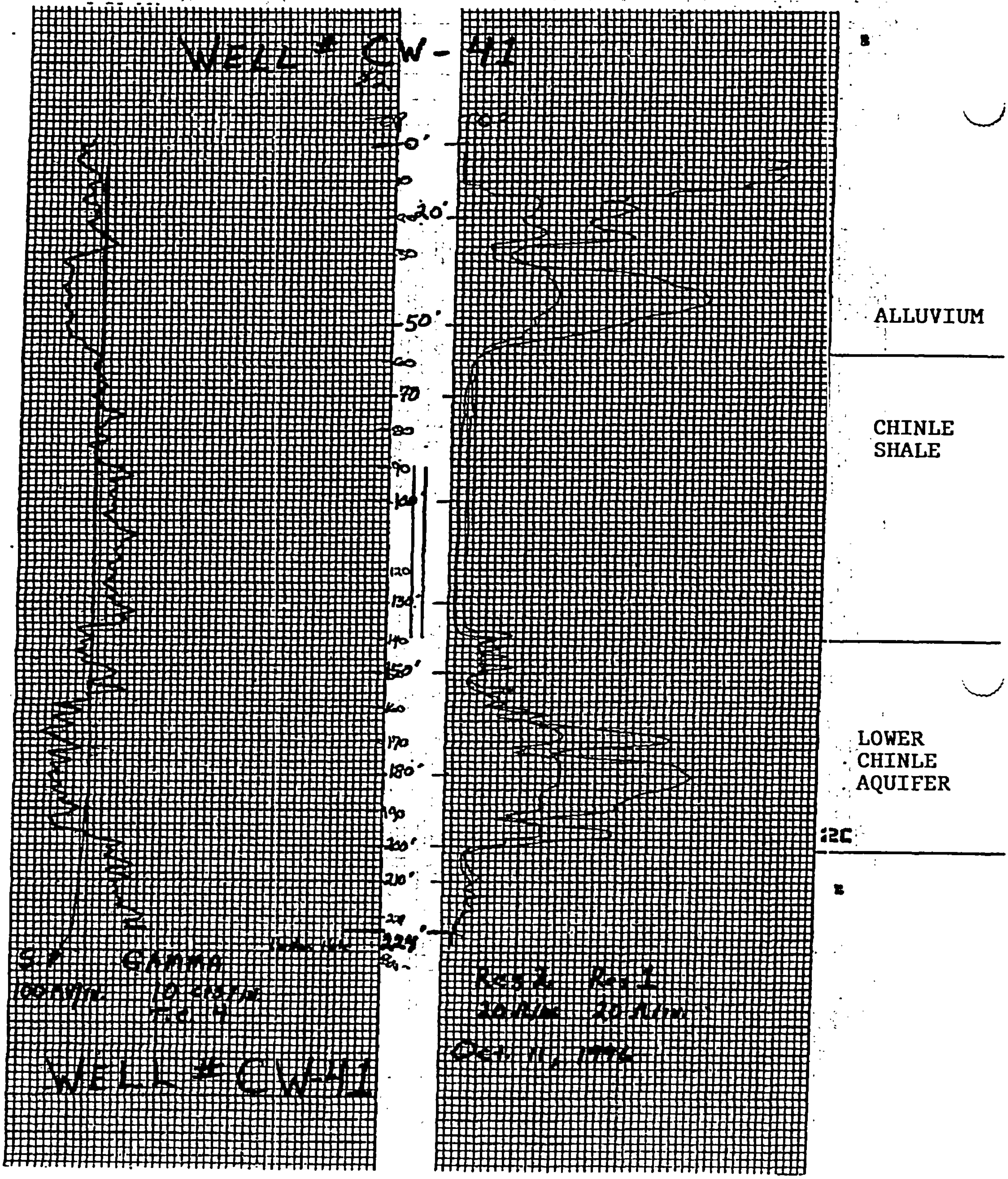

FIGURE A.3-9. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW41.

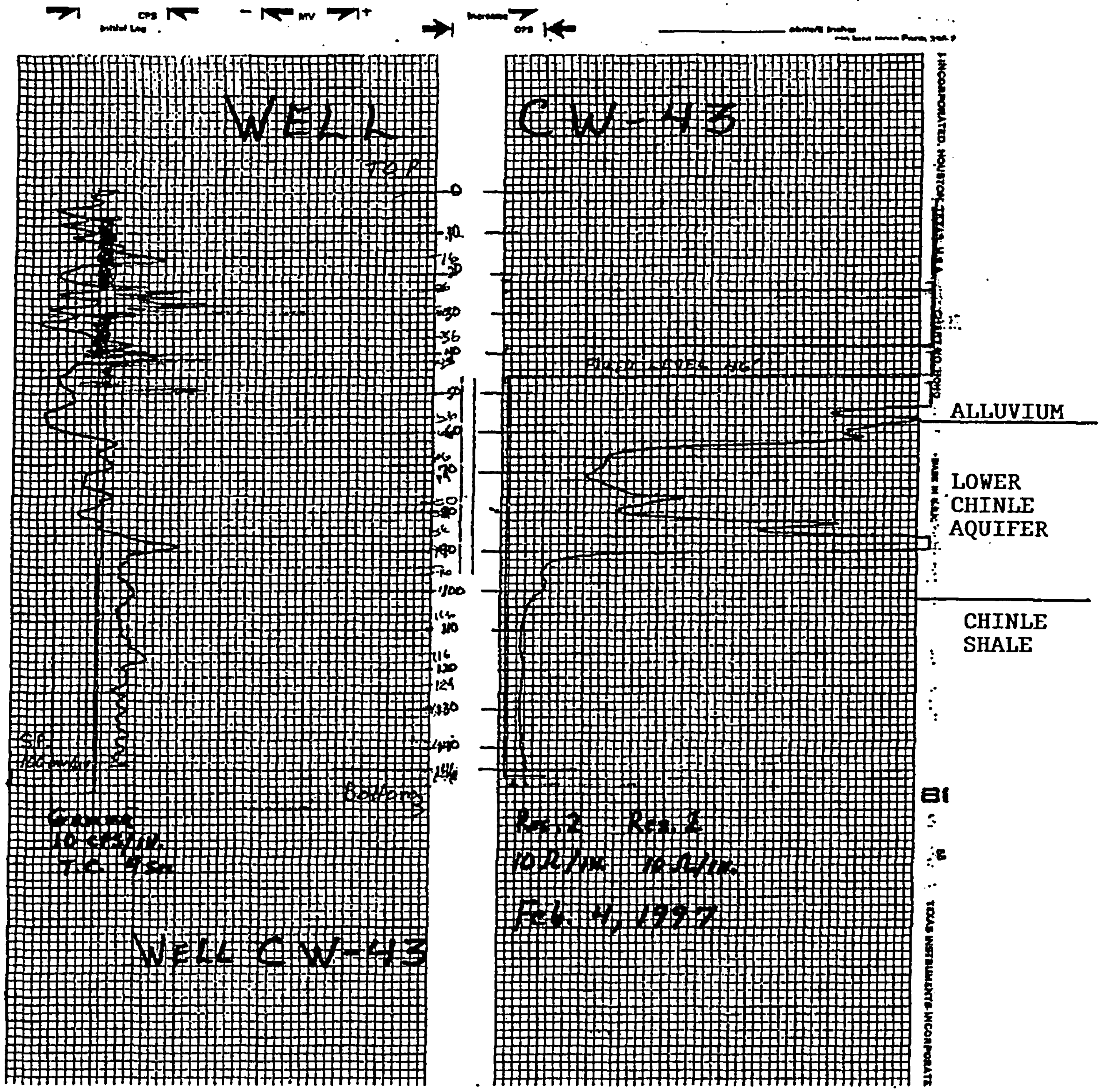

FIGURE A.3-10. GEOPHYSICAL LOGS FOR LOWER CHINLE WELL CW43.

APPENDIX B

WELL SCHEMATICS

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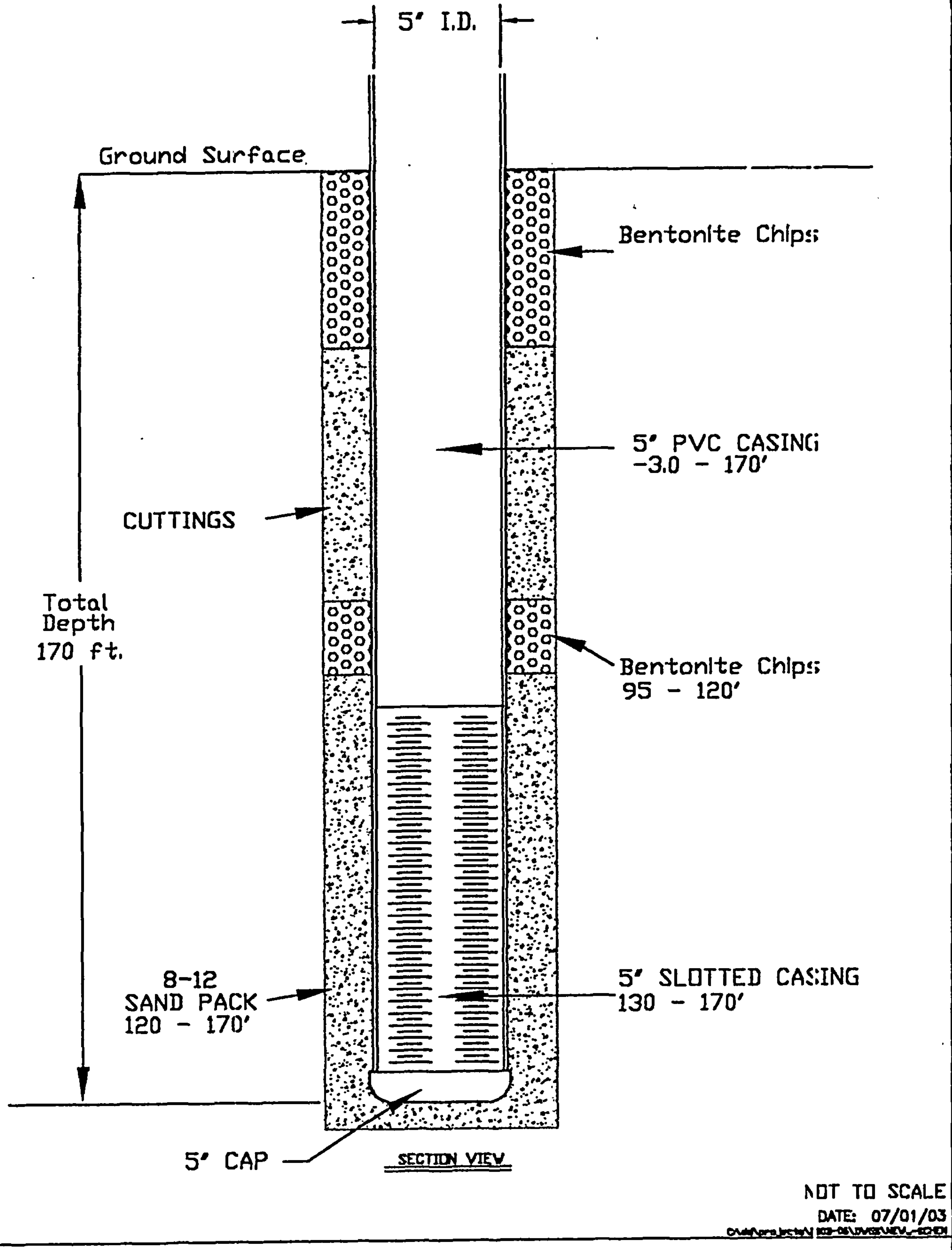


FIGURE B.1-1. WELL SCHEMATIC FOR UPPER CHINLE WELL CW50

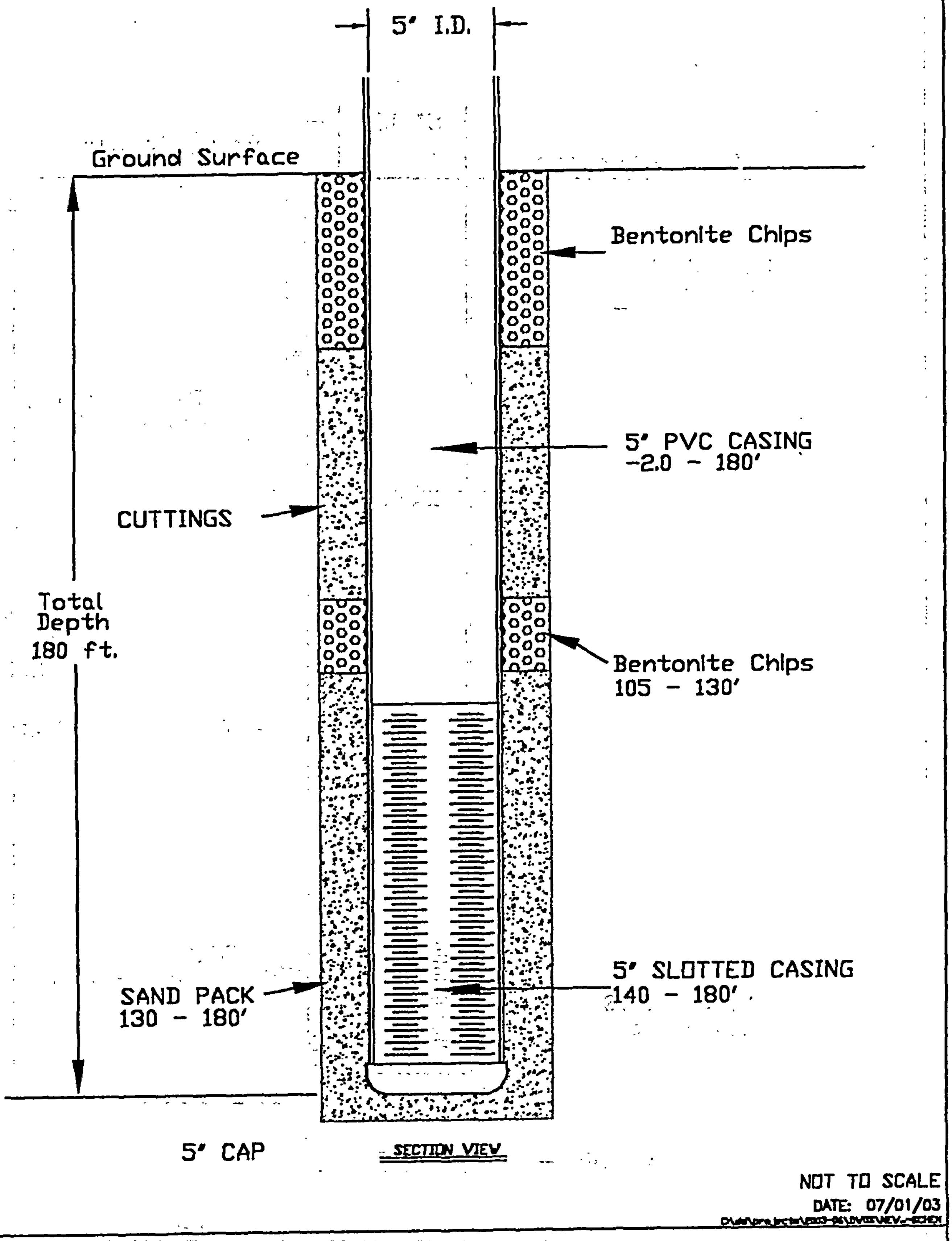
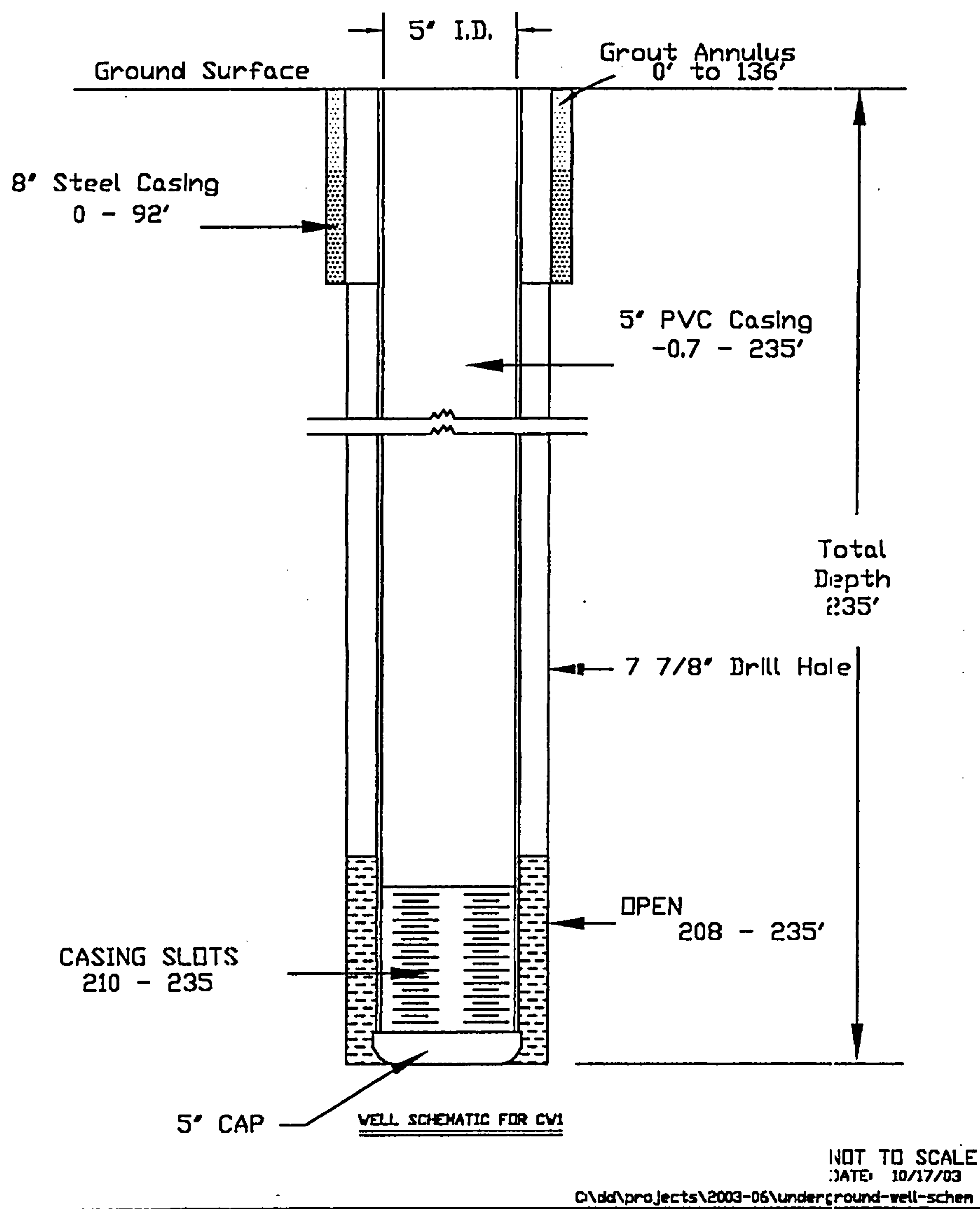


FIGURE B.1-2. WELL SCHEMATIC FOR UPPER CHINLE WELL CW52



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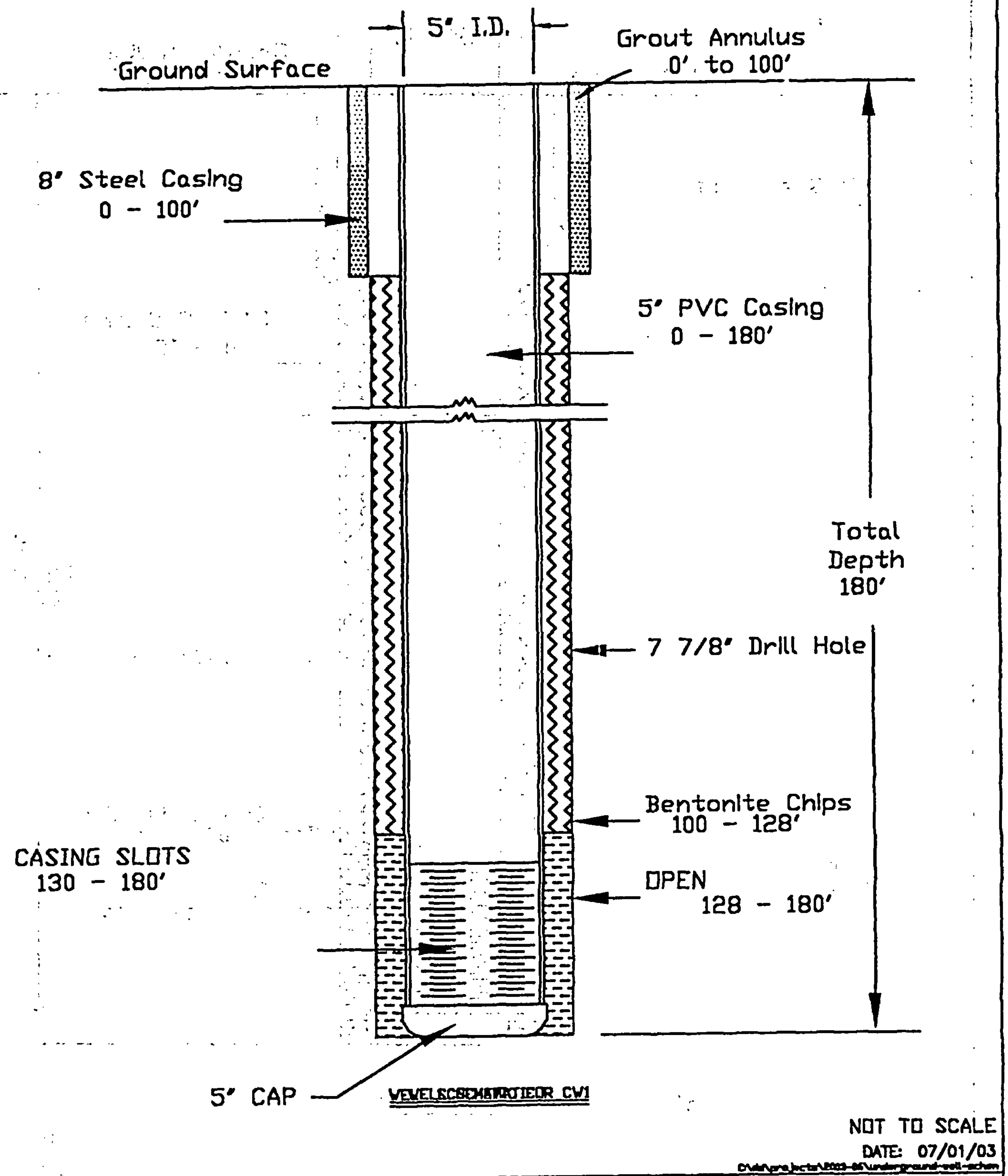

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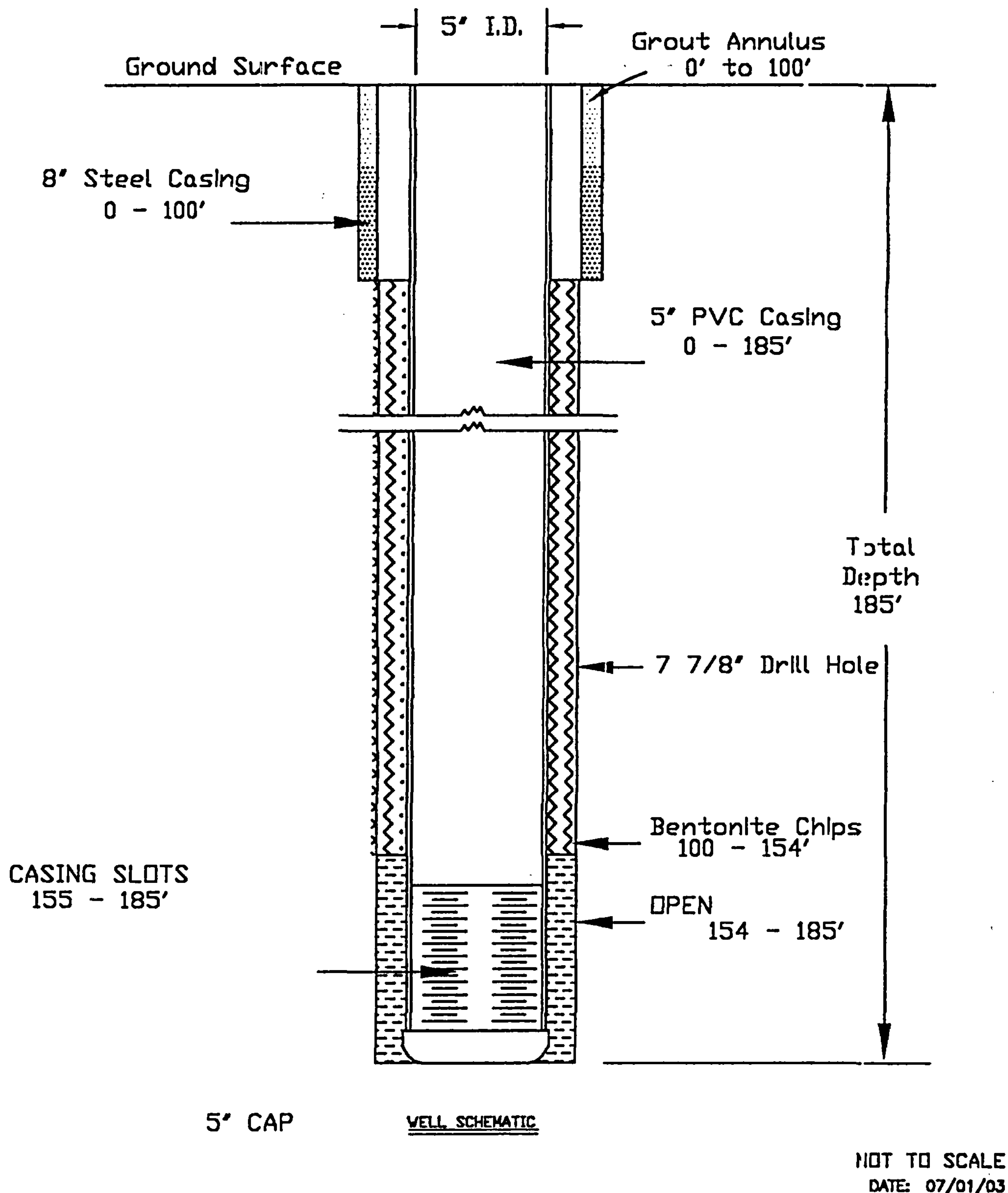
FIGURE B.1-4. WELL SCHEMATIC FOR UPPER CHINLE WELL CW9



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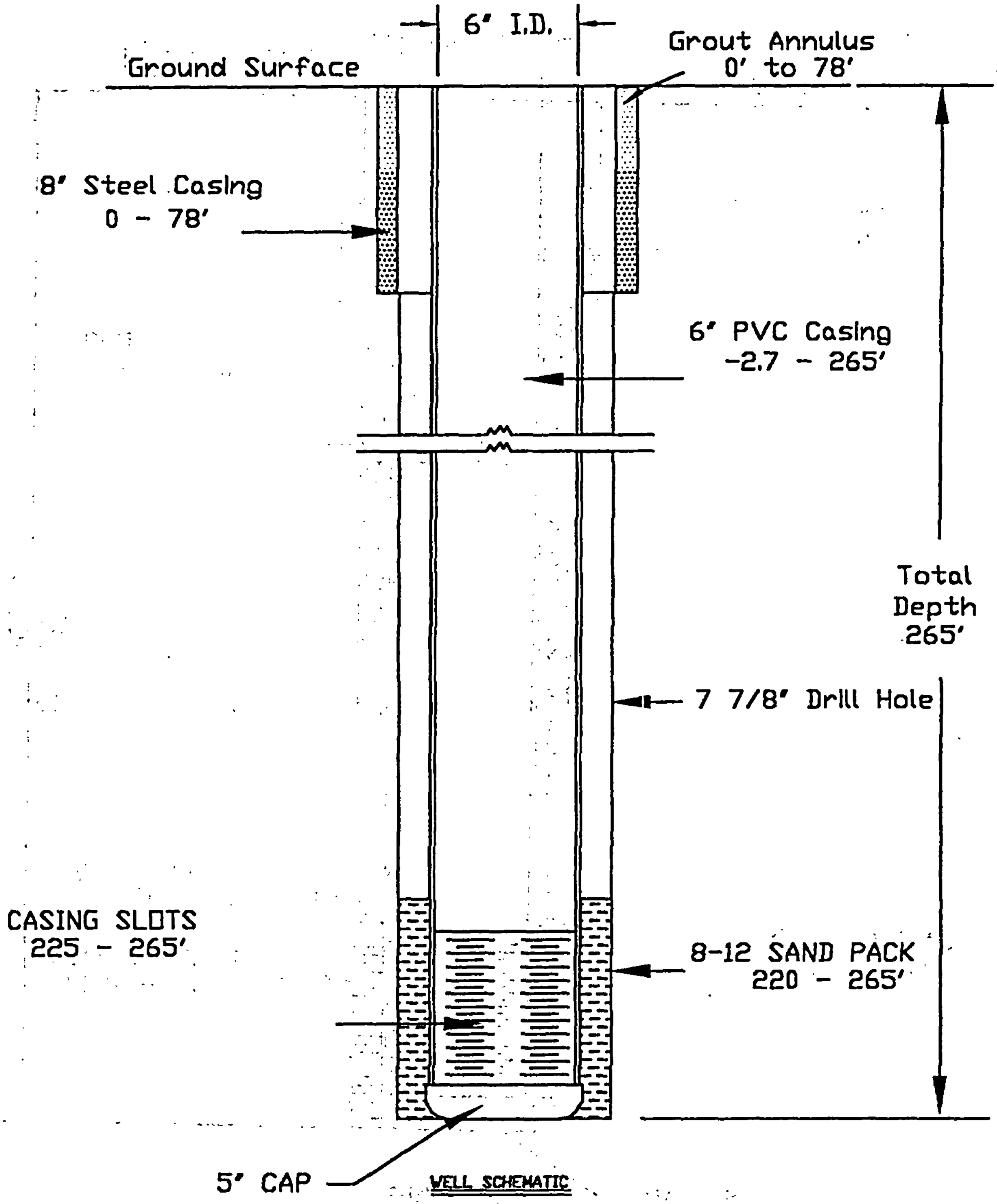

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FIGURE B.1-6. WELL SCHEMATIC FOR UPPER CHINLE WELL CW13

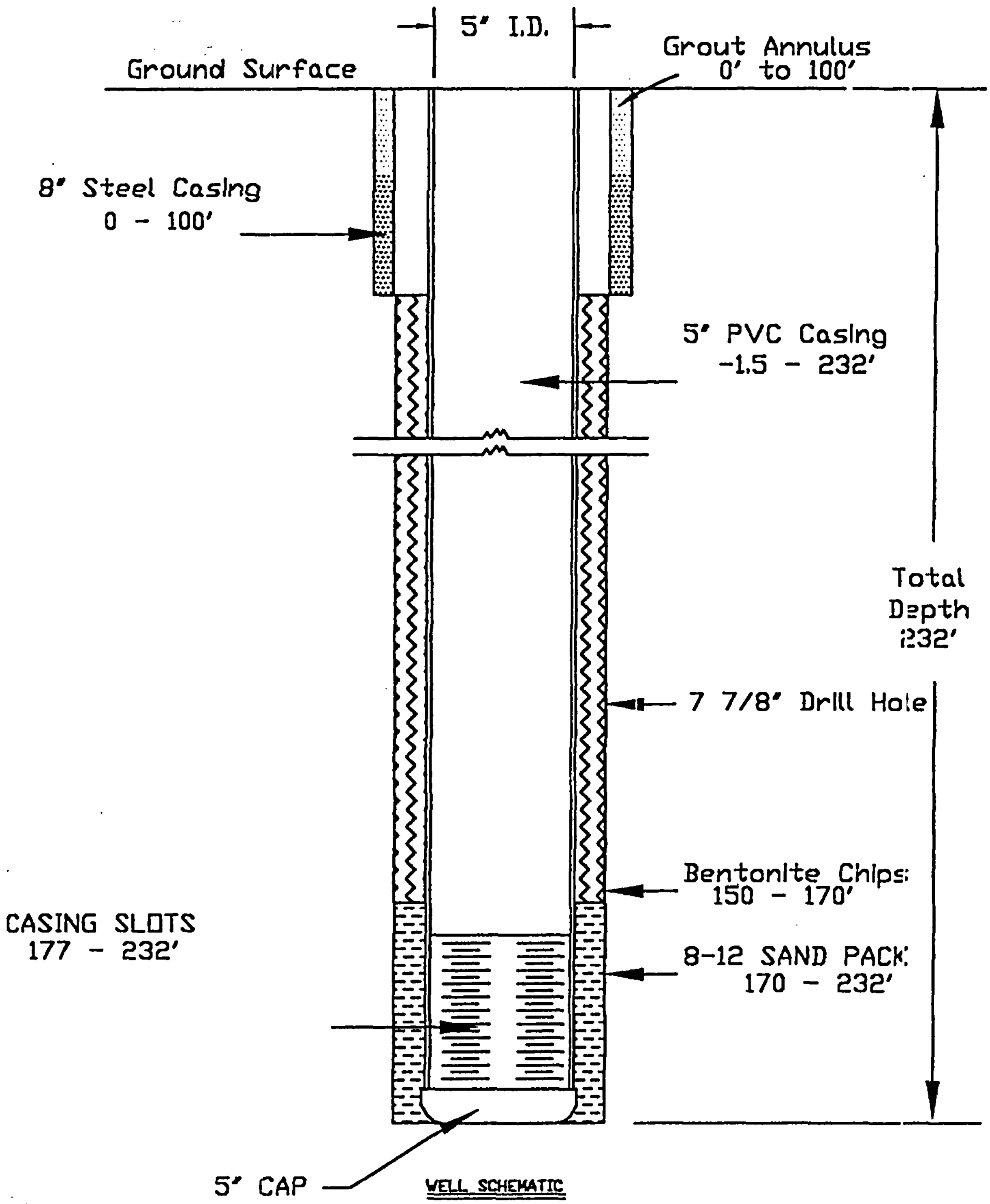

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FIGURE B.1-7. WELL SCHEMATIC FOR UPPER CHINLE WELL CW18

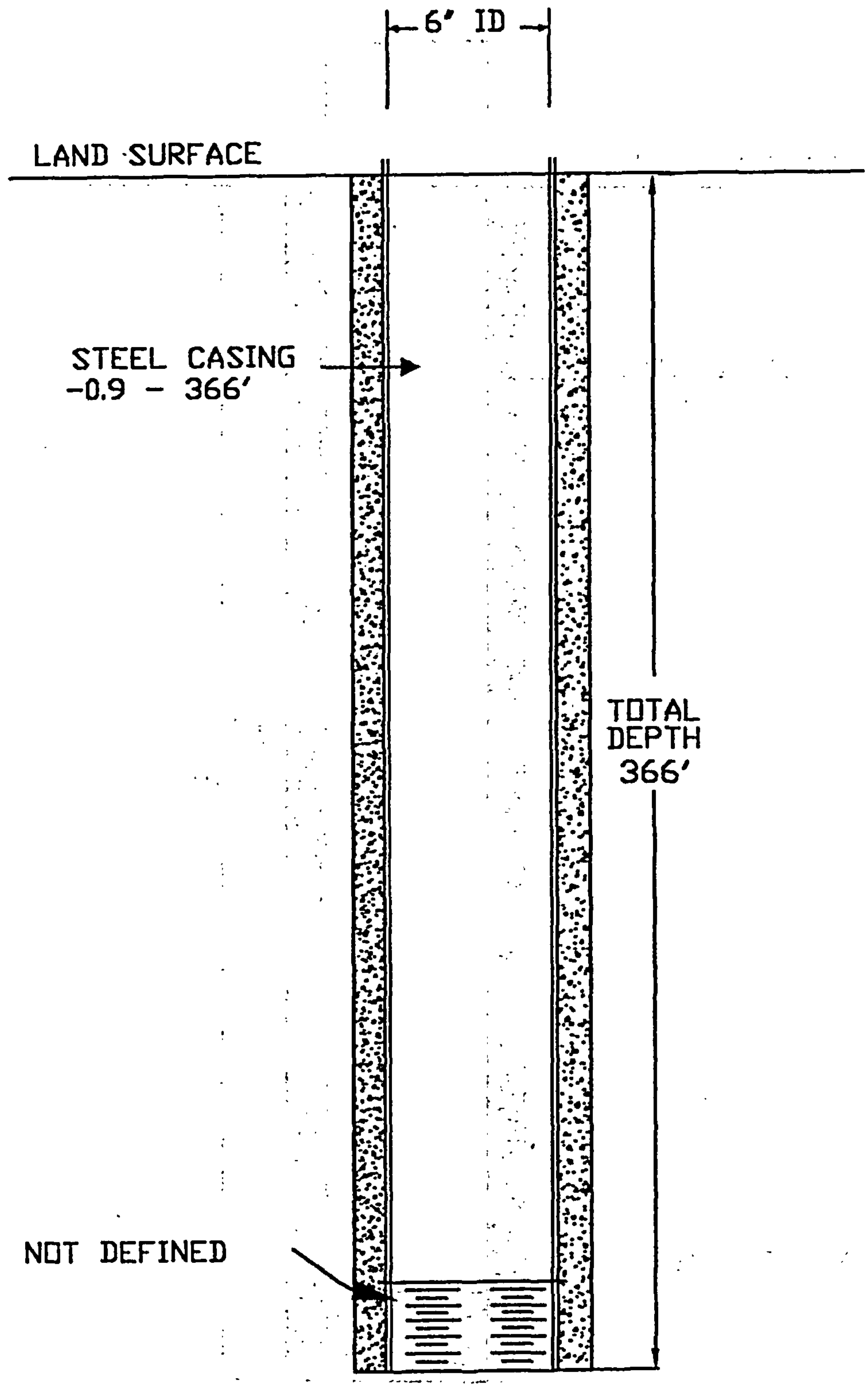

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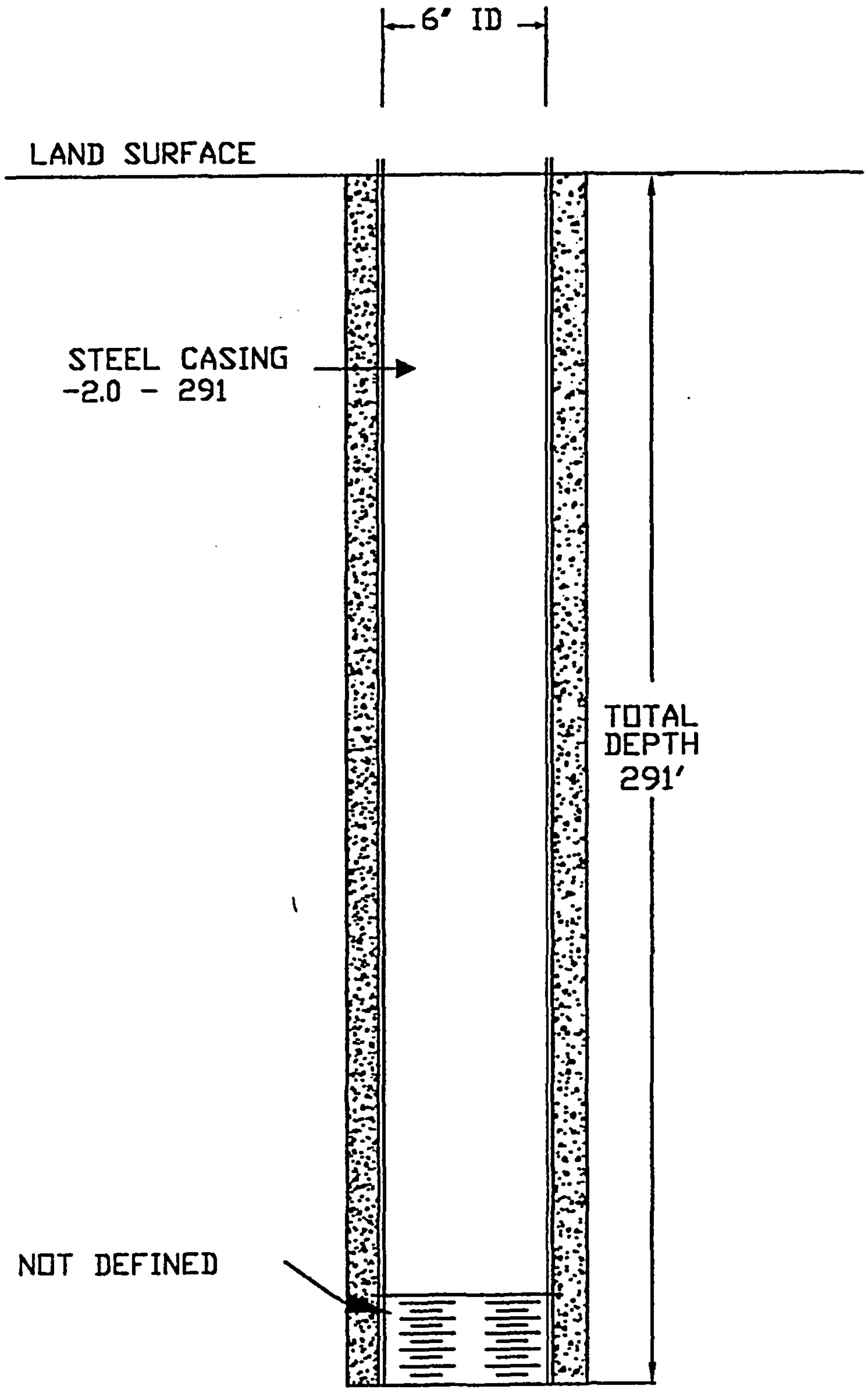
FIGURE B.1-8. WELL SCHEMATIC FOR UPPER CHINLE WELL 931



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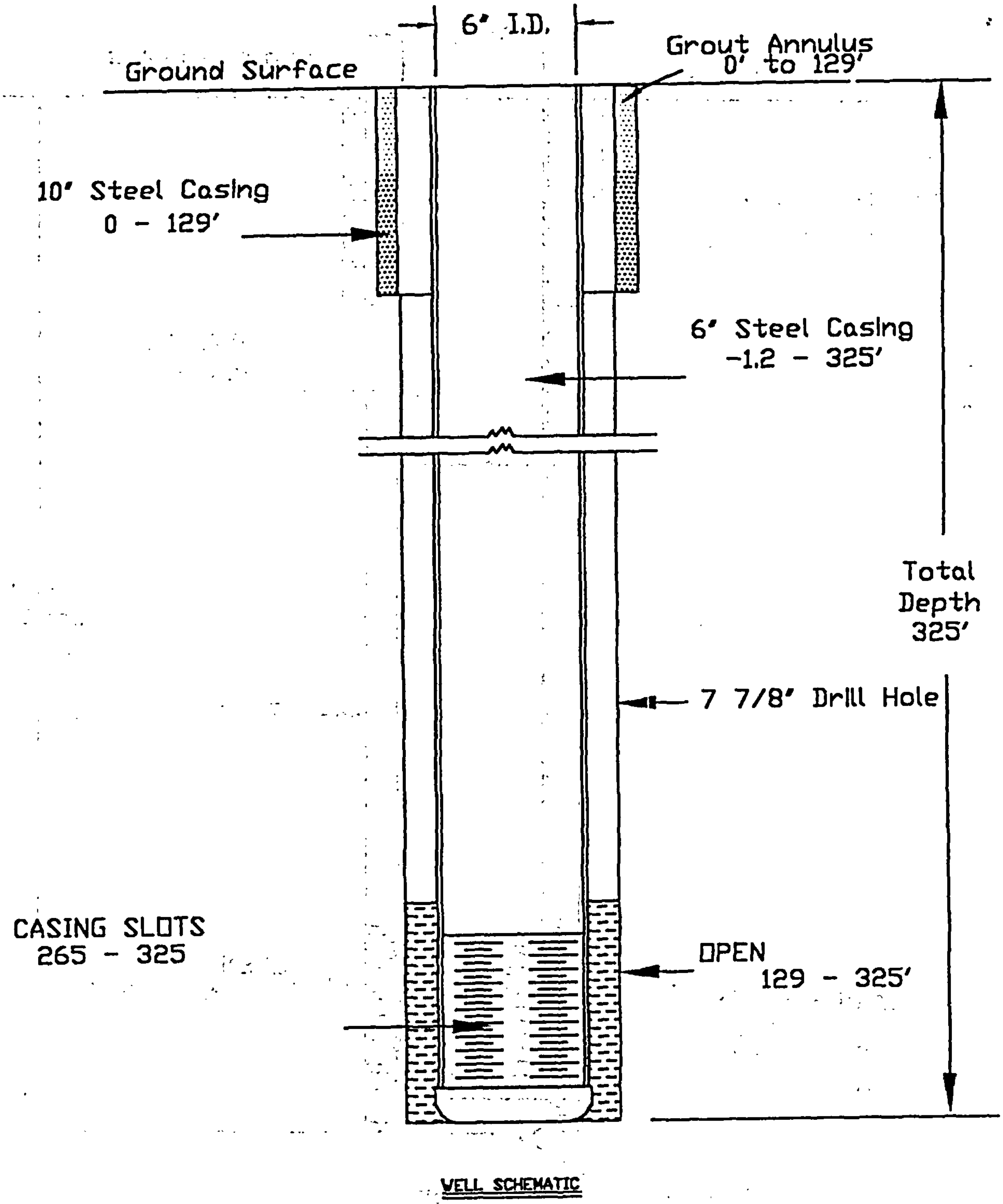

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FIGURE B.2-1. WELL SCHEMATIC FOR MIDDLE CHINLE WELL ACW

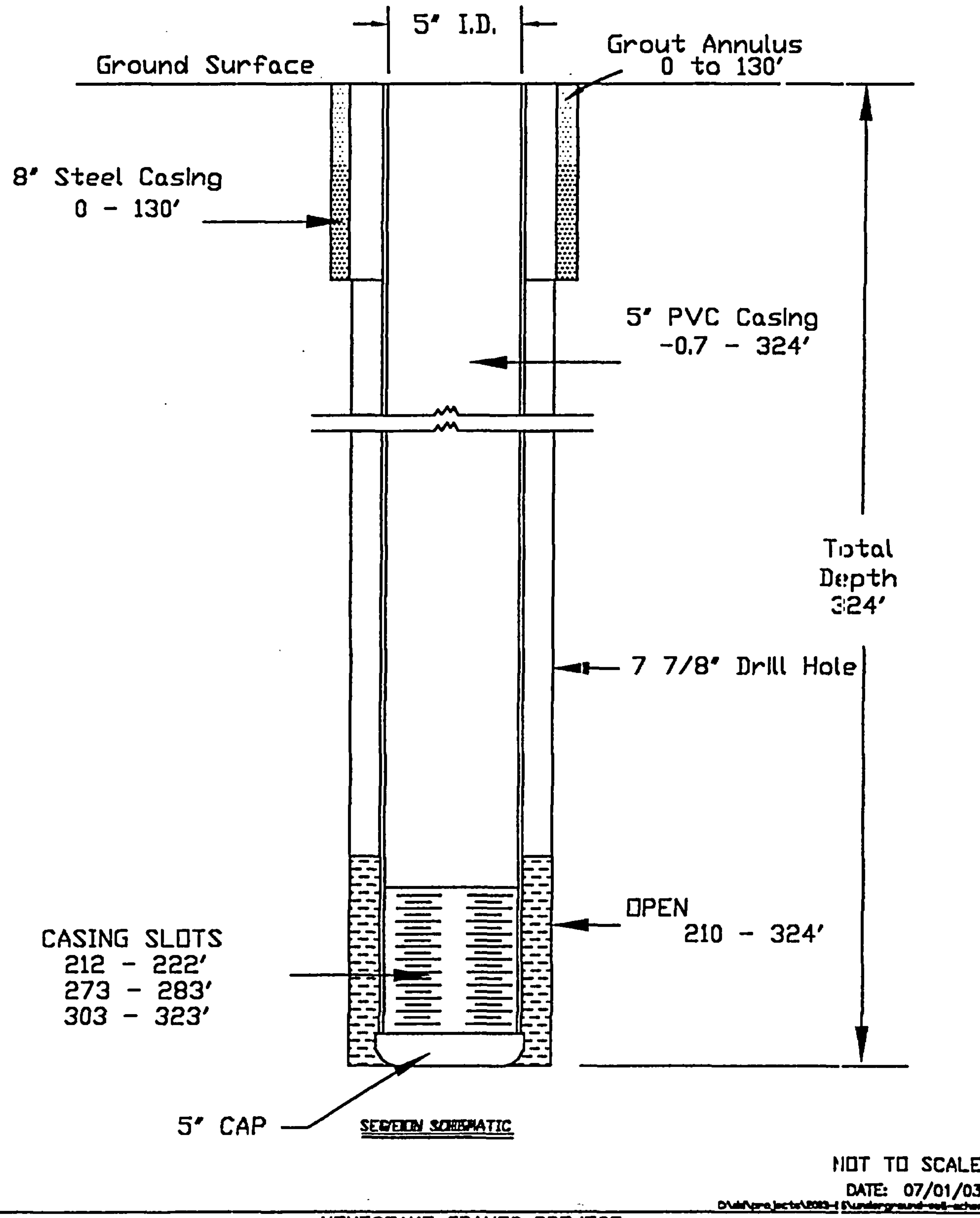

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FIGURE B.2-2. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW1

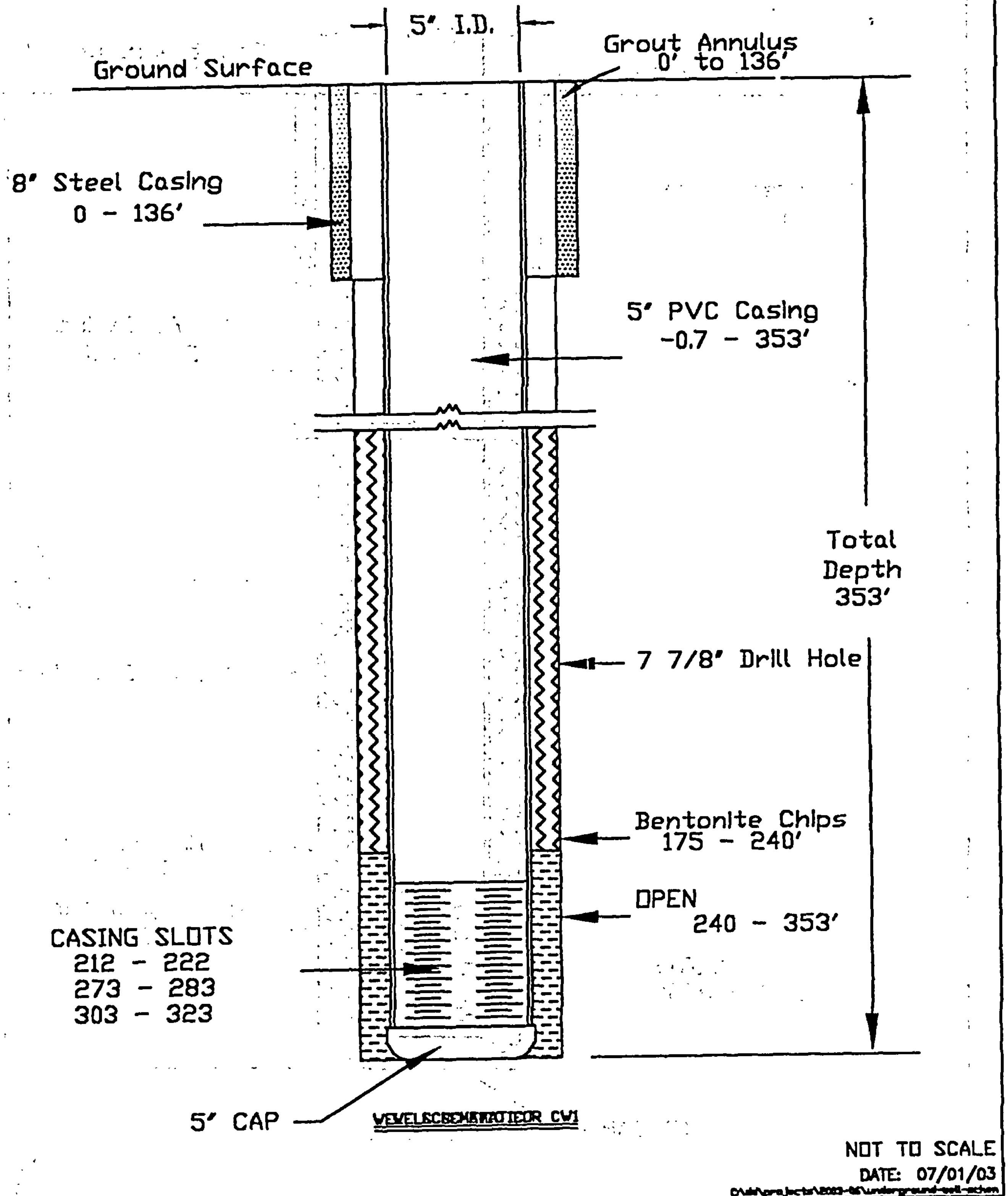

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FIGURE B.2-3. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW2

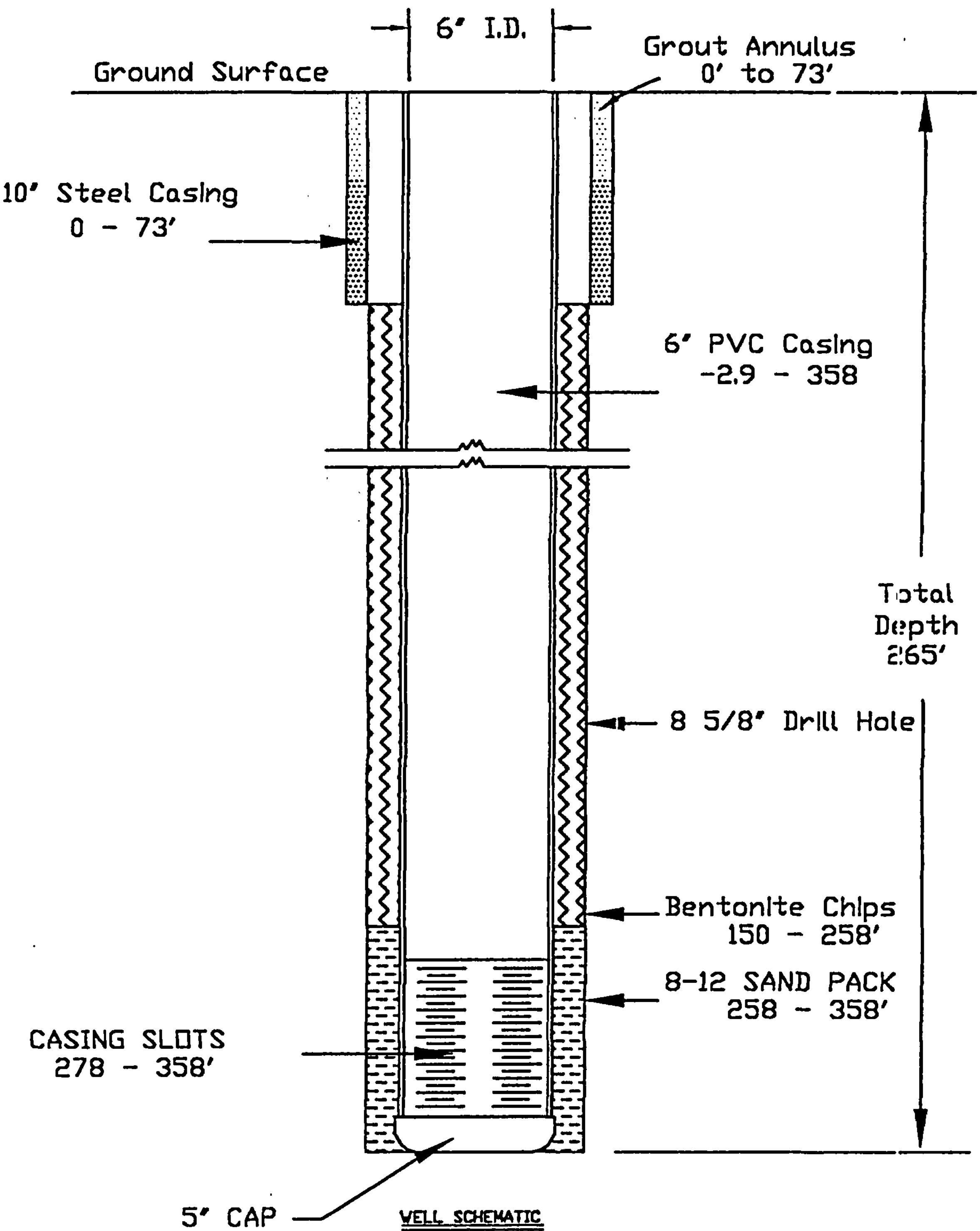

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FIGURE B.2-4. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW14

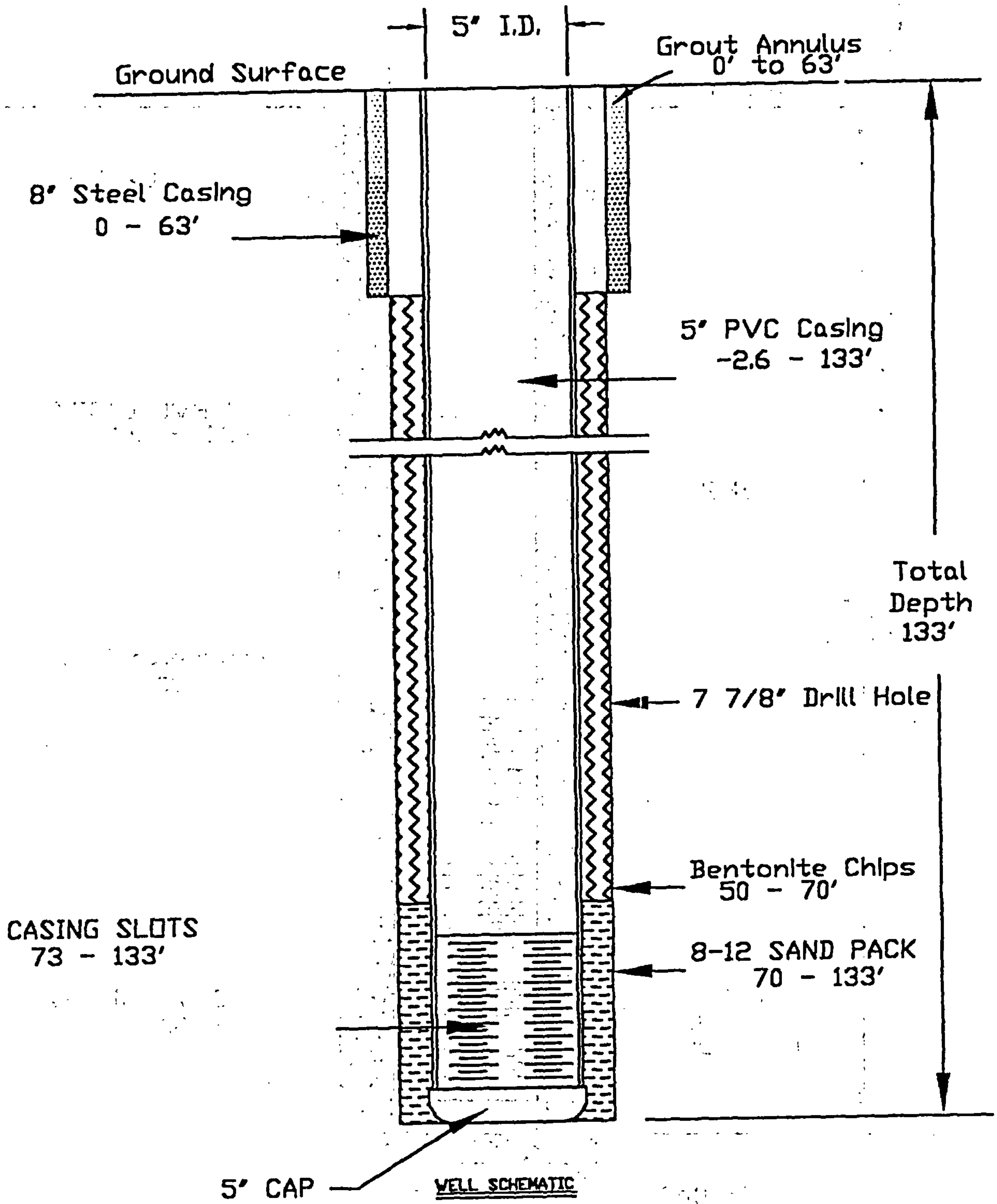

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FIGURE B.2-5. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW15

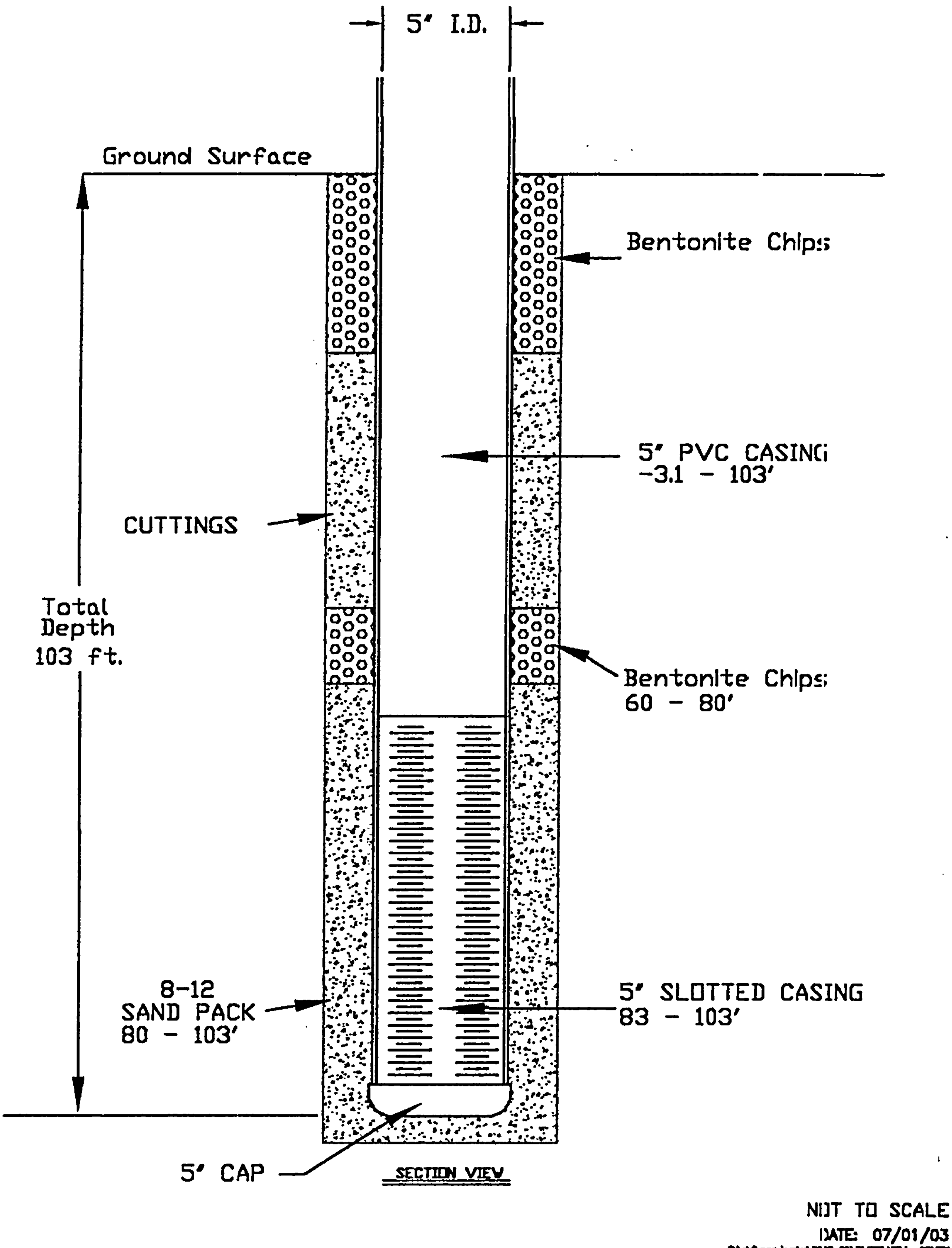
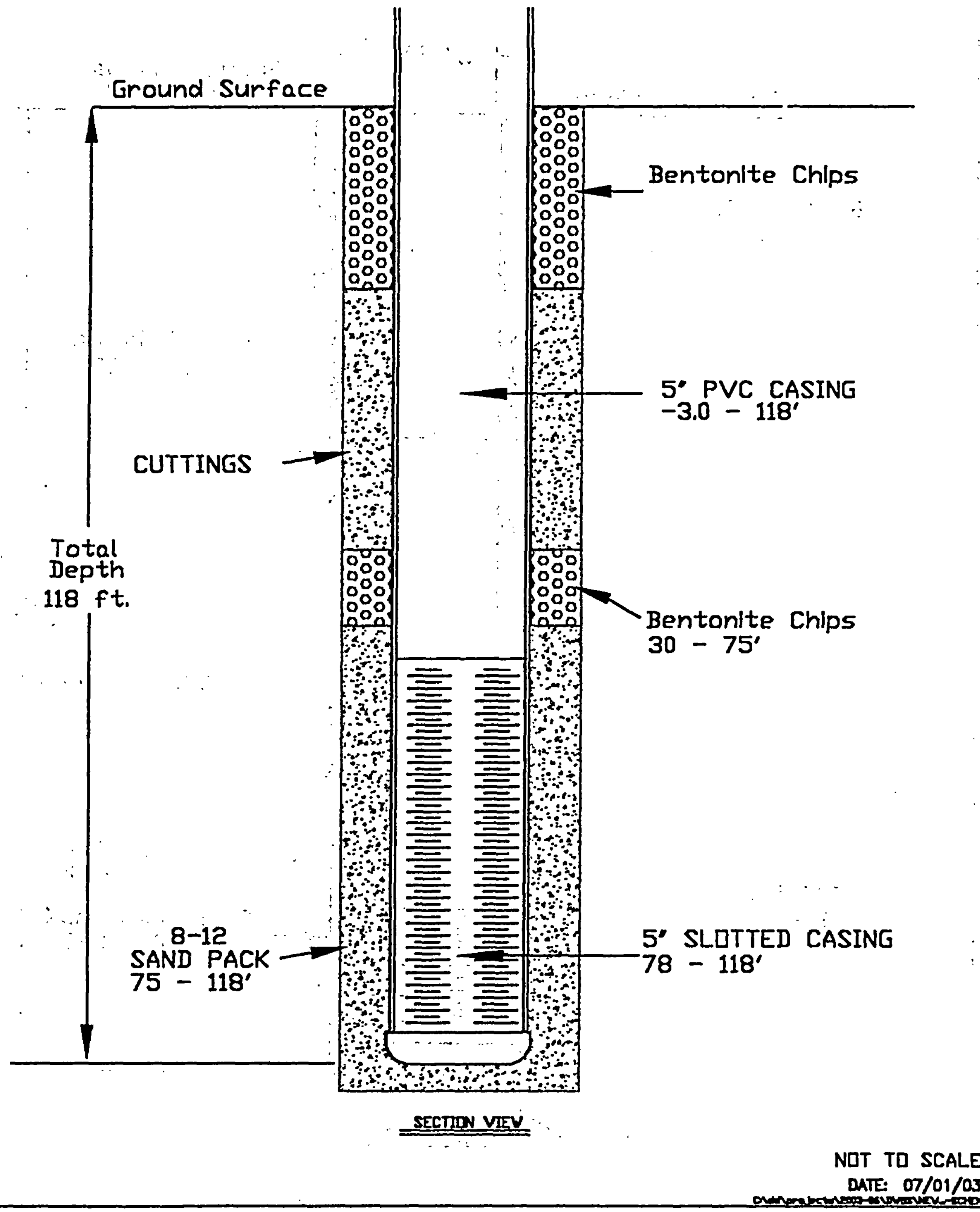


FIGURE B.2-6. WELL SCHEMATIC FOR MIDDLE CHINLE WELL. CW17



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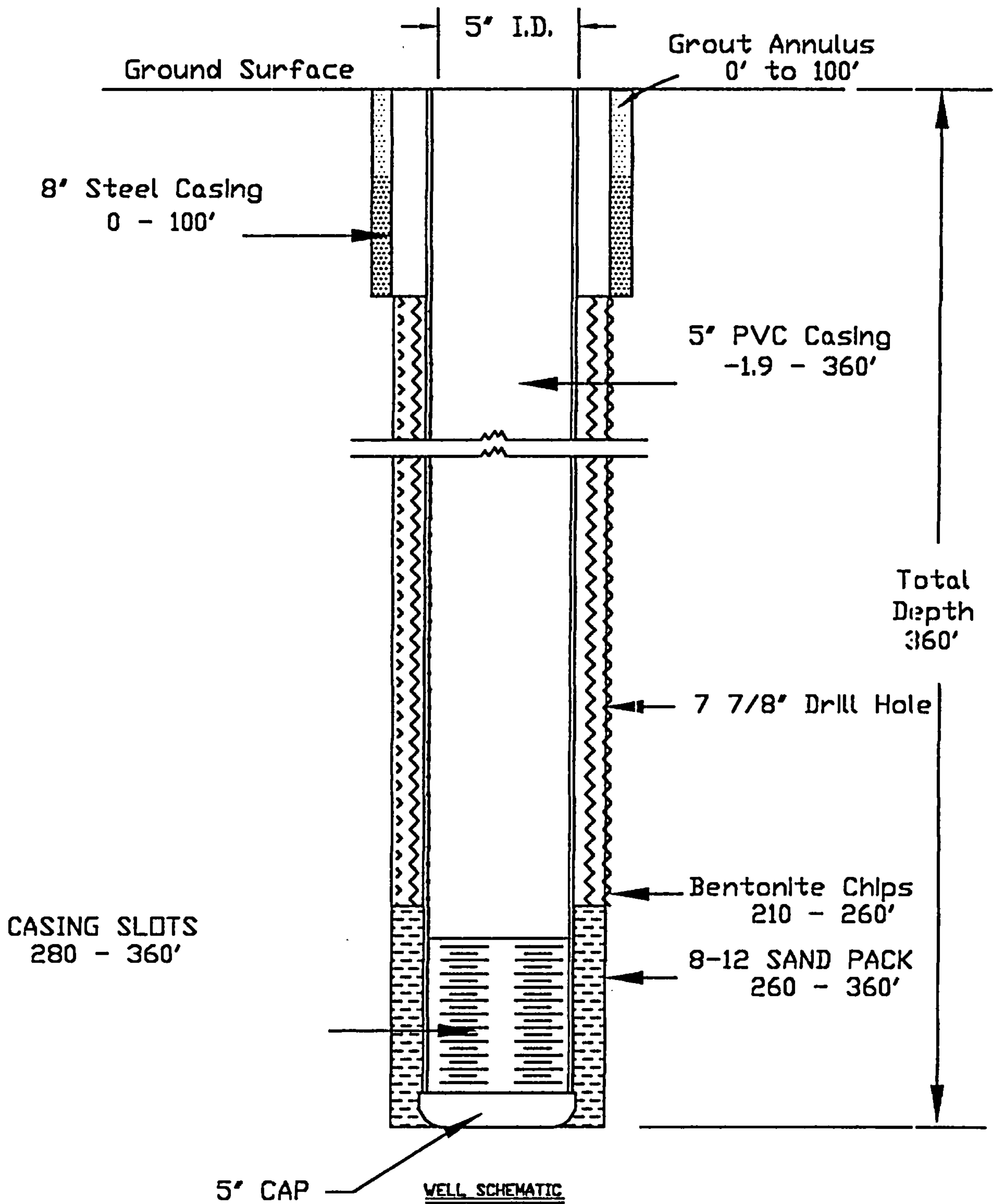

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FIGURE B.2-8. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW28

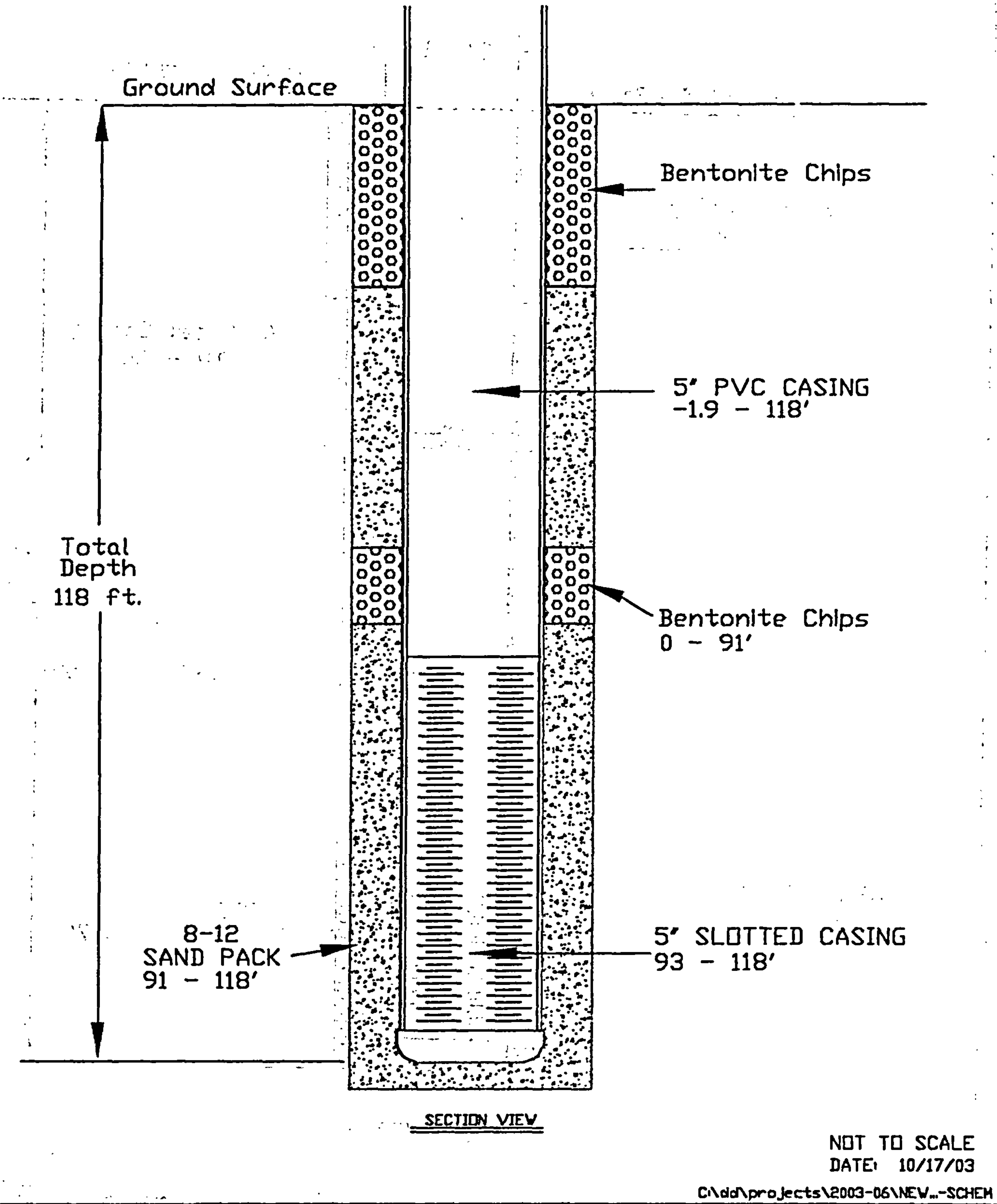
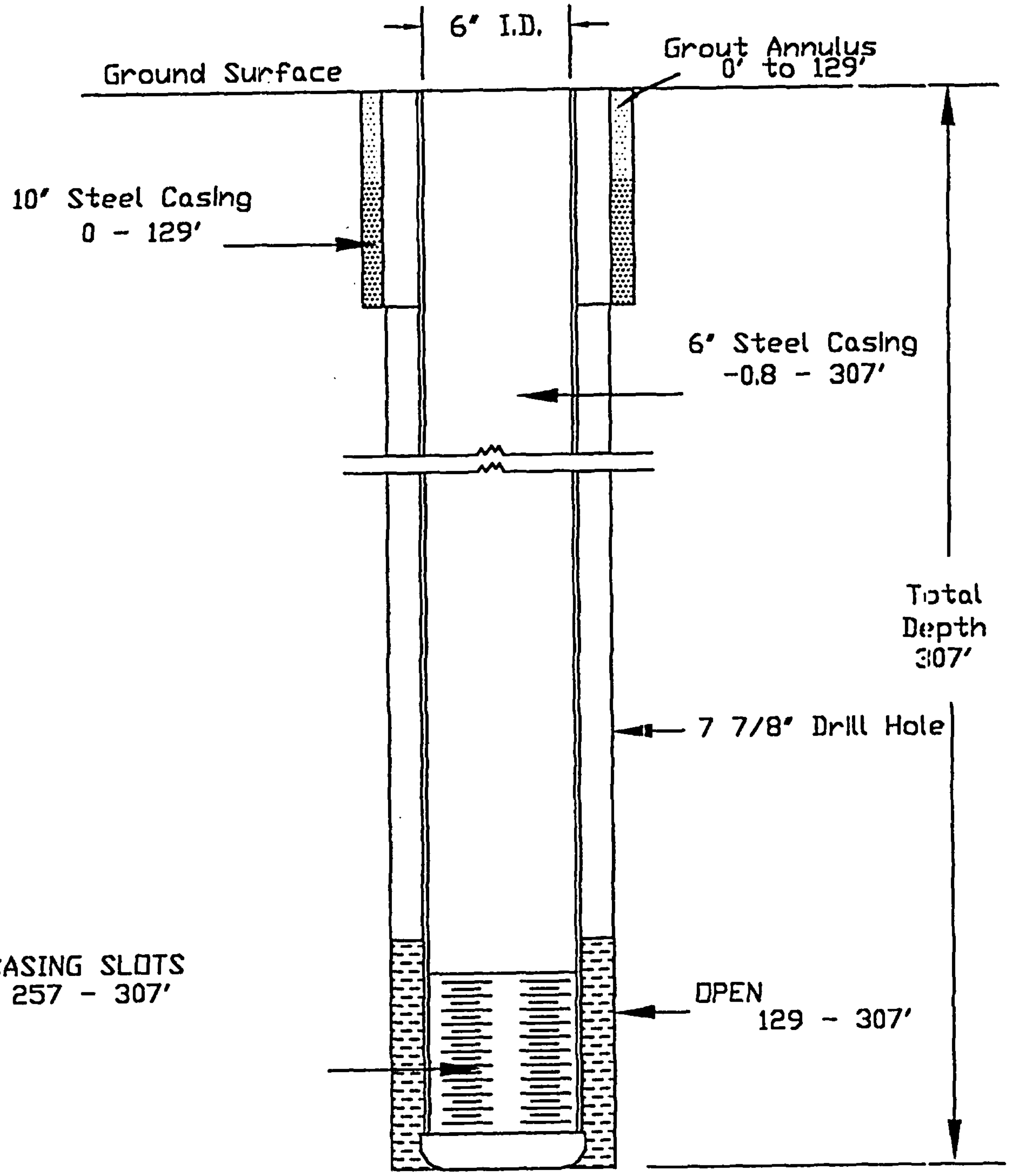


FIGURE B.2-9. WELL SCHEMATIC FOR MIDDLE CHINLE WELL CW35



WELL SCHEMATIC

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DATE: 07/01/03

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FIGURE B.2-10. WELL SCHEMATIC FOR MIDDLE CHINLE WELL WCW

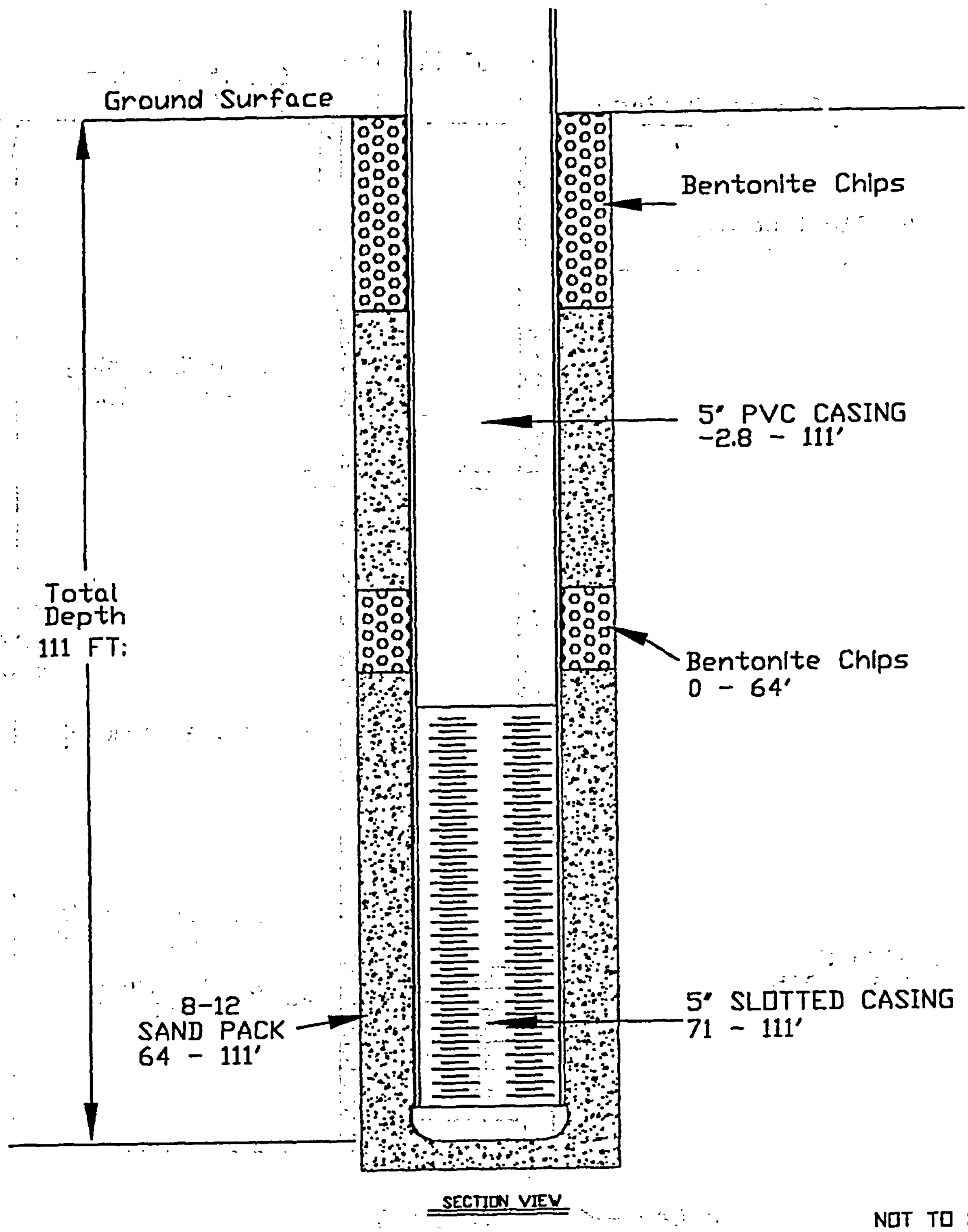

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FIGURE B.2-11. WELL SCHEMATIC FOR MIDDLE CHINLE WELL WR25

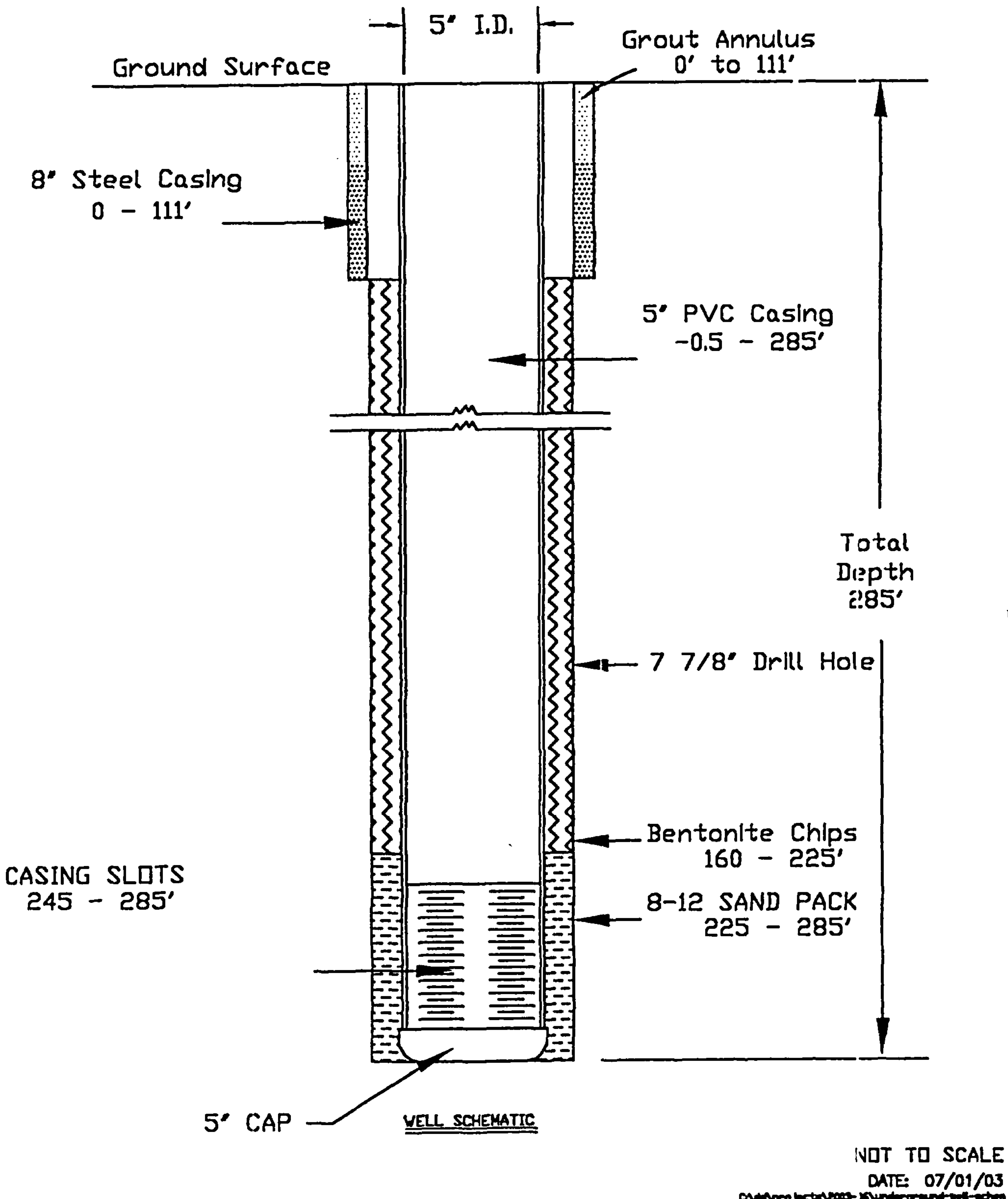

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FIGURE B.3-1. WELL SCHEMATIC FOR LOWER CHINLE WELL CW26

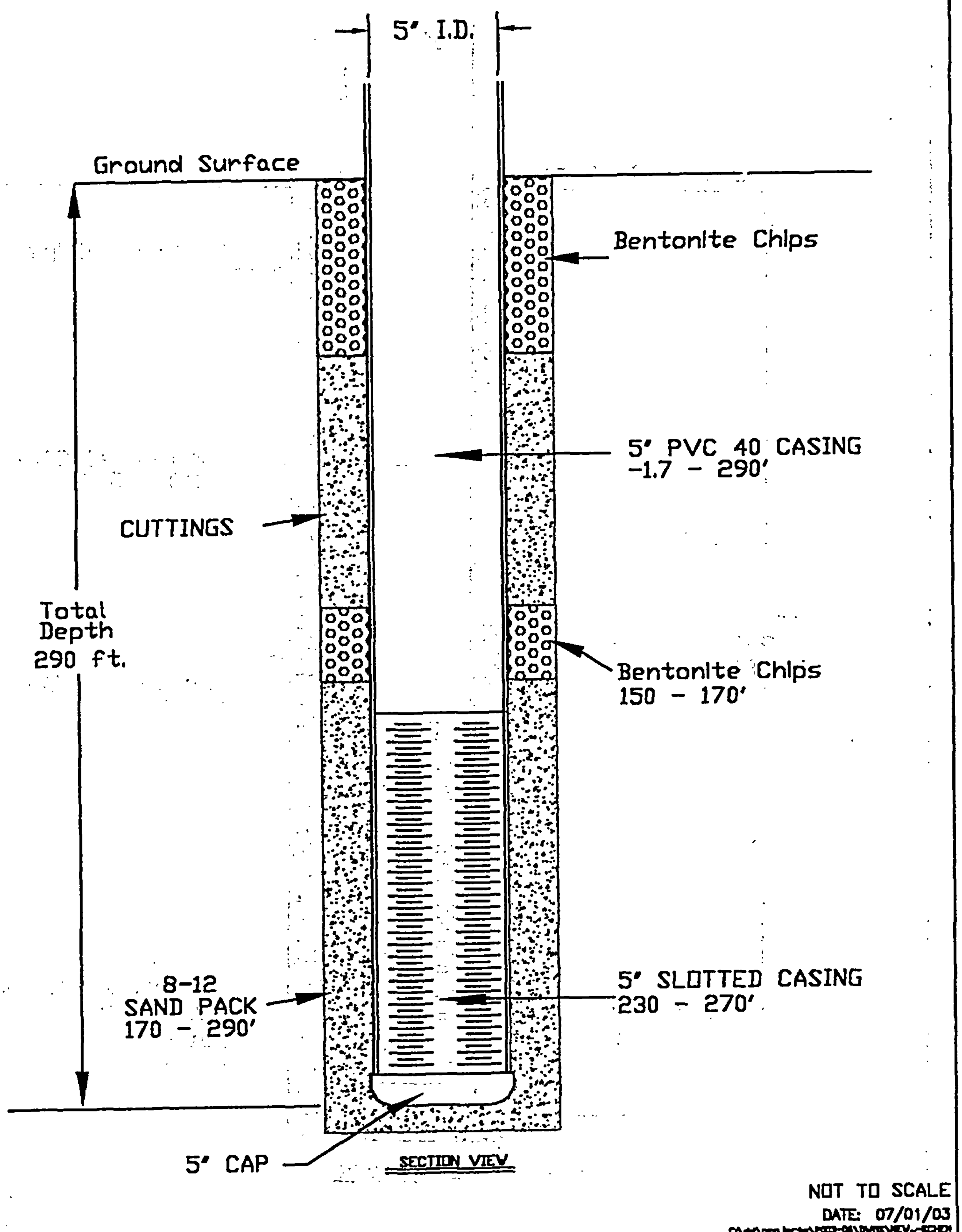

FIGURE B.3-2. WELL SCHEMATIC FOR LOWER CHINLE WELL CW29

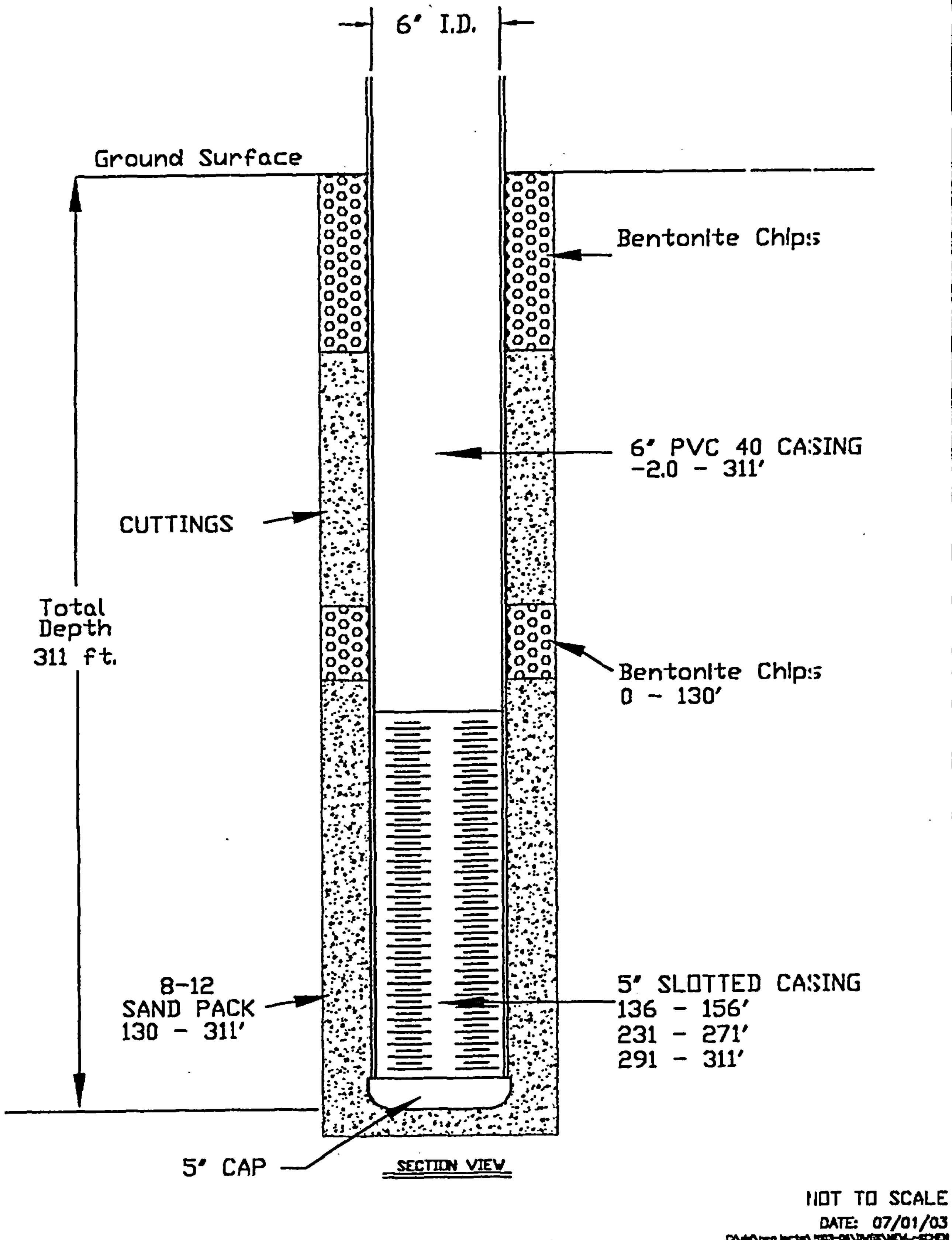

FIGURE B.3-3. WELL SCHEMATIC FOR LOWER CHINLE WELL CW31

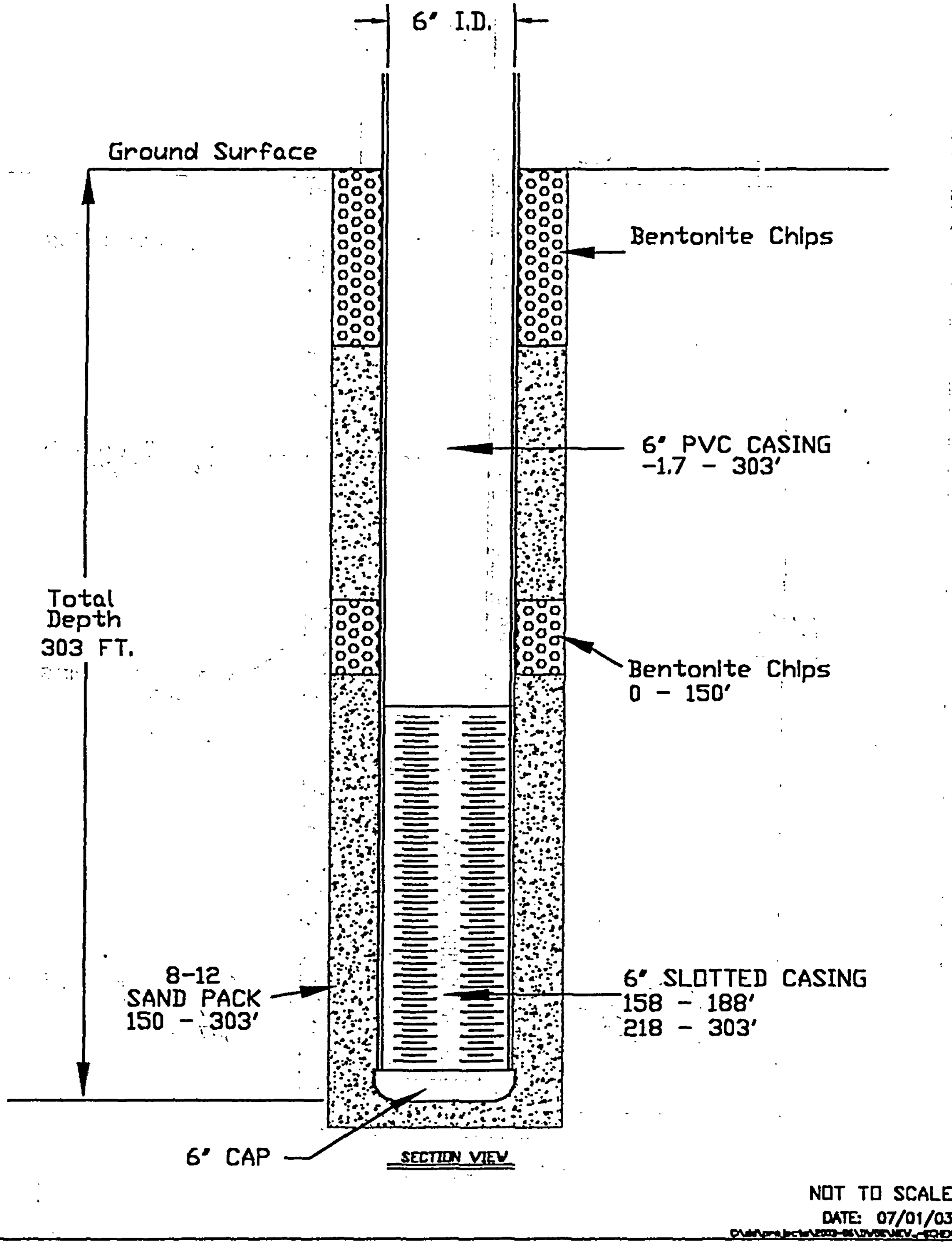

FIGURE B.3-4. WELL SCHEMATIC FOR LOWER CHINLE WELL CW32

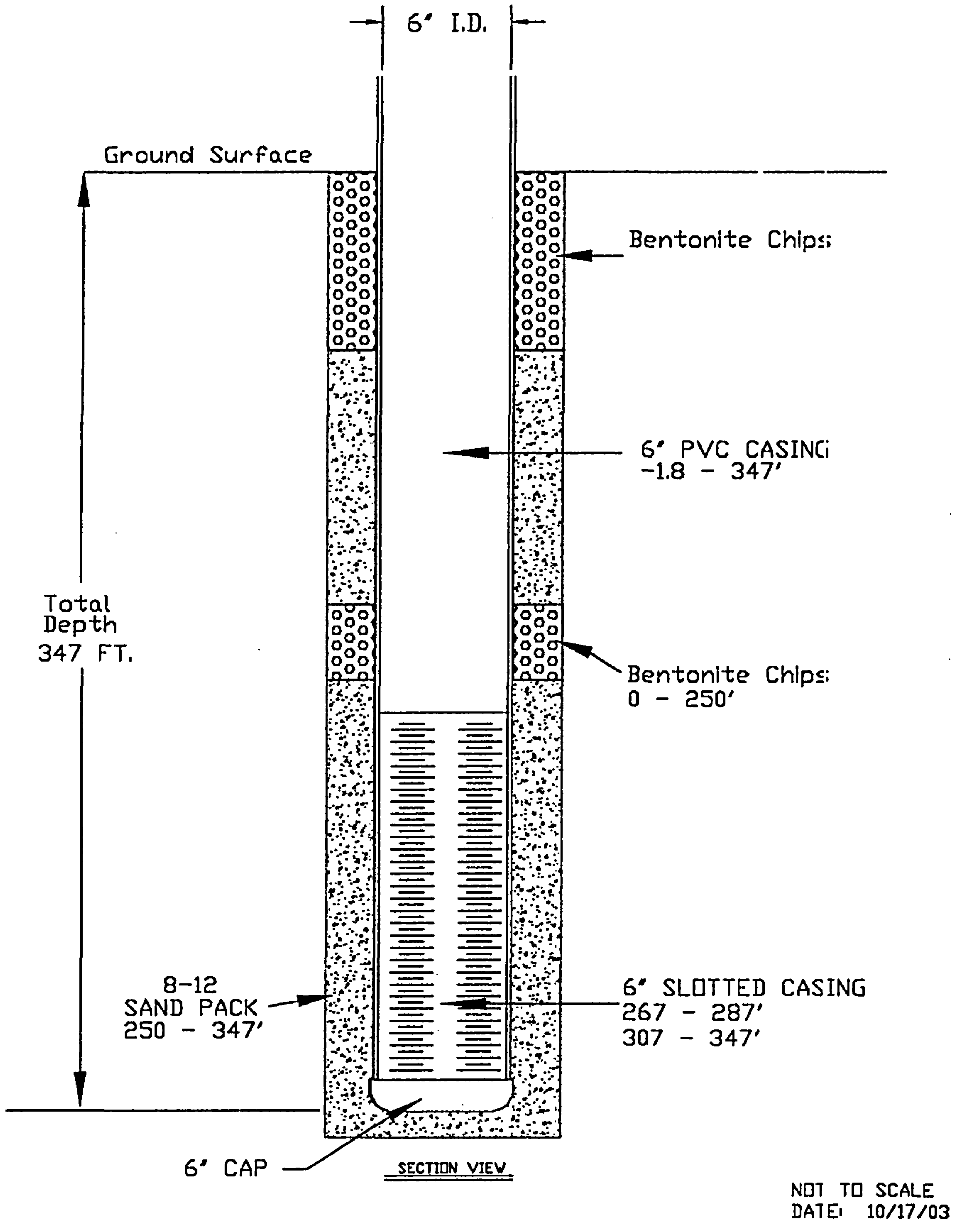

FIGURE B.3-5. WELL SCHEMATIC FOR LOWER CHINLE WELL CW33

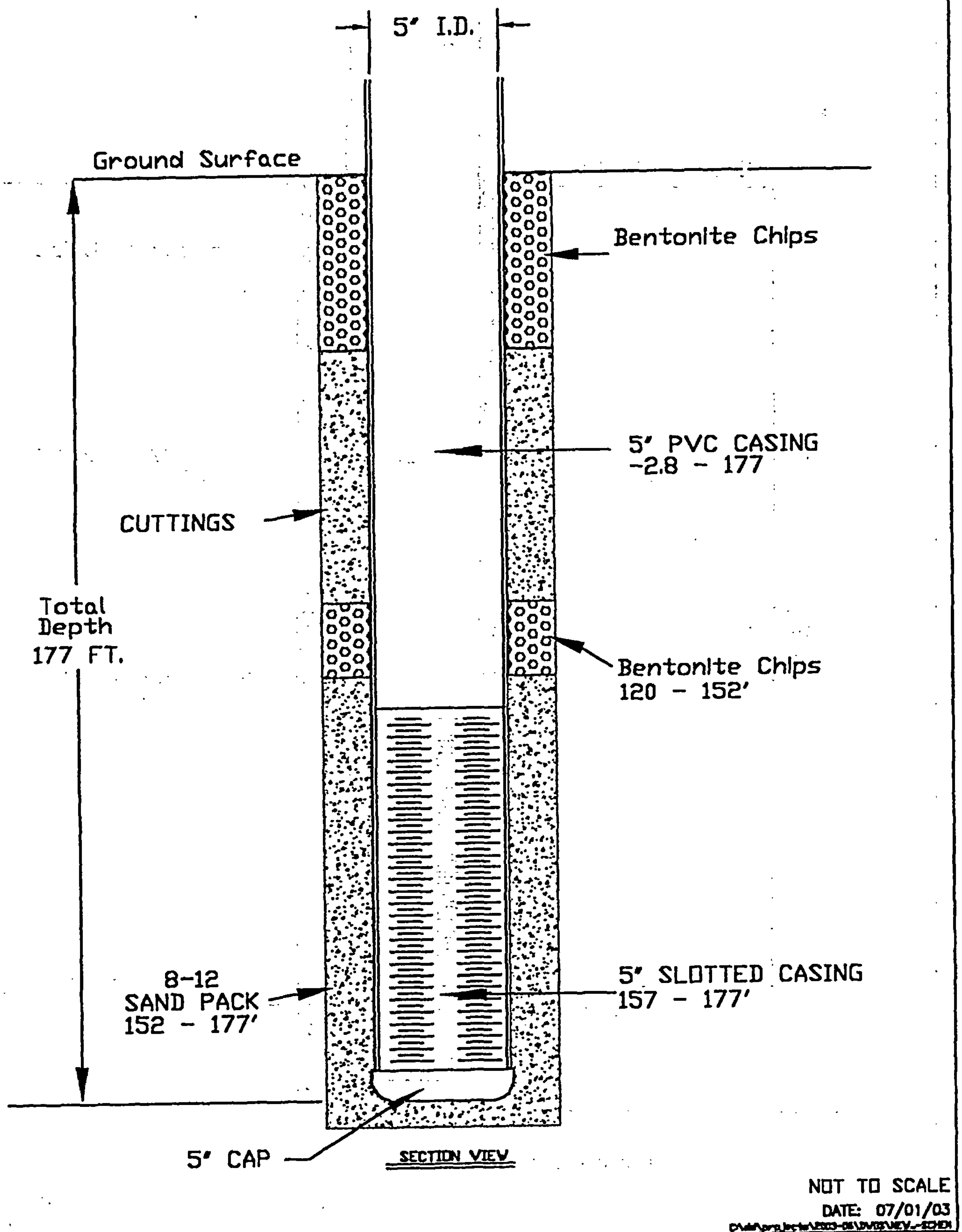

FIGURE B.3-6. WELL SCHEMATIC FOR LOWER CHINLE WELL CW36

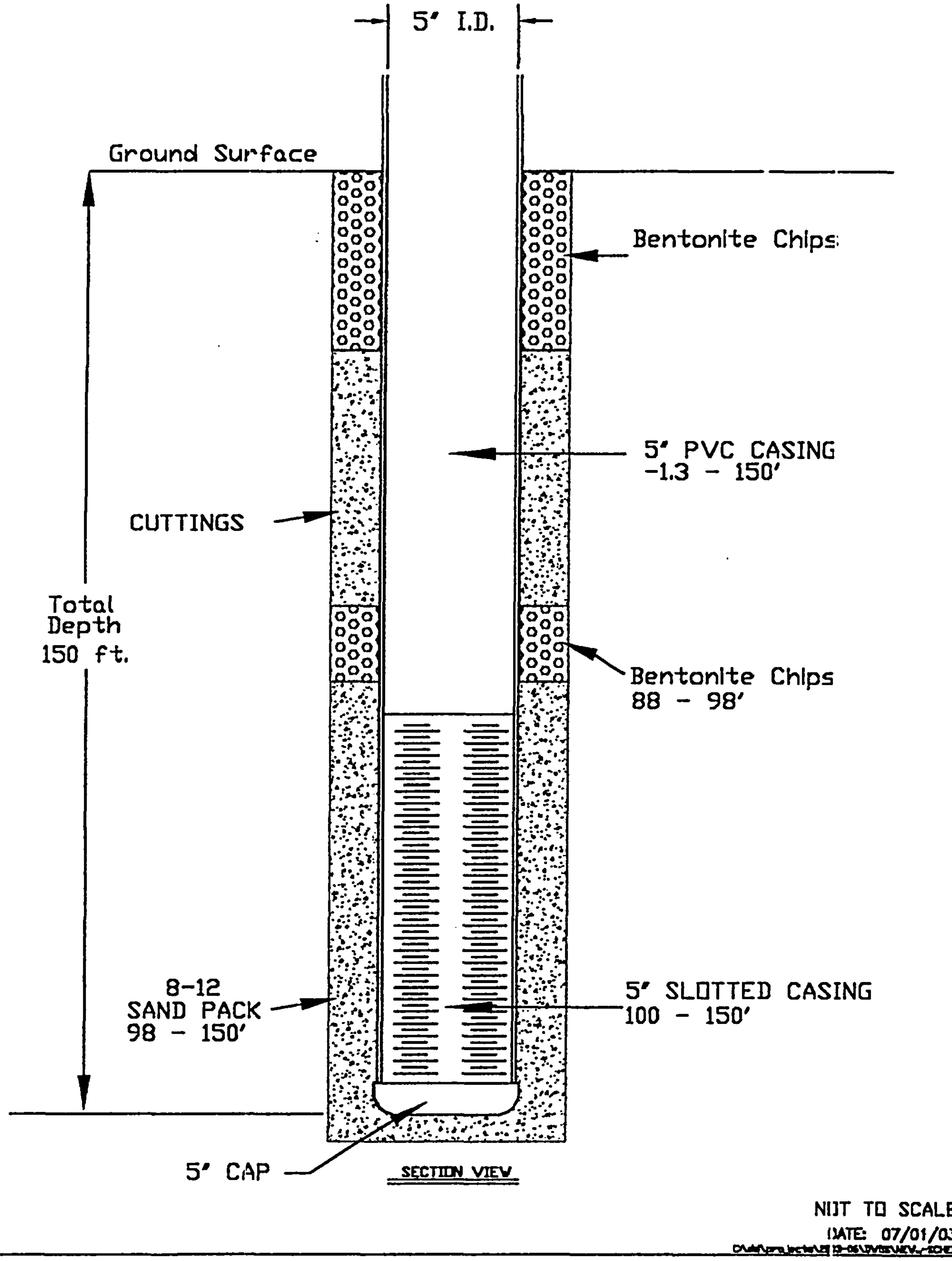

FIGURE B.3-7. WELL SCHEMATIC FOR LOWER CHINLE WELL CW37

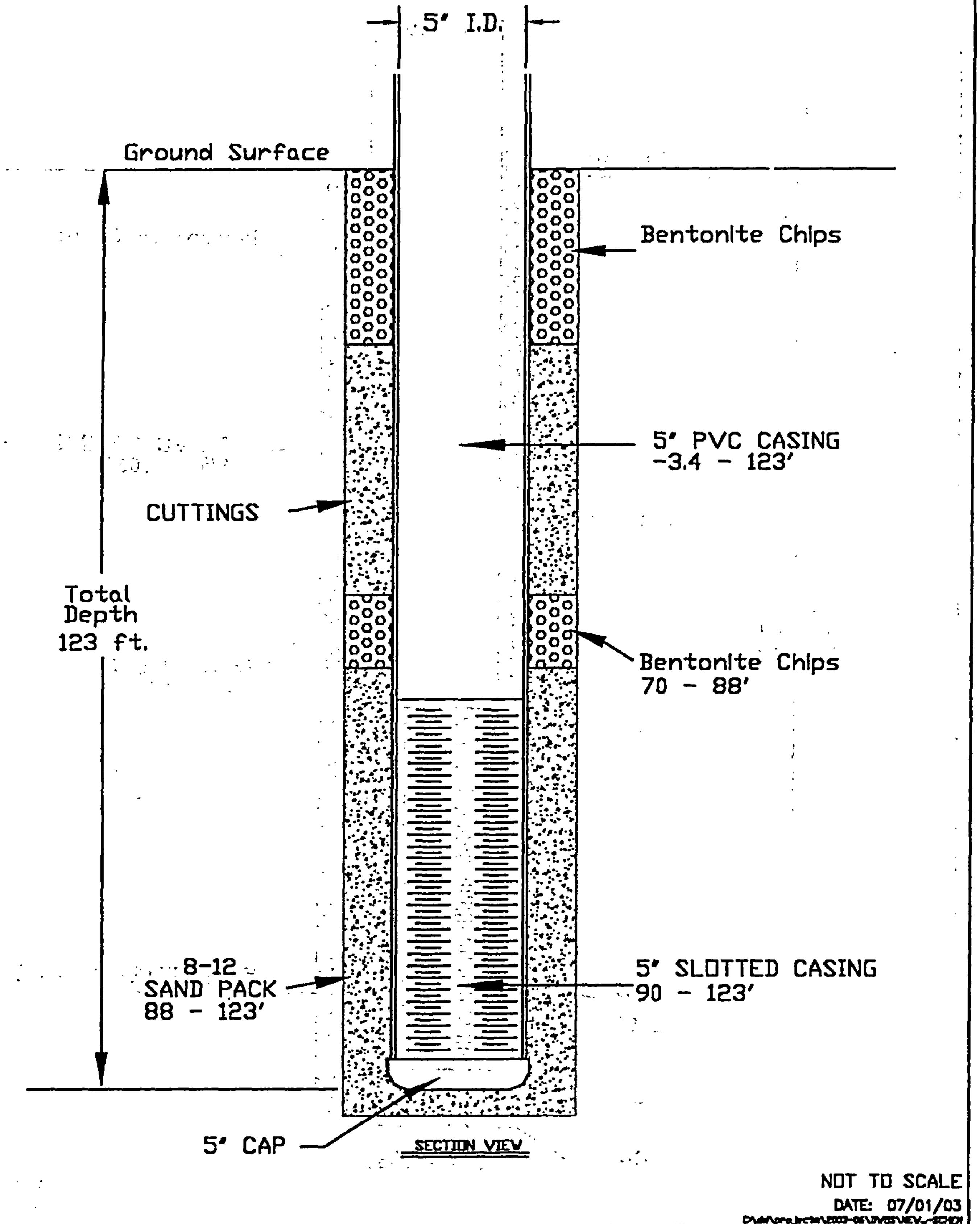

FIGURE B.3-8. WELL SCHEMATIC FOR LOWER CHINLE WELL CW39

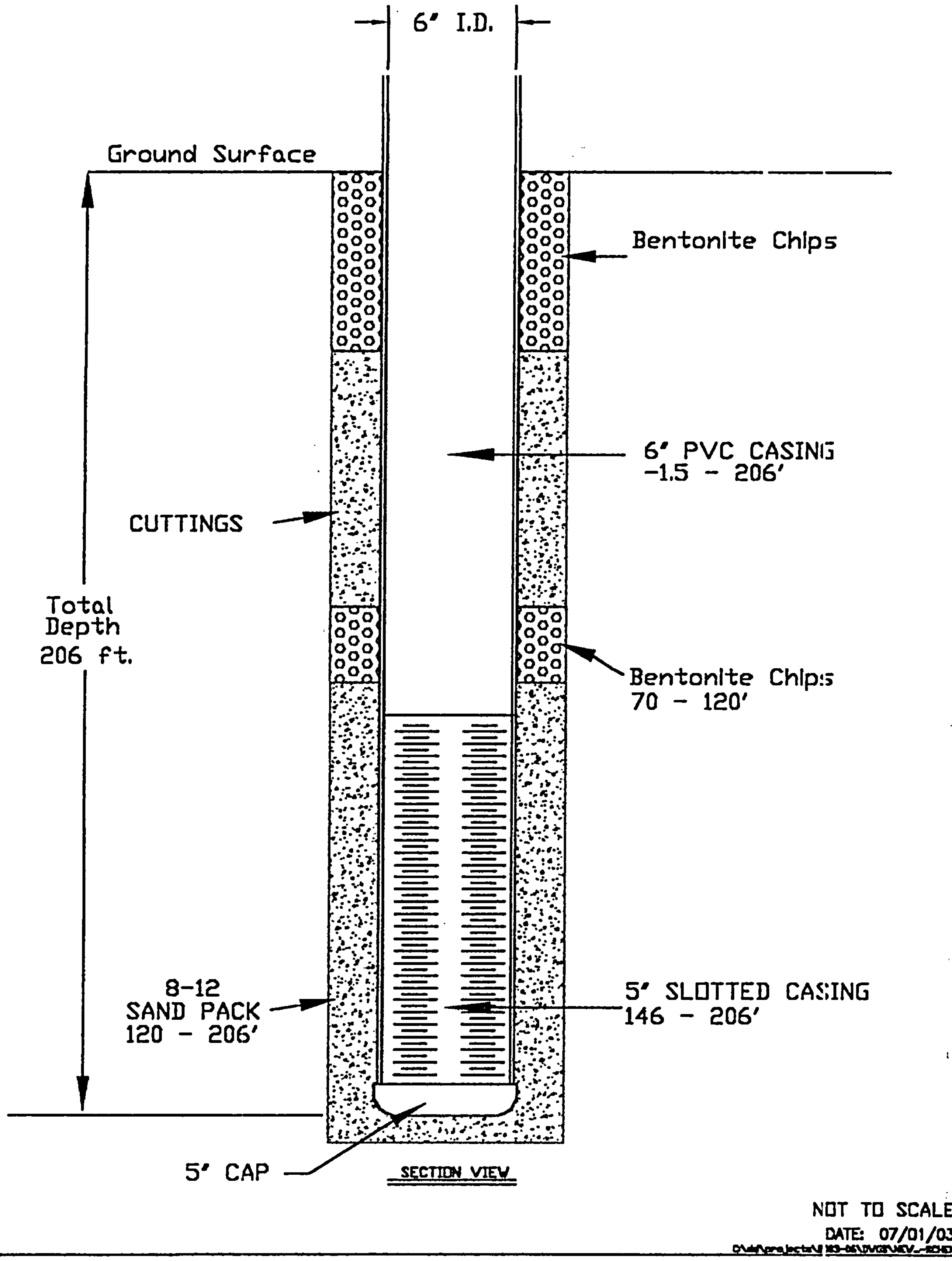

FIGURE B.3-9. WELL SCHEMATIC FOR LOWER CHINLE WELL CW41

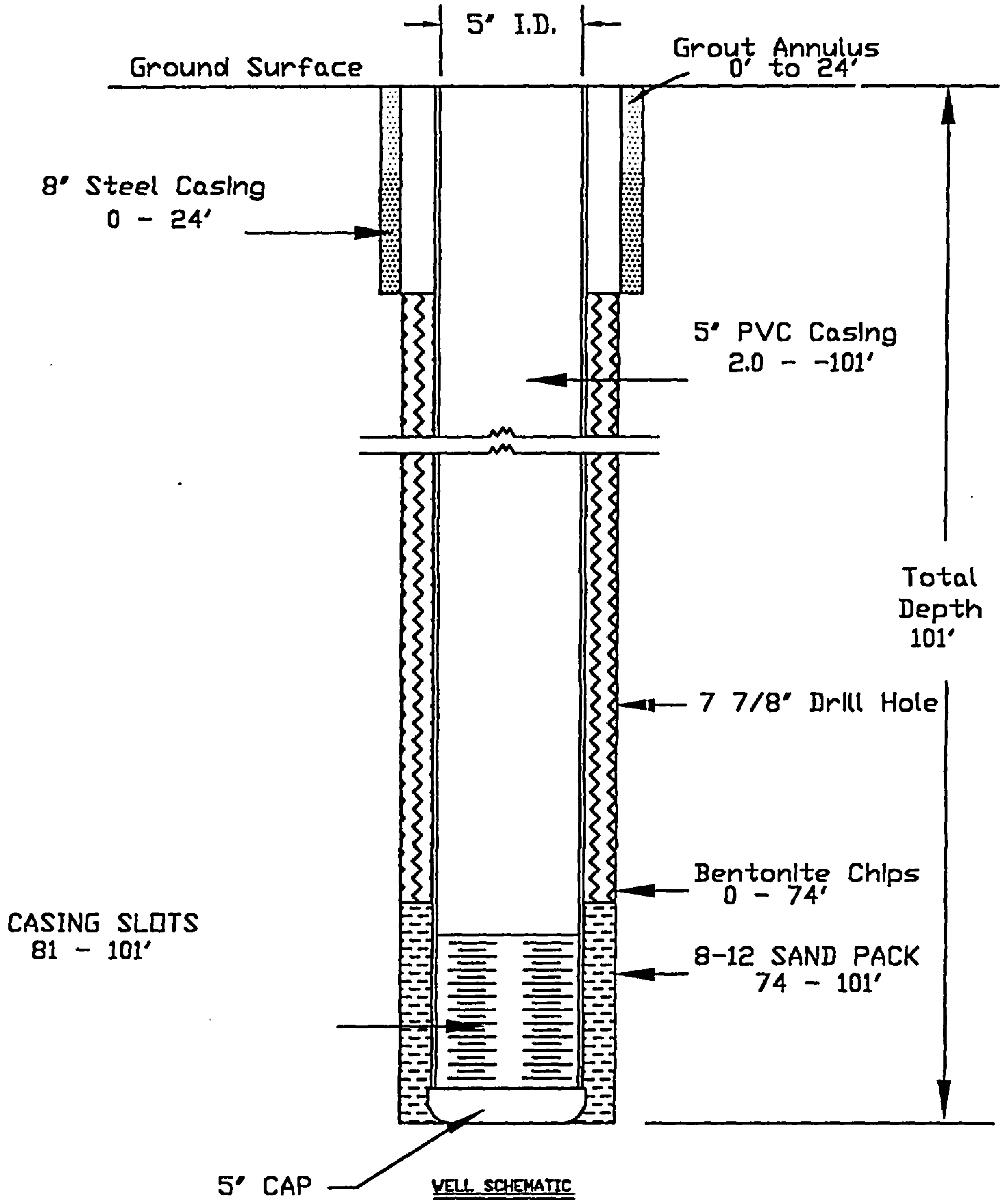

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FIGURE B.3-10. WELL SCHEMATIC FOR LOWER CHINLE WELL CW43