GROUNDWATER FLOW AND QUALITY
AND RESTORATION TIMING

PREPARED FOR:

NUCLEAR REGULATORY COMMISSION

BY:

QUIVIRA MINING COMPANY

AND

HYDRO-ENGINEERING

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I. Introduction

This submittal contains Quivira Mining Company's responses addressing NRC's concerns as contained within license condition #34, paragraph D. This submittal also addresses commitments previously made by Quivira in the September 25, 1989 submittal. The responses contained within this submittal are primarily based on Quivira's Corrective Action Plan as submitted to the NRC on December 21, 1989 and with discussions with Mr. Gary Konwinski.

In order to adequately address the requirements as presented in paragraph D, we must first review the existing groundwater conditions and geologic characteristics at the Ambrosia Lake facility. This information is contained within Quivira's December 21, 1989 submittal.

This submittal contains the groundwater characterization of each of the geologic units, the delineation of hazardous constituent plumes, and Quivira's proposed Groundwater

Corrective Action Plan as now approved by license condition #34, paragraph C.

The corrective action plan for the Dakota and Tres Hermanos B unit as proposed and subsequently approved, requires the maintenance and operation of the mine dewatering program at Quivira's Section 30 and 30 West mines. The dewatering of the mines causes the hazardous constituents to be intercepted by the mines where it is collected and removed from the formations.

The proposed and approved corrective action plan for the alluvium includes the operation and maintenance of the interceptor trench at the toe of the tailings impoundment. In this plan, the area underlying the unlined evaporation ponds is flushed and swept with fresh recharge water from the Environmental Protection Agency's (EPA) permitted NPDES discharge. This flushing and sweeping action is in a westernly direction, toward the interceptor trench where the hazardous constituents are collected and removed from the alluvial unit.

In conjunction with the flushing action, the trench also intercepts solutions migrating from the tailings impoundment so as to prevent further movement of tailings solutions into the alluvium.

II. Dakota Formation

This section responds to license condition #34, paragraph D which states "... the licensee shall by April 1, 1990, submit a proposed plan to withdraw hazardous constituent laden water from the Dakota, utilizing Section 36 wells, ...". In response to this request, Quivira presents the following information.

As described in previous submittals, the Dakota formation is a sandstone unit which has been deposited over an erosional surface developed upon the Brushy Basin. The unit is a clean sandstone being characterized as fine to medium grained. The formation dips to the northeast at approximately 3 degrees. The Dakota formation outcrops just south of the facility in the region of evaporation ponds 7 and 8.

The analysis of Dakota monitor well results indicate that the source of contamination was from the unlined evaporation pond #7. This had been previously postulated in earlier reports submitted to the state of New Mexico in 1980, 1983, 1986 and also to the NRC in 1986. Quivira believes this was confirmed by additional monitor well constructions and development of contaminate plume plots as submitted to NRC as part of the December 21, 1989 submittal.

The plots show that tailings solutions probably entered this unit through the shallow alluvial material overlying the Dakota in the pond 7 area. To eliminate this source of the contamination, pond 7 was emptied of solutions in 1983 thus eliminating further recharge by the tailings solutions.

In an effort to determine the aquifer properties of the unit, pump tests were performed on the Dakota monitor wells 36-06 and 36-04. Both wells are immediately downdip of the source of contamination as shown in Appendix A. The pump test results for Dakota monitor well 36-06 were presented in the December 21 submittal. Quivira wishes to reference this document for inclusion into this submittal.

As shown on page 23 of that document, monitor well 36-06 indicates the transmissivity of the Dakota formation in this area to be 2.9 gallons/day/foot. This transmissivity is based on a recovery and bail test. Based on this information, the continuous yield for this well is approximately 0.05 gallons per minute.

Quivira, in order to verify low yields within this area of the Dakota, performed a bail test at monitor well 36-04. The resultant transmissivity of 0.1 gallon/day/foot which represent a continuous yield of less than 0.01 gallons/minute, confirms earlier pump test results. The results of the pump test for this well are presented in Appendix B.

As demonstrated by the pump tests, the yields within the Dakota in this region are minimal at best. Attempts to utilize a pumping system would be an ineffective means to remove hazardous constituents from the formation. Therefore, because of the very low yields within the Dakota in the Section 36 region, Quivira believes it to be infeasible to remove hazardous constituents utilizing a pumping system in the Section 36 monitoring wells.

III. Alluvial Formation

Quivira presents the following information in response to license condition #34, paragraph D, which reads "... the licensee shall by April 1, 1990, submit a proposed plan to ... recover seepage from the alluvial material downgradient of the currently approved corrective action."

The alluvial material within the Ambrosia Lake area can be characterized as being a very fine grain sand, containing an intermix of clay material with an occasional basal layer of gravel. Available records indicate the alluvium was dry prior to mining and milling activities. This was demonstrated by the installation of an alluvial monitoring well 30-68 for the NRC. The well was drilled northwest of Section 30 West mine, away from any mine or mill discharges. The well was dry confirming the alluvium had been dry prior to mining and milling activities.

With the inception of milling at the Ambrosia Lake site, the original ponds to evaporate process water were unlined. This includes ponds 4, 5, and 6 located in the northeast corner of Section 31. In 1983, to eliminate this source of mill tailings solutions seeping into the alluvium and to recover the solutions from the unlined evaporation ponds, Quivira initiated a program which called for the abandonment of all unlined evaporation ponds including 4, 5, 6, and the construction and maintenance of an "Interceptor Trench".

The interceptor trench was constructed at the toe of tailings impoundment #1. This construction prevented further migration of tailings seepage from the impoundment into the alluvium. In addition to preventing solutions from entering the alluvium, the interceptor trench also created a local hydrologic gradient back towards the trench. This gradient causes solutions in the alluvium to the east of the trench to be "pulled back" towards the interceptor trench, where they are collected and removed from the unit. The interceptor trench as presently constructed has a total length of 6,200 feet and forms the northern, eastern, and southern boundary of the tailings impoundment #1. The trench has been constructed to a depth of 36 feet thereby enabling the hydrologic gradient to be towards the trench. This is shown in Appendices A and B of the September 25, 1989 Corrective Action Plan submittal. Quivira wishes to reference this material for this report.

In conjunction with the reversed hydrologic gradient in the area, the hazardous constituents underlying the unlined evaporation ponds 4, 5, and 6 are being swept and flushed towards the trench for collection and removal. The solutions are being swept and flushed using fresh uncontaminated recharge water permitted by the Environmental Protection Agency (EPA) through an NPDES permit. The fresh NPDES recharge water flows along the northern and eastern perimeter of the restricted area property. The two systems together act as a "push-pull" system with the "push" being the NPDES recharge water and the "pull" being the dewatering action of the interceptor trench.

This cleansing action caused by the sweeping and flushing action of the NPDES recharge water and the interceptor trench was confirmed in the hazardous constituent delineation plots as submitted to the NRC in the December 21 submittal in Appendix B. Quivira wishes to reference this appendix for inclusion into this submittal. Those plots delineating the hazardous constituents whose NPDES concentrations are less than the solutions from the unlined evaporation ponds and tailings impoundments relatively speaking, are contained within the restricted area boundary. As such, they are being removed by the sweeping action and subsequent removal from the interceptor trench. This includes antimony, arsenic, beryllium, cadmium, nickel, thallium, lead 210 and combined radium 226 and 228. The historical NPDES analytical results for these parameters are listed in Appendix C.

However, for those hazardous constituents whose Federally permitted NPDES discharge concentrations exceed the groundwater background standards, the delineation plumes extend beyond the NPDES recharge waters. These parameters include uranium, gross alpha, molybdenum, and selenium. Attached as Appendix C are the historical average NPDES discharge values for those available parameters whose concentrations exceed the background groundwater protection standards as established for the Ambrosia Lake facility.

It should also be noted that even alluvial wells outside the NPDES recharge water - interceptor trench collection and pump back system are gradually being cleaned. This is demonstrated by the concentrations versus time plots of the conservative parameters chlorides, TDS, and sulfates as presented within Appendix C of the September 25, 1989 submittal. These wells include AW-1, 32-42, 32-50, 32-49, 32-02, 30-04, 32-43, and 30-48. Quivira wishes to reference this material for inclusion into this report.

As evident from these plots and the analytical data collected to date, the approved collection and pump back system intercepts and removes those hazardous constituents whose concentrations are greater than those permitted by the NPDES discharge. Only those hazardous constituents in the contaminated solutions which are less than those contained in the NPDES outfall and permitted by EPA, does the plume extent beyond the collection and pump back system.

As such, Quivira does not believe that additional groundwater recovery programs are necessary at this time as the contamination is primarily contained and controlled within restricted area by the collection and pump back system. In addition, it has been demonstrated that even areas outside the interceptor trench's influence are being cleaned. Quivira does not consider it reasonable that it should be required to recover solutions that have been and continue to be Federally permitted. A requirement to recover these solutions would not provide additional health protection nor do we believe it would be in keeping with the intent of 10 CFR 40, Appendix A, Criteria 5 guidelines.

IV. Hydrologic Evaluation

In accordance with commitments made by Quivira in its September 25, 1989 Groundwater Correction Action Plan submittal, included are the gradient maps and the current estimated time frame to effect cleanup for each of the impacted geologic units.

The direction and rate of groundwater movement through the different geologic units at the Quivira tailings site have determined those areas affected by seepage. The groundwater flow rates will also greatly affect the length of time required for groundwater restoration. Piezometric maps of the alluvium, Tres Hermanos B and Dakota units have been developed and used to obtain estimates of groundwater movement rates. The water quality information was submitted to the NRC December 21, 1989 submittal.

A. Alluvium Unit

The groundwater flow in the alluvial aquifer at the Quivira site is fairly complicated due to the different sources and as pronounced. These mounds are causing fresh NPDES recharge water to flow away from the channel both directions.

The saturation limits of the alluvial unit were estimated where the water level elevation equals the base elevation of the alluvial. The dash-dot line on Map 1 shows that the alluvium unit is limited to the northeast where the elevation of the base of the alluvium exceeds the heads in the unit. The top of the Mancos formation or base of alluvium also limits the western edge of the alluvial unit.

Groundwater flow rate is obtained by multiplying the horizontal hydraulic conductivity (permeability) times the hydraulic gradient and dividing by the effective porosity (specific yield).

The gradients in the alluvial unit for the 4th quarter of 1989 varied considerably. Gradients varied from 0.003 to roughly 0.1 foot/foot. A gradient of 0.01 foot/foot is fairly typical. A permeability of one foot/day was recommended in the December 21 submittal for the alluvial unit. A specific yield of 0.15 was also obtained for the alluvial unit based on data from well 32-52.

These three parameters indicate that the alluvial water is moving at an average rate of 24 feet/year. It should be noted that the average gradients were higher prior to the construction of the interceptor trench and thus resulted in greater groundwater velocities. This groundwater velocity is thought to be representative of average movement rates in the area containing contaminated water.

1. Water Quality

The alluvial water quality has been mainly affected by the tailings seepage to the east and southeast of the tailings ponds. Detail evaluations of the water quality conditions in the alluvial unit at Ambrosia Lake area were performed in 1980 and 1983 by Kerr-McGee Nuclear and by Quivira in 1986, and 1989. The hazardous constituents as delineated by Quivira were included in the December 21, 1989 submittal.

In order to delineate and to create gradient maps to determine the time to effect cleanup, the conservative parameters of chloride and TDS were reviewed. Although sulfate could have been used in developing the maps, the TDS results were used because TDS and sulfate are affected by the same process. Both TDS and sulfate are affected by the buffering capacity of the Ambrosia Lake alluvial material which has been determined to contain up to 2% $CaCO_3$. After the seepage is neutralized both of these constituents become conservative.

2. pH

The pH of the alluvial water is important because the changes in pH of the water greatly affects the mobility of several hazardous constituents as the acidic tailings solution is buffered. The neutralization of the acidic water not only affects the movement of several hazardous constituents but greatly decreases the levels of sulfate and TDS. Sulfate is precipitated as gypsum as the seepage is neutralized. Sulfate and therefore TDS become fairly conservative parameters after the seepage is buffered. Chloride ions should not be affected by this process and therefore are considered conservative.

Map 2 presents the 1989 pH contours for the alluvial unit. This map shows that the pH of the alluvial water is near neutral except near the tailings. The mobility of several of the constituents is affected after the pH rises above approximately four. The saturation limits of the alluvial unit are also shown on the water quality maps.

3. Chloride

Quivira believes that chloride is an important constituent in defining seepage impacts at acidic uranium tailings sites due to its conservative nature. Map 3 presents chloride concentrations in the alluvial unit for the 4th quarter of 1989. Chloride concentrations exceed 2,000 mg/l near the tailings ponds. The concentrations sharply decline to less than 300 mg/l within several hundred feet of the tailings ponds except at wells 32-50 and 5-01. Quivira believes the chloride concentrations have sharply declined because of the groundwater velocities and the NPDES fresh water recharge sweeping the area.

The observed chloride concentrations at alluvial well 31-63 were used to obtain the groundwater velocity and dispersion coefficient for the alluvial unit. The one-dimensional ion migration equation was used to simulate the constituent movement (see page 391 of "Groundwater, Freeze and Cherry, 1979"). Information used in the simulation included a chloride concentration of 6,000 mg/liter at a distance of 320 feet from well 31-63 for period of 25 years (1958-1983). Also used were an effective porosity of 0.15 and a bulk density of 2.6 g/cc.

The simulation resulted in a groundwater velocity of 42.6 feet/year and dispersion coefficient of 3,230 feet^2/year. These results produced the best fit amongst the observed concentrations. Presented in Appendix D as Figure 1 are the results of the simulation which show the observed chloride concentrations and the simulation concentrations.

4. TDS

Map 4 presents the TDS contours for the alluvial unit during the 4th quarter of 1989. The concentration of TDS near the tailings ponds is greater than 10,000 mg/l. The TDS concentration of approximately 7,500 mg/l is thought to be the level at which the constituent becomes conservative. TDS is not as good of an indicator of area impact as chloride because of the natural variability is much greater than the natural range of chloride. In general though, the TDS indicates a very similar area of impact as that of chlorides.

5. Time Frame To Effect Cleanup

The groundwater restoration program for the alluvial unit consists of using the EPA permitted NPDES fresh recharge water flowing on the northern and eastern restricted area boundary, to sweep and flush the areas underlying the unlined evaporation ponds. The solutions underlying these ponds are then collection and removed from the interceptor trench.

In selecting the appropriate hazardous constituents to model, parameters such as molybdenum, selenium, uranium and gross alpha, had to be discarded because their EPA permitted concentrations exceed the alluvial groundwater site standards. As such, chromium and nickel were selected as being the best parameters to indicate restoration of the alluvial unit.

The longest flow distance for the restoration of the alluvial water is from the pond 4 area to the alluvial trench. Water with low chromium and nickel concentrations were simulated to move 2,000 feet from this area through the alluvium with an average concentration of 0.2 and 0.15 mg/l for chromium and nickel respectively. The groundwater velocity and dispersion coefficient obtained in the chloride calibration were used with the ion migration equation to simulate the hazardous constituents. Figure 2 in Appendix D shows the predicted decline of these two constituents. This simulation indicates that it will take to the year 2046 and 2043 to decrease the chromium and nickel concentrations respectively, to the site standards of 0.05 and 0.06 mg/l.

However, Quivira wishes to stress the simulation predictions represent worst case cleanup times. The average time to effect cleanup for the hazardous constituents will be considerably less because the predictions do not account for retardation of the hazardous constituents nor the buffering capacity of the alluvium. The retardation of these constituents will continue to be significant as the concentrations are reduced. Additionally, because of the low concentration levels of these two parameters, the levels should decrease significantly quicker than the conservative simulations. Another factor which will greatly reduce the restoration time are zones of higher permeability material that will transmit a greater amount of the water.

Quivira also notes that the hazardous constituents in excess of the NPDES permit recharge water, primarily stay within the restricted area of the facility. As such, there is no point of exposure to the public. Quivira will continue to monitor the progress of the restoration as the effectiveness of the collection systems will be evaluated annually and compared to the projected performance.

It should be noted the restoration times for hazardous constituents are based on only those parameters whose concentrations exceeds those allowed within the

Environmental Protection Agency's NPDES permit. As such, Alternate Concentration Limits (ACL) will be requested for those constituents whose EPA permitted concentrations exceed the site standards.

B. Tres Hermanos B Unit

The Tres Hermanos B groundwater existence is limited by areas where the formation has been eroded and also where the base elevation is above the water level elevation. Map 5 presents the limits of saturation of the Tres Hermanos B unit with a dash-dot line. The limits of the outcrop and subcrop are presented with a dash-two dot line.

As shown on the map, the Arroyo Del Puerto has eroded a large area of the formation in Section 32 and 5. A zero saturation line is shown as the western limit of the unit and also in a significant portion in the mining area to the north of the tailings. The base structure of the Tres Hermanos B unit was estimated as 200 feet above the Dakota base and was used with water level contours to predict and construct the zero saturation line limit. Sampling results from the ventilation holes were also used, but a ventilation hole with a no flow condition from the Tres Hermanos B unit was not necessarily included in the zero saturated area because a very small drainage from Tres Hermanos B unit might not have been observed.

The piezometric surface indicates that some of the Tres Hermanos B unit water could discharge to the alluvial unit near the area of Ponds 9 and 10. To the north of this area where Tres Hermanos B subcrops against the alluvium near wells 32-69 and 32-50, some alluvial water could flow into the Tres Hermanos B unit and move north to the mine area where it is intercepted, collected and removed.

The gradient of the Tres Hermanos B unit varies from 0.01 to 0.05 ft/ft. An average value of 0.03 ft/ft represents a large percentage of this unit. An average permeability of 0.05 ft/day was estimated from pump tests on the Tres Hermanos B. An effective porosity of 0.05 is thought to be representative of this system.

1. <u>pH</u>

   Attached as Map 6 are the pH values for the Tres Hermanos B unit for 4th quarter of 1989. This figure shows that the pH ranges from 6.3 to 7.5 or near neutral.

2. <u>Chloride</u>

   Map 7 presents the chloride concentrations for the Tres Hermanos B unit for the 4th quarter of 1989. The chloride concentration in Tres Hermanos B monitor well

31-66 indicates a velocity of at 164 feet/year. This velocity is greater than the one obtained from the aquifer properties but is thought to be more appropriate for ion migration simulations.

The movement of chloride ions to be east of tailings impoundment #1 fit the groundwater velocity estimate for the unit much better than those to the west of the tailings piles. The limit of affected chloride ions from tailing seepage is estimated to be approximately 6,000 feet north and northeast of the tailings impoundment #1.

3. TDS

TDS concentrations for 1989 for the Tres Hermanos B unit are presented on Map 8. The TDS contours indicate similar limits of affects from seepage on the Tres Hermanos B unit as previously indicated from the chloride contour map. The TDS concentrations for Section 17's venthole #5, which is physically located on Section 20 has a value of 5,288 mg/l. This indicates that a TDS of greater than 5,000 mg/l is needed to be confident that seepage has affected the water quality. The chloride in this venthole was relatively low at 55 mg/l, thereby indicating that seepage has not reached this area of the Tres Hermanos B unit.

4. Time Frame To Effect Cleanup

The proposed method of restoration for the Tres Hermanos B unit is the collection of elevated concentrations by intercepting the contamination and removal from the formation by the mine dewatering system. This method will require that the elevated concentrations flow to the north in the area of hydrologic depression caused by the dewatering of the vent holes and mine shafts. The tailings impoundment #1 will have to drain before the last elevated constituents in this aquifer can be removed by the mine dewatering systems.

The nickel, chromium, and molybdenum constituents in the formation were selected for simulation as they were the ones mostly likely to be the constituents of concern. As part of the one-dimensional transport model, the velocity of 164 feet/year, dispersion coefficient of 3230 feet^2/year, effective porosity of 0.05, and a bulk density of 2.65 gm/cc were used as input parameters.

Figure 3 of Appendix D shows the predicted concentrations at the mine in the Tres Hermanos B formation for nickel, chromium, and molybdenum. Seepage concentrations of 0.4, 0.3 and 0.25 mg/l respectively were used. These are thought to be the level of concentrations in the unit near the tailings after neutralization.

The simulations predict it will take approximately 52 years or to the year 2042 for these concentrations to be restored to background values. This represents worst case. Continual retardation of the hazardous constituents should result in the restoration of the unit prior to the predicted times because these simulations do not account for the retardation of the constituents.

Quivira has evaluated the collection of the Tres Hermanos B water solutions that contain elevated concentrations as a means to decrease the estimated time frame required to restore the water quality. Pump tests on wells 31-66, 31-67 and 36-02Trb indicate that these wells may yield approximately 0.1, 1.0 and 0.2 gpm respectively. This data indicates that it will be unlikely that a sufficient quantity of water can be pumped from the Tres Hermanos B formation to significantly affect the restoration time.

C. Dakota Unit

The groundwater flow in the Dakota sandstone is affected by the structure of the base of this unit. Map 9 presents the water level elevation of the Dakota aquifer. This map shows the groundwater in the Dakota is moving to the north, toward the mines where it is intercepted, collected, and removed by the dewatering of the mines. In local areas, the structure of the base of the Dakota controls the groundwater flow direction and changes the flow direction for short distances.

The gradient of the Dakota water surface varies from 0.01 to close to 0.1 ft/ft. To obtain a movement rate, an average gradient and permeability value of 0.05 ft/ft and 0.1 ft/day were used respectively. The zero saturation levels as shown on Map 9 are where the elevation at the base of the Dakota exceeds the water level elevation.

1. pH

Map 10 plots the pH values for the Dakota water. All of the pH values are fairly close to neutral except the pH of 4.1 from well 36-06. As such, the tailings seepage within the formation have been neutralized with the exception of the area just north of evaporation pond 7. However, the pH in the Dakota aquifer a few hundred feet to the north of Pond 7 is high enough to start buffering the solutions thereby restricting the mobility of the hazardous constituents.

2. <u>Chloride</u>

Map 11 presents the chloride concentrations for the 4th quarter of 1989. The maximum chloride concentrations in the Dakota exist at wells 36-04Kd and 36-01Kd, approximately 5,000 feet downgradient of evaporation pond 7. The shape of the chloride contours indicates that the source has been removed. Process solutions were last stored in pond 7 in 1983.

The area to the northeast of the restricted area near wells 32-50Kd and 30-48Kd, contains elevated chloride levels which are thought to be from leakage from the upper units to the Dakota where the units are displaced adjacent to each other.

3. <u>TDS</u>

The TDS concentrations in the Dakota aquifer are presented in Map 12. These contours show a very similar pattern to that observed for chloride. Maximum TDS concentrations exist at wells 36-04Kd and 36-01Kd also. The areas of no saturation were developed from contours of the water level elevations and base structure elevations.

4. Time Frame To Effect Cleanup

The aquifer properties and groundwater gradient for the Dakota aquifer indicate that groundwater in this system presently moves at an average velocity of 36 feet/year. However, the water quality migration simulations indicate that the average Dakota formation velocity is 492 feet/year. This velocity is probably the more reliable groundwater velocity and is recommended to be used in predicting restoration of the Dakota system.

The proposed method of restoration of the Dakota aquifer is the interception, collection and removal of the seepage water by the mine dewatering system as describe for the Tres Hermanos B unit.

The most mobile hazardous constituents in the Dakota unit seems to be nickel, chromium, and molybdenum. However, the molybdenum and radionuclides in the formation seem to have naturally higher concentrations due to mineralization in this sandstone. Adjustment of the site standards for the Dakota may have to be performed upon further investigation and documentation.

Figure 5 of Appendix D presents the simulated chromium, nickel, and molybdenum concentrations at the mine ventilation holes. Initial concentrations of 2.5, 1.5, and 0.8 mg/l were used for nickel, chromium, and molybdenum respectively in the simulations. These concentrations are the maximum levels observed in the Dakota after the neutralization of the acid seepage. Also used in the simulation was a distance of 8,000 feet, a seepage velocity of 492 feet/year and a dispersion coefficient of 538,000 feet^2.

As indicated on Figure 5, nickel, chromium, and molybdenum concentrations near the mines should reach the site standards of 0.03, 0.05, and 0.06 mg/l in the year 2031, 2024, and 2017 respectively. Once again, Quivira stress that these simulations do not account for the retardation of the hazardous constituents and therefore the simulations represent worse case.

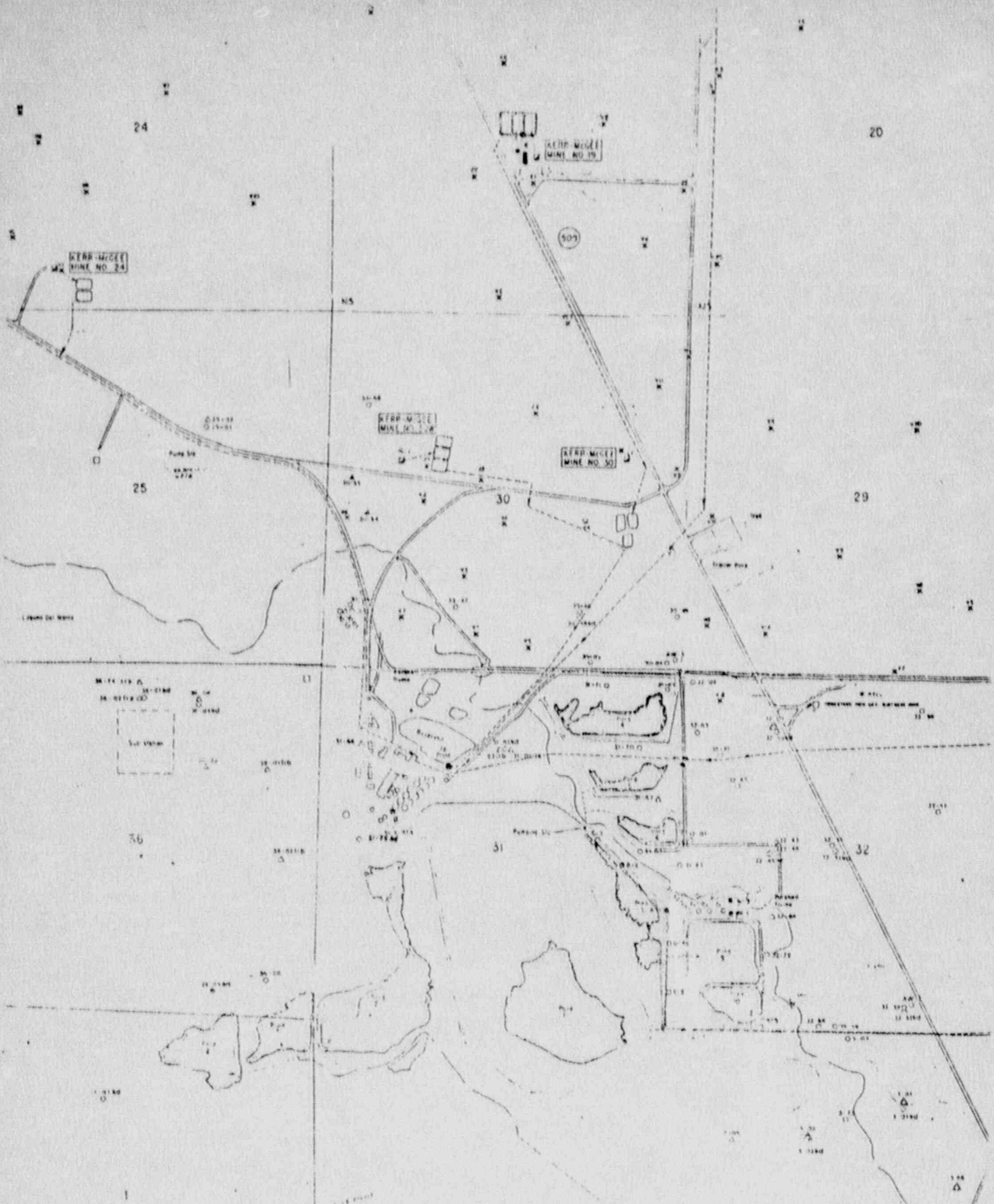
Quivira believes that the analytical results and the retardation capacity of the formation will allow for a <u>much quicker restoration period</u> then the conservative simulations. Hazardous constituents such as molybdenum, nickel, and a few radionuclides in the Dakota unit are likely to be the last hazardous constituents to be restored. Most of the hazardous constituents have been retarded fairly close to the source. Retardation of the low levels of hazardous constituents will be important in restoration of the hazardous constituents.

Therefore, the time to restore the hazardous constituents should be less than that required for the conservative ions. Mobility of molybdenum and some of the radionuclides seem to be greater but additional results may show that some of these concentrations are due to mineralization and ACLs may be appropriate.

An additional option Quivira has considered in an effort to reduce the time to restore the Dakota aquifer was the use of collection wells. Dakota wells 36-04Kd and 36-06Kd were bailed and pumped to determine their potential use as collection wells. A volume of 31.8 gallons of water was bailed from well 36-04Kd over 112 minutes or at an average rate of 0.28 gpm. This test indicates that the Dakota transmissivity is very low at this well at approximately 0.1 gal/day/ft. This indicates that the continuous rate of discharge would likely be less than 0.01 gpm. The transmissivity and potential drawdown from wells 36-04Kd and 36-06Kd indicates that these wells may yield 0.01 and 0.05 gpm respectively. These wells show that the Dakota aquifer will not produce a reasonable rate in the main plume and therefore collection wells do not seem to be a prudent option.

APPENDIX A

AMBROSIA LAKE FACILITY MAP


24
20
KERR-McGEE MINE NO. 19
509
KERR-McGEE MINE NO. 24
KERR-McGEE MINE NO.
KERR-McGEE MINE NO. 30
25
30
29
36
31
32
1
6
5
7100
R 10 W
R 9 W

APPENDIX B

DAKOTA WELL 36-04 PUMP TEST RESULTS

RECOVERY DATA FOR BAILING WELL 36-04KD

DATE	TIME	t/t'	WATER LEVEL (FT BELOW MP)	RESIDUAL DRAWDOWN (FT)	RECOVERY RATE (GPM)	s'	T
2/24/90	912.0		307.60 INITIAL WATER LEVEL				
2/24/90	930.0		BEGAN BAILING				
2/24/89	1000.0		315.8				
2/24/89	1032.0		BAILED 14.8 GALLONS; T = 14.5 C = 11000 pH = 6.5				
2/24/89	1048.0		BAILED 20.8 GALLONS; T = 14.5 C = 11000 pH = 6.6				
2/24/89	1109.0		BAILED 20.8 GALLONS; T = 14.8 C = 11000 pH = 6.7				
2/24/90	1122.0		STOPPED BAILING; T = 14.5 C = 11000 pH = 7.1				
2/24/90	1128.0	19.66	336.90	29.30	0.000	0.0	0.00
2/24/90	1132.0	12.20	336.90	29.30	0.000	29.3	31.00
2/24/90	1134.0	10.33	336.90	29.30	0.000	29.3	21.00
2/24/90	1136.0	9.00	336.90	29.30	0.000	29.3	16.00
2/24/90	1138.0	8.00	336.90	29.30	0.000	29.3	12.00
2/24/90	1140.0	7.22	336.90	29.30	0.000	29.3	10.00
2/24/90	1145.0	5.87	336.90	29.30	0.000	29.3	7.30
2/24/90	1151.0	4.86	336.70	29.10	0.022	29.1	5.40
2/24/90	1200.0	3.95	336.70	29.10	0.000	29.1	3.90
2/24/90	1215.0	3.11	336.70	29.10	0.000	29.1	2.70
2/24/90	1400.0	1.71	335.90	28.30	0.005	28.3	0.85
2/24/90	1500.0	1.51	334.90	27.30	0.011	27.3	0.63
2/25/90	720.0	1.09	328.90	21.30	0.004	21.3	0.14
2/25/90	1215.0	1.08	327.05	19.45	0.004	19.4	0.13
2/25/90	1520.0	1.07	319.10	11.50	0.003	11.4	0.10

APPENDIX C

HISTORICAL NPDES RESULTS

NPDES Annual Averages

The following parameters are those hazardous constituents for which the *permitted release levels are below the background concentrations levels.*

Year	As	Be	Cd	Ni	Th-230	Pb-210	Ra-226
1989	< 0.001	< 0.01	< 0.005	< 0.01	0.0	1.1	4.3
1990	0.005	< 0.01	< 0.005	< 0.01	0.6	2.6	4.0
Ave.	< 0.003	< 0.01	< 0.005	< 0.01	0.3	1.9	4.2

Background Groundwater Protection Standards

0.05	0.01	0.01	0.06	3.1	4.9	5.0

The following parameters are those hazardous constituents whose concentrations are *Federally permitted and excess the background concentration levels or the concentrations with the alluvium.*

Year	Mo	U	Se	Gross Alpha
1986	0.62	0.81	0.05	NA
1987	0.98	0.98	0.11	NA
1988	0.35	1.37	0.34	NA
1989	0.32	0.93	0.22	620
1990	0.41	0.83	0.36	720
Average	0.54	0.98	0.22	670

Background Groundwater Protection Standards

0.06	0.06	0.05	57

APPENDIX D

SIMULATION RESULTS

FIGURE 1 ALLUVIUM WELL 31-63

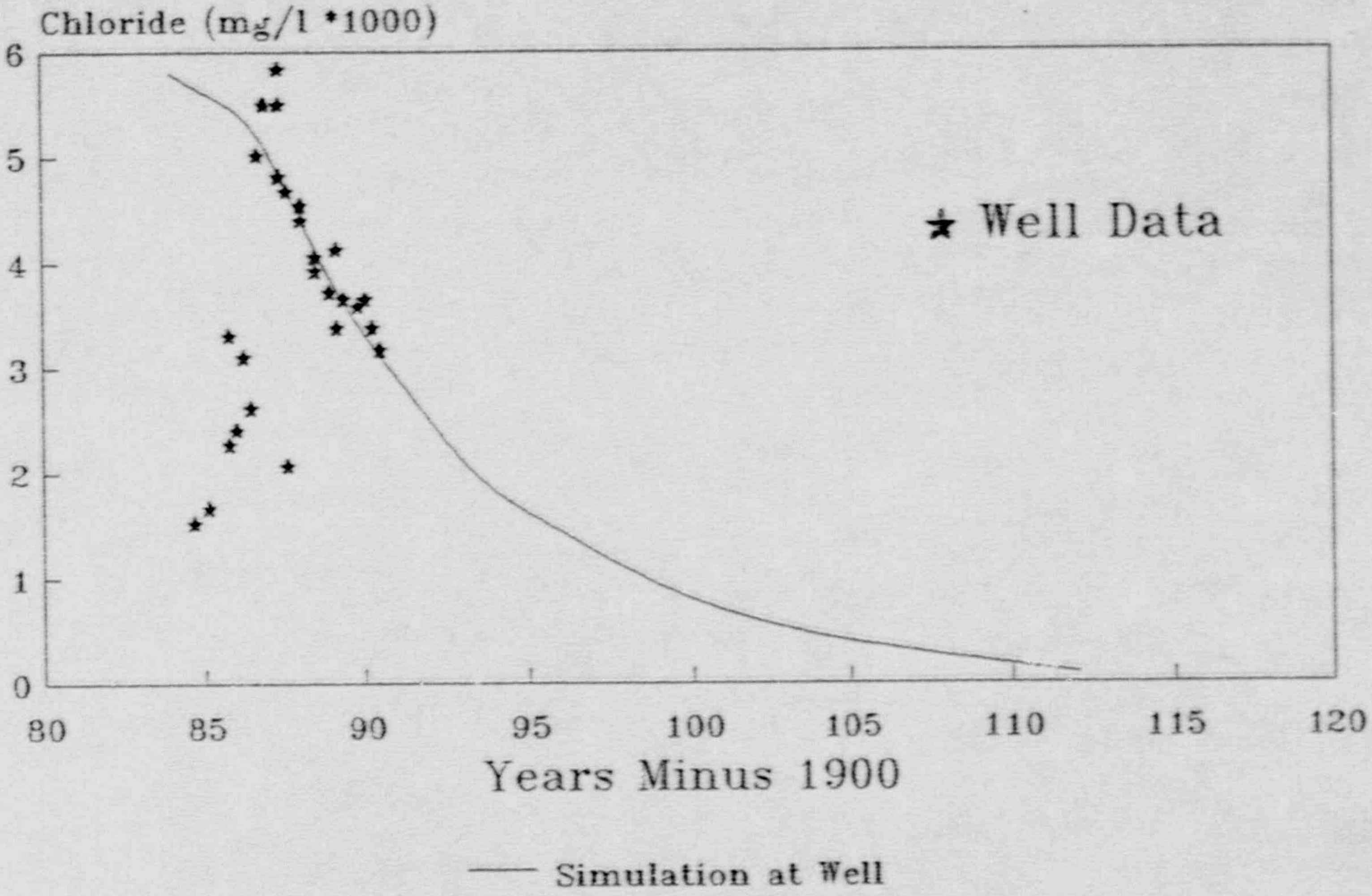


FIGURE 2 ALLUVIAL UNIT
Simulation of Concentrations

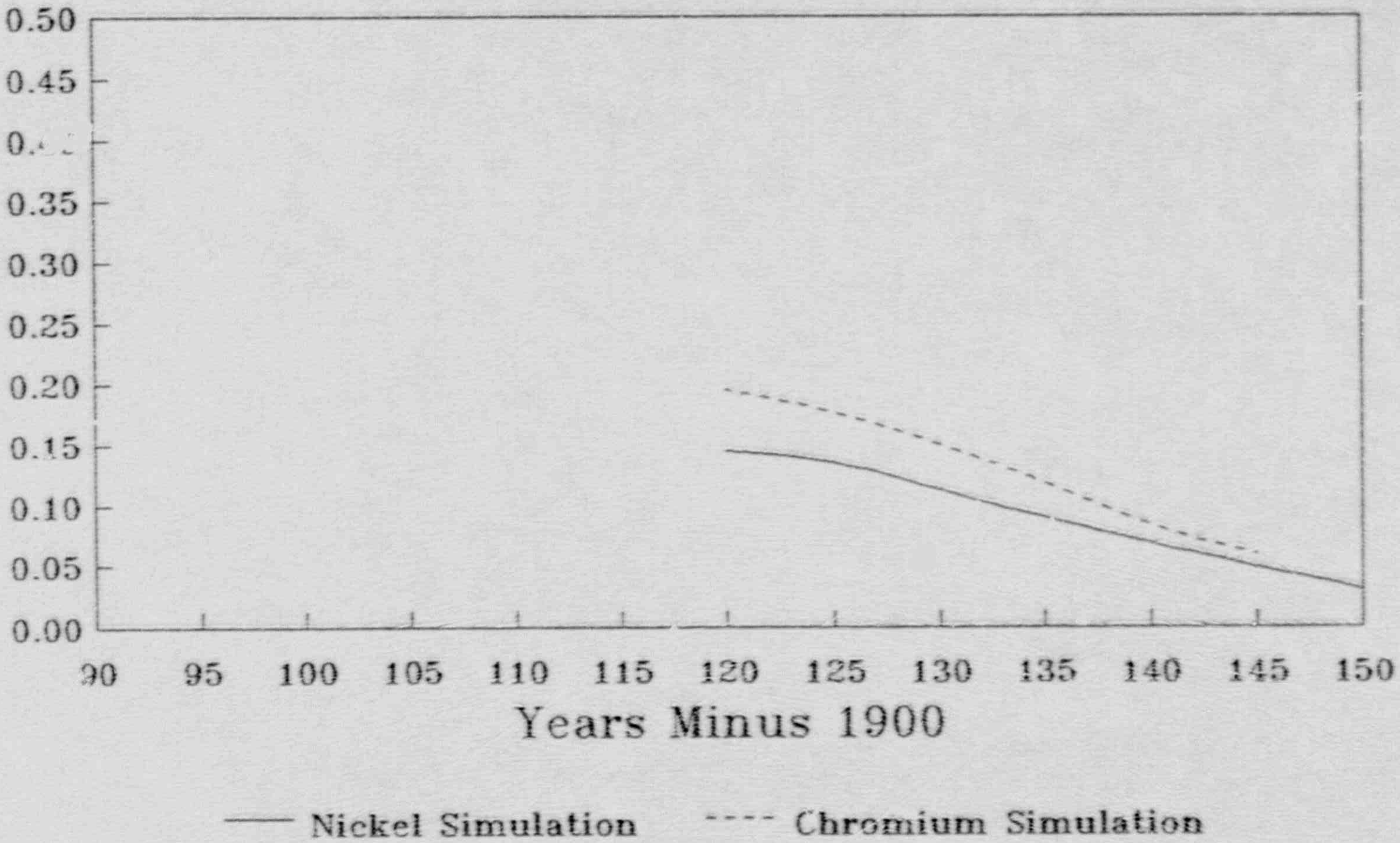


FIGURE 3 – TRES HERMANOS B

Simulations of Concentrations

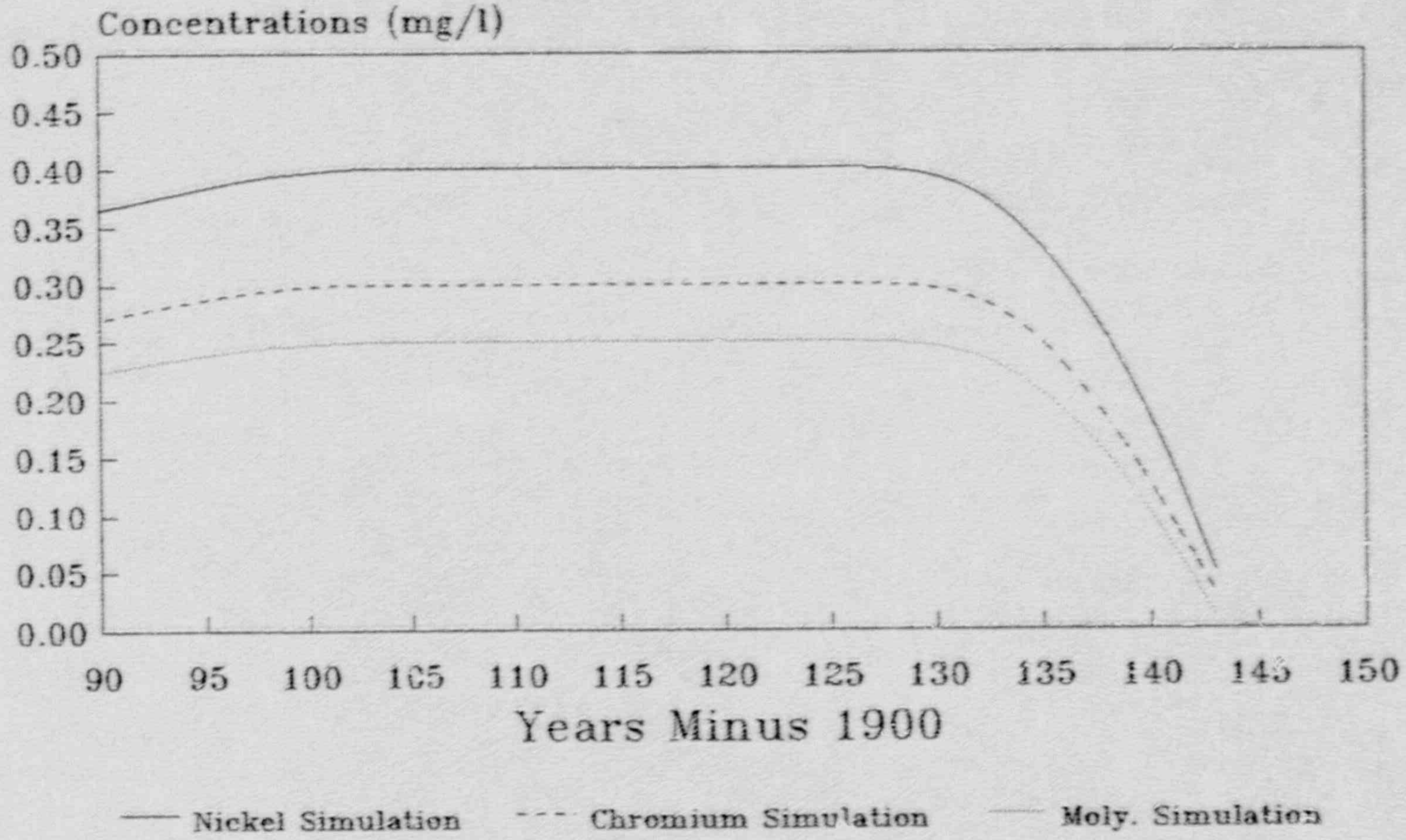


FIGURE 4 SIMULATION IN DAKOTA UNIT

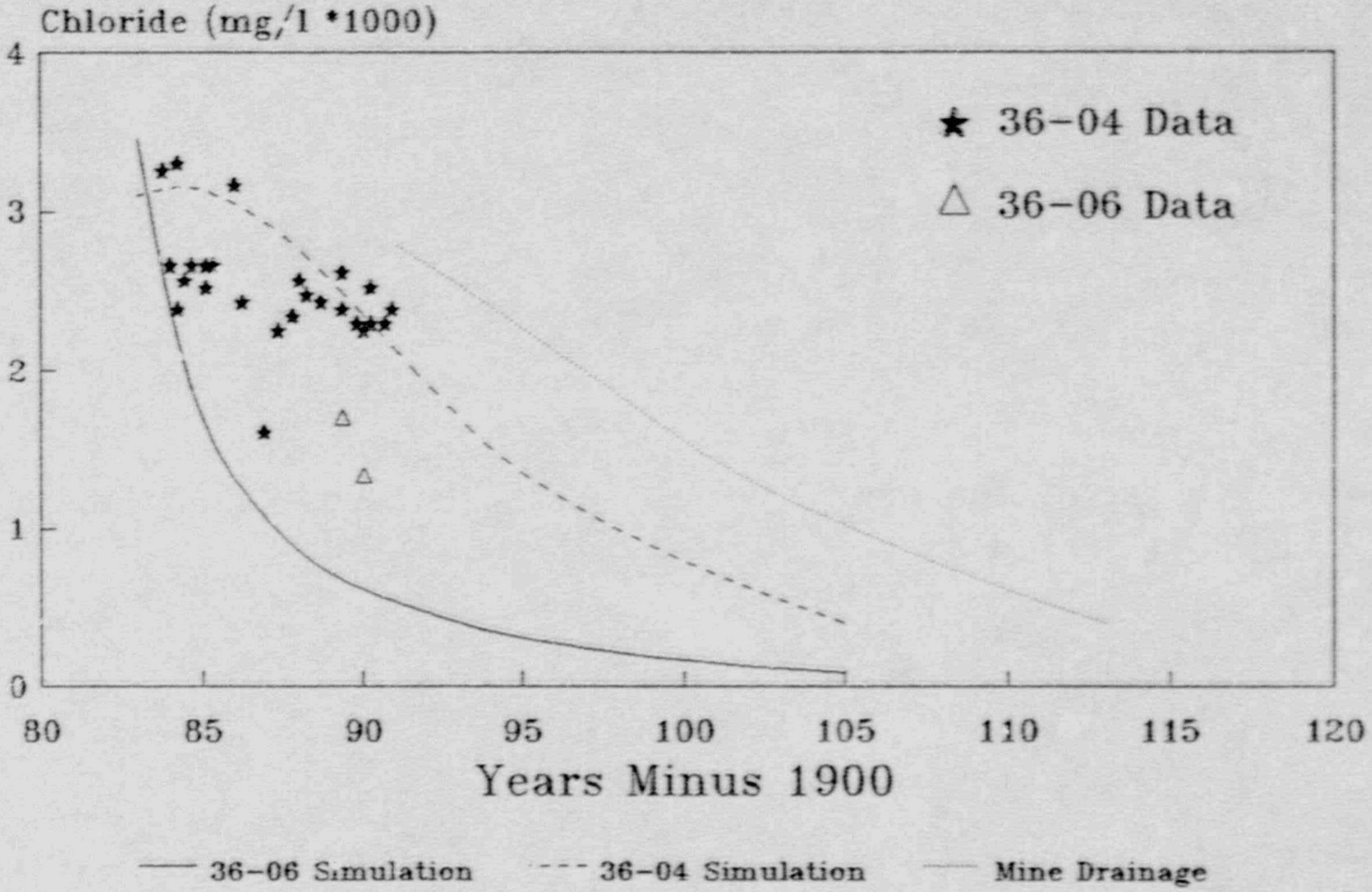
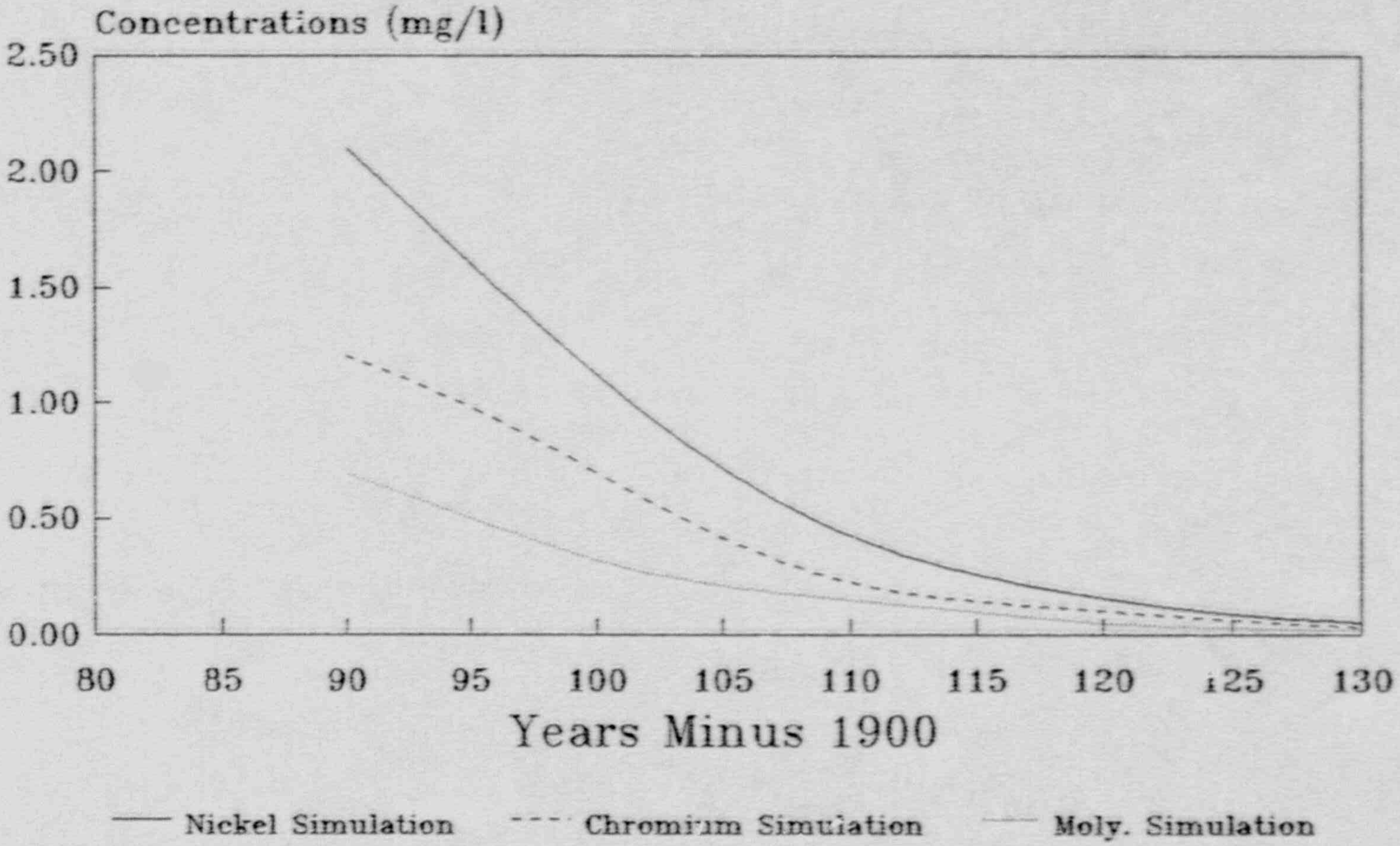


FIGURE 5 DAKOTA UNIT

Simulation of Concentrations



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