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SOURCES OF GROUNDWATER CONTAMINATION IN THE OGALLALA AQUIFER IN EASTERN NEW MEXICO

Technical Completion Report

Project No. 3109-147

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TECHNICAL COMPLETION REPORT

Project No. 3109-147

New Mexico Water Resources Research Institute
in cooperation with
Department of Biology
and
Department of Chemistry
Eastern New Mexico University
Portales, New Mexico

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PROJECT OBJECTIVES:

1. To examine the physical characteristics of the Portales Valley Water Basin, i.e., drawdown characteristics, existence of channeling for major wells, and vertical constant head permeability values.

2. To relate the effects of agricultural practices in an agro-economic area to the parameters of aquifer water quality.

3. To show and establish logical or causal connections between chemical and microbiological characteristics of the water, and the physical characteristics of the Basin.

DEGREE OF ACHIEVEMENT OF PROJECT OBJECTIVES:

The physical characteristics of the Portales Valley Water Basin were examined. Drawdown characteristics, channeling existence, and vertical constant head permeability values were measured. The results from the physical parameters yielded insight into the movements of various chemical and biological contaminants, in addition to giving explanations to the observed changes in trends of concentrations of the various measured parameters. Vertical constant head permeability values demonstrated that downward movement of water was sufficiently rapid to account for aquifer contamination by return flow in most of the soil associations examined. Subsurface strata composition indicated ion exchange, both cation and anion, played little, if any, role in affecting contaminant percolation.

Water quality of the aquifer was monitored by both chemical and biolcgical parameters. Eighteen chemical and biological parameters were examined routinely on seventeen wells throughout the Portales Valley Water Basin. Water under agricultural industries was monitored where the individual industries were isolated from synergistic effects. Lack of any appreciable rainfall during the fall and winter – post cultivation – months has resulted in base line fluctuations but a conspicuous absence of any trends. Minor trends were manifested as general decreases in measured parameters during the post irrigation season, and paralleled the previous study of 1971 (Project Number 3109-45 A-034 New Mexico). The absence of any winter moisture during the study period has created a repetition of environmental conditions which existed just prior to the 1971 study. As pre-planting ground preparation has required application of irrigation moisture to the soil, the terminal months of the study have produced a trend of increasing nitrate contamination in the groundwater. If the trend continues at the indicated rate, nitrate values of the same or higher levels than observed in 1971 can be expected.

The physical characteristics of the Water Basin, when considered with land use activites, permitted interpretation of the various parameters of water contaminants monitored. Comparisons indicated the relationship of sub-surface chloride concentration to animal density on land, as reported by Jones (1973), was paralleled in the Portales Valley Water Basin. The existence of high numbers of fecal and total coliforms in the water of the Valley apparently negated the observation of the fluctuations in nitrate concentrations reported by Jones (1973). (Fecal and total coliforms are capable of reducing nitrate to the more insidious nitrite ion.) Nitrite was commonly found to exist in the range of 5 to 15 ppb in the Valley's aquifer water. However, levels of nitrate concentrations have been observed as high as 5000 ppb. Attempts to identify the sources of the observed pulses of high nitrite concentrations have not been successful. The pulses were tracable in movement with the general movement of water within the aquifer. The movement of nitrite pulses were at the same rates determined by other physical measurements of watertable movement rates.

Water movement within the aquifer was measured by use of fluorescein dye marker. The rate of movement was calculated to be over six miles per year. Channeling was not evident in the wells monitored by this method. Calculations using Darcy's law indicated (on the basis of State Engineer-provided coefficient of permeability) that the expected-to-observed time for observation of the tracer material were equal.

Core sampling in the various soil associations, and subsequent chemical analyses at various intervals, has indicated that zones of concentrations exist. These zones would be expected to move downward with available moisture during the past irrigation season. The dry season, which has followed the irrigation season, has prevented results from this hypothesis.

PROCEDURES AND RESULTS

The objectives of the project have been accomplished by the following research procedures. The procedures are subdivided as per the objectives for which they were employed. All facilities required for the procedures were available.

1. Physical Characteristics

The drawdown characteristics have been determined on wells selected to represent eight compass points within the Portales Valley. This coordination confirmed the homogeneity and continuity of the Valley fill with the Ogallala formation, and produced sufficient evidence to indicate that cross contamination from overlapping drawdown influential radii can occur in the wells monitored.

Before pumping, a water stood in a well to a depth D which was indicative of the water table height. While pumping, the water level dropped to a lower point giving a new depth, d ; the water table in the vicinity being influenced by the withdrawal. Obviously, the slope of the drawdown curve at any point will be that necessary to cause flow into the well. The cone of depression and the drawdown slope can be determined by use of observation wells; however, the expense for establishing observation wells relative to the usefulness of the drawdown information to the project prohibited such a method.

The radius of the circle of influence, however, was quite useful for determining potential cross contamination. This radius, R , is defined as the distance from the center of the well to a point on the water table where the influence of the well is not noticeable. The dimensions of R were estimated by the amount of water flowing in the aquifer, which was largely dependent upon the slope, S , of the water table. Water flowing into the well can be considered as that water passing through a strip equal in width to the diameter of the circle of influence, or

$$Q = 2RDKpS \qquad (1)$$

where Q is the quantity of water in cubic feet per day, S the water table slope, p the porosity ratio and K is the velocity of flow in feet per day.

Water flowing into the well can also be determined by the previously defined terms of D, d, R, and r (the well radius), as indicated below:

$$Q = \pi Kp \frac{(D^2 - d^2)}{\log_e \frac{R}{r}} \qquad (2)$$

Since the Q of equation (1) is the same as in equation (2), by equating and simplifying, equation (3) is obtained:

$$R = \frac{(D^2 - d^2) \log_e \frac{r}{R}}{2DS} \qquad (3)$$

The values of S, p, and K were obtained from the State Engineer's Office for the areas examined. The measurable values of D and d were then obtained from direct observation in the wells monitored.

The radius of the circle of influence R was determined from equation (3) by approximation methods using computer analyses. The results from these analyses are found below.

It is obvious from the values obtained for R (expressed in feet) that permeability of the water bearing strata is extremely great. This great permeability, when coupled with the extremely shallow slopes of the Portales Valley aquifer produced very large values for the radii (R) of influence. These values indicate the potential for cross contamination and movement of contaminants from one area to another is most plausable. The values for radii of influence, when examined in conjunction with the data obtained on channeling, indicates that it is imperitive to define downward movement and percolation rates. It is obvious, when the data of these two sections are examined, that once contaminants enter the aquifer, they are capable of influencing extremely large areas of the Basin. Percolation rates and downward movements however, were not part of the objectives of this study. The results of the physical parameters of this study have now delineated, however, these physical characteristics imperative to examine.

Radii of Influence on Several Typical Wells

Radius of influence	=	3.786×10^4 feet
Radius of influence	=	1.743×10^4 feet
Radius of influence	=	8.050×10^3 feet
Radius of influence	=	1.745×10^4 feet
Radius of influence	=	9.310×10^4 feet

2. Channeling

Since channeling, if prominant, could also be responsible for cross contamination from areas where contamination exists, its prevalence was investigated. The coefficient of Transmissibility was obtained from the State Engineer's Office for areas in the Portales Valley water basin. The coefficient of Transmissibility was converted to the coefficient of Permeability by the following relationship:

$$\frac{\text{Coefficient of Transmissibility}}{\text{Saturated Thickness}} = \text{Coefficient of Permeability}$$

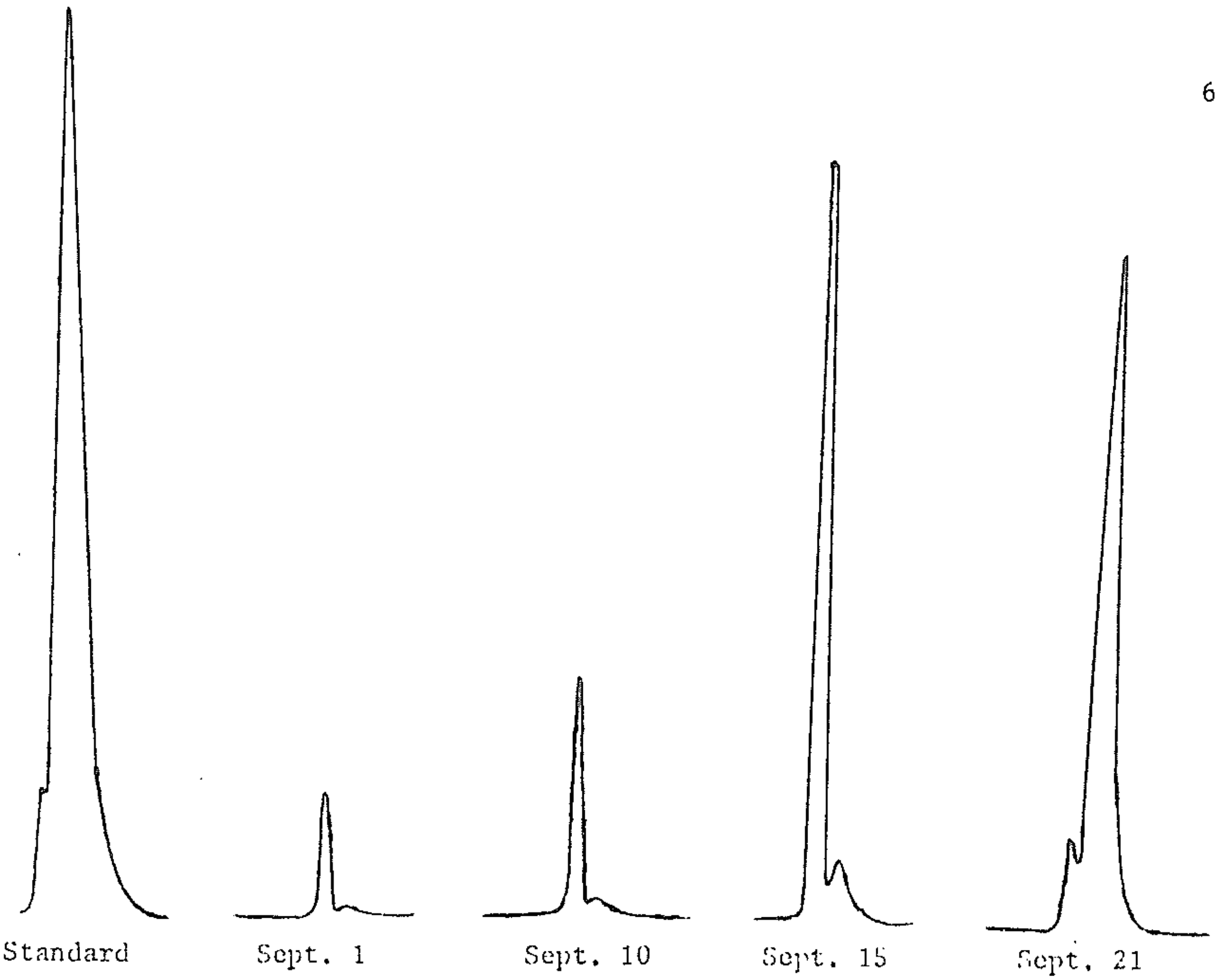
The time for a marker to migrate a given distance through the aquifer was calculated from Darcy's law:

$$V = KS$$

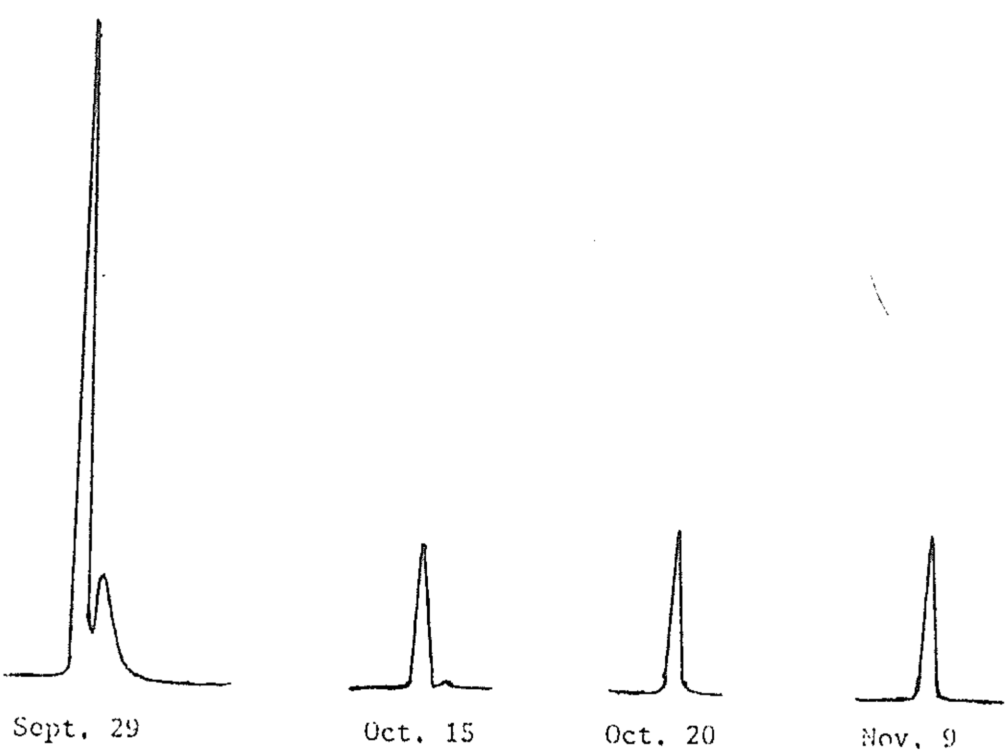
The velocity (V) is usually in the same units as the coefficient of permeability, K (ft/day), since the slope, s , (ft/ft) is dimensionless.

When a marker, such as fluorescein, was placed into a well, and observation wells surrounding the marked well were monitored, the ratio of the time expected for appearance to the time observed for appearance could be obtained. The expected to observed ratio approached unity, and channeling was not a prominent feature around the wells under observation. Fluorescein was employed in nonpopulated areas and detected by fluorimetry. Fluorimetric analysis of fluorescein results in a dissection limit of 10 ppb at 512 nm.

It was found from Darcy's law that the expected flow rate was 6.108 miles per year. In the monitored situation, the flow rate was found to be 6.139 miles per year. Fluorescein was found to be an excellent labeling material in the aquifer as its detection was typical of pulse labeled flow. Several fluorimetric traces are provided to demonstrate the pulse appearance of the indicator. The peak demonstrating a shoulder on the left is a reflective peak not characteristic of pure fluorescein. The peak on the right (512 nm) is characteristic of fluorescein and serves to identify its presence in the sample.



FLUORIMETRIC ANALYSES OF FLUORESCEIN. PEAK ON THE LEFT IS REFLECTANCE AT 471 nm. PEAK ON RIGHT IS EMISSION AT 512 nm.



3. Vertical Constant Head Permeability Values

Infiltration of contamination lies both in the characteristics of the contaminant and the permeability of the soil, sub-soil, and aquifer material. Various contaminants (i.e. nitrate) are known to not be absorbed by or adsorbed to soil or sub-soil materials. Consequently, the rate of downward percolation of these contaminants lies in the function of permeability of the materials through which they pass. Vertical constant head permeability values were determined for the major soil associations and industries (i.e., dairies, feedlots, etc.) within the Valley in addition to the related sub-soils.

The vertical constant head permeability values were established using the apparatus diagrammed in Figure 1. By use of a power core soil sampler, samples at the surface, and below the surface at five foot intervals were taken to a depth of 37 feet where possible. (Collapse of the walls prevented deeper sampling without the use of casing.) These samples, the diameter of which were at least 40 times the mean particle size to avoid wall effect, were placed in Area A (Figure 1) and the vertical constant head permeability measured for each sample.

A disadvantage of this laboratory measurement of permeability was that the test samples were small and it was difficult to obtain undisturbed samples. However, the investigators of this project felt that planning data for the Valley would be more reliable if based on data from the Valley rather than on findings for adjacent areas.

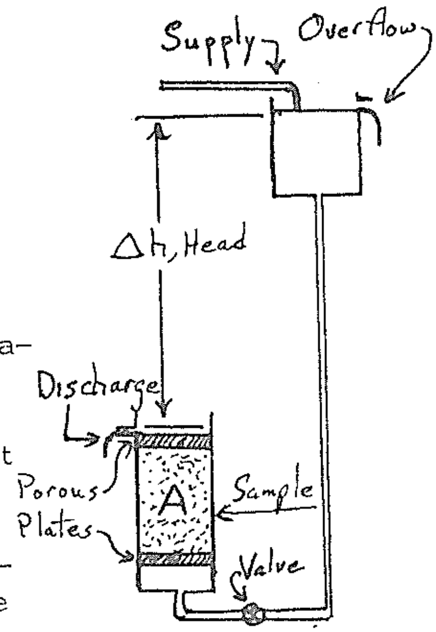


Figure 1

The vertical constant head permeability values demonstrated the high permeability of overlying soil associations - and the sub-surface aquifer material. Most of the Portales Valley is composed of two major soil associations: The Amarillo-Clovis fine sandy loams and the Potter-Mansker association. The Amarillo-Clovis fine sandy loams are characterized by deep and moderately deep, moderately sandy land. The Potter-Mansker association is characterized by very shallow to moderately deep calcareous soils.

Three other associations, which together occupy a very small portion of the valley area (Amarillo-Clovis loams; Amarillo-Clovis loamy fine sands; Tivoli-Springer-Brownfield sands), are characterized generally as deep and moderately deep sandy lands.

The following Table indicates the degree of soil permeability with depth. It is obvious that strata exist in the sub-surface material. These strata, differing in the various areas of the surface soil association, preclude my observable trends in permeability. In general, the calcareous soils and strata were considerably less permeable then the sandy soils, subsoils and aquifer materials. One stratum of unconsolidated calcium carbonate had an estimated minimum permeability of 10^{-11} cm/sec. However, the consolidated counterpart, caliche, has apparently undergone dessication in the area resulting in a fractured, porous formation with a permeability approaching free flow, or 32 ft/sec.

Table of Vertical Constant Head
Permeability Values

Depth (Ft.)	Soil Association	Flow Rate (cm/sec)*
1	Amarillo-Clovis Fine Sandy Loams	$10-0.8 \times 10^{-4}$
2	"	$2 - 3 \times 10^{-4}$
4	"	1.5×10^{-3}
10	"	5×10^{-5}
16	"	$11 - 0.4 \times 10^{-2}$
17	"	$36 - 0.3 \times 10^{-4}$
19	"	6×10^{-3}
23	"	1.2×10^{-2}
28	"	$6.5 - 7 \times 10^{-3}$
37	"	$4.8 - 6.7 \times 10^{-3}$
1	Amarillo-Clovis Loamy Fine Sands	$1.2 - 1.0 \times 10^{-2}$
2	"	$1.2 - 1.0 \times 10^{-2}$
3	"	$1.4 - 0.8 \times 10^{-2}$
.5	Amarillo-Clovis Loams	$1.3 - 1.1 \times 10^{-3}$
1.0	"	$4.0 - 2.5 \times 10^{-3}$
2	"	$6.7 - 6.0 \times 10^{-4}$
1	Potter-Mansker	$2.6 - 2.2 \times 10^{-3}$
2	"	$24 - 0.1 \times 10^{-4}$
3	"	$2.2 - 0.3 \times 10^{-2}$
4	"	1.5×10^{-3}
5	"	$8.1 - 4.0 \times 10^{-4}$
5.5	"	1.5×10^{-4}
6.5	"	$1.5 - 1.1 \times 10^{-4}$
7.5	"	$2.5 - 1.4 \times 10^{-5}$
8.5	"	$8.0 - 7.3 \times 10^{-5}$
9.5	"	$2.0 - 1.9 \times 10^{-4}$
14	"	1.4×10^{-5}

1	Tivoli-Springer-Brownfield Sands	$2.7 - 2.5 \times 10^{-3}$
2	"	$5.7 - 5.6 \times 10^{-4}$

*Ranges are extremes of data values.

4. Agricultural Effects on Water Quality and Causal Connections of the Basin Characteristics

The Portales Valley is fortunate to have a diversity of agricultural industries. Even more salubrious to the investigation was the fact that examples of most industries were found in areas where little if any synergistic contamination was expected to occur. This advantage permitted tenative identification of effects of the invididual industries upon the aquifer water quality.

Water quality was examined by both chemical and bacterial parameters to determine the individual effects of each agricultural industry. Chemical parameters included conductivity, nitrate analysis by the brucine sulfate technique, and metallic ions (potassium, magnesium, etc.) monitored by atomic absorption-flame emission spectroscopy. The bacterial parameters included total coliforms, fecal coliforms (as indicators of recent pollution) and fecal streptococci. Membrane filtration was the method employed. Speciation as to Aerobactor (common inhabitors of plant debris) and E. Coli (fecal inhabitors) was accomplished by the standard IMViC tests.

Each industry monitored (i.e. dairies, feedlots, manured irrigated farming, etc.) also had the parameters of soil type recorded in addition to rainfall, and animal densities if appropriate. The collected data on surface activity when correlated to vertical constant head permeability values and variations in aquifer water quality permitted an assessment of the effect of the monitored industry.

The following table indicates four typical wells of varied agricultural industries selected from over twenty which were routinely measured. The ranges of selected parameters are included. Comments as to seasonal fluctuations are included. Each well is discussed below as to the various physical and land use parameters which appeared to have influence on the quantitatively measured aspects of water quality.

Well 7801: It can be seen from the table that seasonal decreases occurred in nitrate, coliforms and fecal coliforms. The industry concerned was a dairy and while fulfilling the requirements of being isolated from synergistic contamination, an influence of the physical ground water flow was evident. Groundwater movement has a flow rate of 0.51 miles per month based on fluorimetric measurements and calculations from Darcy's law. The flow direction is from the northwest to the southeast.

The isolation of the dairy industry had no other major or minor influencing industry located in the up-stream direction. The well for the dairy was also located at the northwest side of the industry location. A plausable absence of industry influence is explained on the basis of the water table movement. One well monitored down-flow from the dairy did demonstrate wide fluctuations including the insidious nitrite ion.

Well 1101: This well was typical of those wells in which all the adjacent industry in the area surrounding the well was row crop farming. The monitored ions and bacterial contamination followed typical summer irrigation. Seasonal fluctuations demonstrated that groundwater contamination paralleled agricultural practices. Summer peaks occurred for the monitored ions which correlated to heavy summer irrigation practices. Bacterial fluctuations paralleled land use characteristics. Summer peaks of coliforms demonstrated the majority of species were of the aerobacter group. The aerobacter are typical inhabitors of plants and plant debris. Typically as crops were harvested and animals turned to graze on fields - an increase in fecal coliforms and fecal streptococci were observed. The fecal coliform: fecal streptococci ratios were consistent with literature ratios indicative of animal contamination (Geldreich and Kenner, 1969; Smith, et.al., 1973).

Well 1401: This well was typical of those wells in which the surrounding adjacent agriculture was alfalfa. There are two rather different phenomonana occurring which could be observed in this well. The bacterial information was reflective of animal activity but land usage for animals was not predominant or prevalent. The time for the appearance of the bacterial peaks was immediately following irrigation seasons for most row-crop activity. When water table flow is considered, these peaks occurring in the post-irrigation season are not misleading. The interesting post-seasonal trends of ion increases-rather than the more frequently observed decreases-can be correlated to winter irrigation when meteoric moisture was not available. In the absence of any winter moisture it was necessary to irrigate the perennial crop of alfalfa.

Well 1603: This well type may be described as the easiest of well types to correlate physical activity to water quality, being surrounded entirely by unirrigated pasture. Animal density was low explaining the lack of trends in the ions of chloride and sodium. Cattle feed and excrement could easily be traced to periods of animal occupation of the pasture area and the small amounts of received meteoric water. The summer peaks followed cattle occupation and the minor peaks in the winter followed the only winter moisture in the valley.

COMPUTER ANALYSES

Computer analyses and techniques were used in the handling and processing of the volumes if data generated. SYMAP was used to correlate findings of the current study to similar data locations of a previous exploratory study. Changes in values and contour intervals were evident. (See attached out put)

SYMAP is a computer program for producing maps which graphically depict spatially arrayed quantitative information. It is suited to a broad range of applications, and has numerous options for meeting widely varying requirements. Combinations of standard computer characters are used to display a scale of tone from black to white which corresponds to the data value range. Options are available for rescaling of raw data and for variations in symbolism.

SYMAP was obtained from the Laboratory for Computer Graphics and Spatial Analysis, Harvard Center for Environmental Design Studies, Graduate School of Design, Harvard University. The program is available through the computer facilities at New Mexico State University, Las Cruces. A remote telephone-connected terminal makes the program available to users on the Eastern New Mexico Universtiy campus.

The SYMAP program is written in FORTRAN IV, level G. The source deck consists of approximately 5000 cards. The program uses approximately 200K bytes of core storage and assumes availability of a full operating system.

In addition to SYMAP a plot routine was written and used in conjunction with a data storage and retrival system to follow quarterly data changes. An example of the plot routine and retrival bank are also included.

TRAINING ACCOMPLISHMENTS

Several students in various stages of degree completion were employed in the data collection phases of the project: Edith Kimbrell, Steward Lacey, Ed Bigler, Alice Cone, Terry Pressley, David Augustine, Geoffrey Browne, and James Dyke. Of the students who have graduated and/or left the campus the following have accepted positions:

G. Browne - Chemist with Champion Chemical
J. Dyke - Co-Op program in computer analysis with Los Alamos
A. Cone - Veterinary Asst.
T. Pressley - Water Research Institute at Texas Lutheran College,

TABLE OF TYPICAL WELLS OF VARIED INDUSTRIES

Well Number	Land Use Surrounding Well Area	Parameter	Range	Seasonal Variation
7801	Dairy	NO_3^-	5–11 ppm	Seasonal Decrease from July
		Cl^-	120–180 ppm	No seasonal trend
		Na+	63–84 ppm	No seasonal trend
		TDS	1040–1680ppm	No seasonal trend
		Coliforms	0–TNTC	Seasonal Decrease from July
		Fecal Coliforms	0–6	Seasonal Decrease from July
		Fecal Strep	0	No Seasonal trend
1101	Row Crop	NO_3^-	2–4 ppm	Seasonal Decrease from July
		Cl^-	240–500ppm	Seasonal Decrease from July
		Na^+	140–322ppm	Seasonal Decrease from July
		TDS	1840–2720ppm	No seasonal trend
		Coliforms	0–TNTC	High values only from July–Sept.
		Fecal coliforms	0–TNTC	Peak in Sept. Seasonal Decrease
		Fecal Strep	0–20	Peak in Sept. Seasonal Decrease

Well Number	Land Use Surrounding Well Area	Parameter	Range	Seasonal Variation
1401	Alfalfa	NO_3^-	1–7 ppm	Seasonal increase during Post Irrig.
		Cl^-	300–500ppm	Seasonal increase during Post Irrig.
		Na^+	231–273ppm	No Seasonal Trend
		TDS	2160–3240ppm	Seasonal increase during Post Irrig.
		Coliforms	0–TNTC	Peaks in July, Sept., Nov.
		Fecal coliforms	0–88	Peaks in Sept., Nov.
		Fecal Strep	0–440	Peaks Oct., Nov.
1603	Dryland Pasture	NO_3^-	1–8ppm	Peaks in July and Dec.
		Cl^-	20–60ppm	No Seasonal trend
		Na^+	77–182ppm	No Seasonal trend
		TDS	480–960ppm	No Seasonal trend
		Coliforms	0–TNTC	Peak July minor peak Nov.
		Fecal coliforms	0–60	Peak July minor peak Nov.
		Fecal Strep	0–120	Seasonal Peak in Nov.

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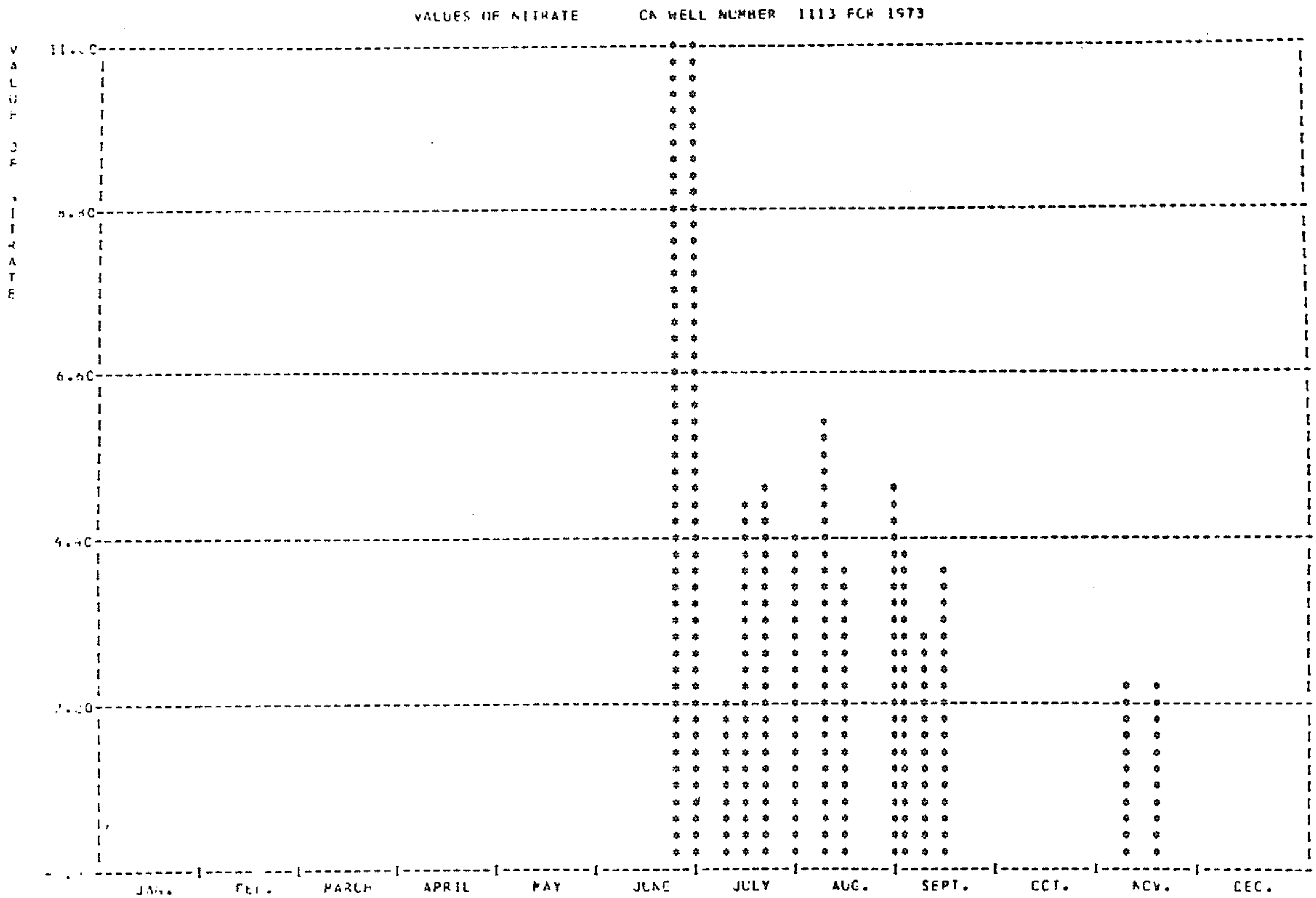
TABLE OF WELLS MONITORED THROUGHOUT THE VALLEY

WELL	LEGAL DESCRIPTION	DATE DR.	DEPTH	TYPE OF WELL	SURROUNDINGS
1	NO LEGAL DESCRIPTION AVAILABLE		*		
2	NO LEGAL DESCRIPTION AVAILABLE		*		
3	NO LEGAL DESCRIPTION AVAILABLE		*		
4	NO LEGAL DESCRIPTION AVAILABLE		*		
5	NO LEGAL DESCRIPTION AVAILABLE		*		
6	NO LEGAL DESCRIPTION AVAILABLE		*		
7	NO LEGAL DESCRIPTION AVAILABLE		*		
8	NO LEGAL DESCRIPTION AVAILABLE		*		
9	NO LEGAL DESCRIPTION AVAILABLE		*	CITY	
601	SW1/4 SW1/4 SW1/4 S15 R32E T 1S		*	SCHOOL	DRY PASTURE
602	NE1/4 NE1/4 NW1/4 S 2 R34E T 1S		*	PARK	DRY PASTURE
1101	SE1/4 SW1/4 SW1/4 S25 R33E T 1S	8/**/55	120	HOUSE	ROW CROP
1102	SW1/4 SW1/4 SE1/4 S28 R33E T 1S	2/**/52	136	HOUSE	ROW CROP
1103	NW1/4 NW1/4 NW1/4 S31 R33E T 1S	2/**/65	86	HOUSE	ROW CROP
1104	SW1/4 NW1/4 NW1/4 S 4 R35E T 2S		*	HOUSE	ROW CROP
1105	NE1/4 NE1/4 SE1/4 S13 R35E T 2S		*	HOUSE	ROW CROP
1106	SW1/4 NW1/4 SW1/4 S19 R36E T 2S		*	HOUSE	ROW CROP
1107	SW1/4 NW1/4 NW1/4 S29 R36E T 2S	8/15/59	115	HOUSE	ROW CROP
1108	SW1/4 SW1/4 SW1/4 S 9 R35E T 2S	6/ 5/69	119	HOUSE	ROW CROP
1109	SW1/4 NW1/4 SE1/4 S19 R35E T 3S	*/**/46	60	HOUSE	X-DIARY,ROWC
1110	NW1/4 SW1/4 NE1/4 S 5 R32E T 1S		*	HOUSE	ROW CROP
1111	NE1/4 NE1/4 SE1/4 S16 R31E T 1N		*	HOUSE	ROW CROP
1112	SW1/4 NE1/4 SE1/4 S 7 R33E T 1S		*	HOUSE	ROW CROP
1113	SW1/4 SW1/4 SE1/4 S30 R35E T 1S		*	HOUSE	ROW CROP
1114	NW1/4 SW1/4 NW1/4 S33 R35E T 1S		*	HOUSE	ROW CROP
1115	SE1/4 SE1/4 SE1/4 S11 R35E T 2S		*	HOUSE	ROW CROP
1401	NW1/4 SW1/4 SE1/4 S[illegible] R34E T 1S	7/12/65	118	HOUSE	ALFALFA
1402	NW1/4 NE1/4 NW1/4 S 5 R35E T 2S		*	HOUSE	ALFALFA
1501	NW1/4 NW1/4 NW1/4 S34 R34E T 1S		*	HOUSE	PASTURE
1502	SE1/4 NE1/4 SE1/4 S11 R34E T 2S	4/3?/67	128	HOUSE	PASTURE
1503	SE1/4 SE1/4 NE1/4 S28 R34E T 2S		*	HOUSE	PASTURE
1504	NE1/4 NE1/4 NW1/4 S34 R34E T 1S		*	HOUSE	PASTURE
1601	NE1/4 SE1/4 SE1/4 S28 R34E T 2S		*	HOUSE	DRY PASTURE
1602	SE1/4 NE1/4 SE1/4 S26 R34E T 2S		*	HOUSE	DRY PASTURE
1603	NE1/4 SE1/4 SE1/4 S 1 R34E T 1S		*	HOUSE	DRY PASTURE
1604	SE1/4 NE1/4 SE1/4 S13 R34E T [illegible]		*	HOUSE	DRY PASTURE
1605	NE1/4 SW1/4 SE1/4 S 6 R32E T 1S		*	HOUSE	DRY PASTURE
1606	NW1/4 SW1/4 NW1/4 S17 R34E T 2S		*	HOUSE	DRY PASTURE
1607	NW1/4 NW1/4 SW1/4 S14 R31E T 1N		*	HOUSE	DRY PASTURE
1608	SW1/4 SW1/4 SW1/4 S28 R35E T 1S		*	HOUSE	DRY PASTURE
1701	NW1/4 SE1/4 SE1/4 S25 R34E T 1N		*	HOUSE	IRR. PASTURE
1801	SE1/4 SE1/4 SE1/4 S11 R34E T 2S	8/**/55	112	HOUSE	DIARY
1802	SE1/4 NE1/4 NE1/4 S19 R34E T 1S	7/23/56	123	HOUSE	DIARY
3101	SW1/4 SW1/4 SW1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3102	SW1/4 SW1/4 SW1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3103	SW1/4 SW1/4 NW1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3104	SE1/4 SE1/4 SE1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3105	SE1/4 SE1/4 SE1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3106	NE1/4 SE1/4 NW1/4 S17 R31E T 1N		*	IRRIG	ROW CROP
3107	NW1/4 NW1/4 NW1/4 S 5 R32E T 1S		*	IRRIG	ROW CROP
3108	NE1/4 SE1/4 SE1/4 S 6 R32E T 1S		*	IRRIG	ROW CROP
3109	NW1/4 SW1/4 SE1/4 S 6 R32E T 1S		*	IRRIG	ROW CROP
3110	SW1/4 SW1/4 NE1/4 S13 R30E T 1N		*	IRRIG	ROW CROP
3111	NW1/4 SW1/4 SE1/4 S24 R34E T 1S		*	IRRIG	R.CROP,FDLT
5101	SE1/4 NE1/4 SE1/4 S18 R31E T 1N		*	WNDMLL	ROW CROP
5501	SE1/4 NW1/4 SE1/4 S15 R34E T 3S		*	WNDMLL	PASTURE
5601	SE1/4 SE1/4 SE1/4 S31 R32E T 1N		*	WNDMLL	DRY PASTURE
7101	NW1/4 SW1/4 NW1/4 S 5 R32E T 1S		*	TANK	ROW CROP
7801	NE1/4 NE1/4 SW1/4 S30 R35E T 1S		*	TANK	DIARY
9901	SE1/4 SE1/4 SE1/4 S 1 R34E T 1S	3/**/65	158	FEEDLT	FEEDLOT

TABLE OF TYPICAL COMPUTER OUTPUT OF PARAMETERS MEASURED IN EACH WELL

WELL	DATE	COL(/DL) NO3(PPM) NA(PPM)	FC(/DL) PO4(PPM) K(PPM)	FS(/DL) HCO3(PPM) LI(PPB)	TEMP(C) CL(PPM) CA(PPM)	PH(O) NO2(PPB) MG(PPM)	PH(E) COND(MM) TDS(PPM)
1534	1/ 8/74	0.	0.	0.	14.0	7.15	*
		3.50	*	566.0	135.2	*	1560.0
		143.5	7.0	40.	71.0	37.0	1340.
1401	1/ 8/74	0.	0.	4.	11.3	7.30	*
		7.30	*	696.8	403.6	*	3013.0
		258.0	22.0	170.	80.0	202.0	2850.
11 1	1/ 8/74	0.	0.	0.	17.0	7.45	*
		4.30	*	536.8	252.4	*	2214.0
		241.0	13.0	100.	55.0	114.0	2060.
11 2	1/ 8/74	1.	4.	1.	16.0	7.48	*
		4.60	*	595.2	423.6	*	2235.0
		245.0	17.0	120.	57.0	106.0	2030.
11 3	1/ 8/74	0.	2.	0.	10.0	7.55	*
		2.20	*	609.6	220.0	*	1792.0
		241.0	8.0	115.	37.0	8.0	1470.
1112	1/ 6/74	0.	0.	2.	11.0	7.74	*
		4.90	*	711.2	77.4	*	945.0
		63.0	5.0	45.	52.0	34.0	910.
1603	1/ 8/74	6.	0.	3.	14.5	7.60	*
		5.80	*	725.6	133.4	*	1316.0
		105.0	13.0	60.	70.0	35.0	1210.
602	1/ 8/74	0.	0.	0.	14.5	7.75	*
		6.10	*	754.8	111.8	*	711.0
		25.0	8.0	50.	42.0	28.0	580.
7801	1/ 8/74	1.	0.	1.	18.0	7.30	*
		7.50	*	595.2	148.8	*	1782.0
		70.0	6.0	20.	207.0	57.0	1670.
1114	1/ 8/74	2.	1.	1.	14.9	7.25	*
		4.95	*	595.2	115.2	*	1078.0
		47.0	4.5	10.	81.0	40.0	870.
1138	1/ 8/74	52.	29.	0.	16.0	7.80	*
		5.30	*	653.2	173.2	*	1900.0
		167.0	9.0	100.	57.0	106.0	1740.
1136	1/ 8/74	0.	0.	4.	16.6	7.60	*
		3.41	*	812.8	147.6	*	1814.0
		230.0	11.0	60.	47.0	74.0	1560.
1402	1/ 8/74	0.	0.	0.	15.2	7.65	*
		3.80	*	653.2	68.0	*	982.0
		47.0	5.0	10.	65.0	39.0	930.

* MEANS NO DATA, TNTC MEANS TOO NUMEROUS TO COUNT, P MEANS ION IS PRESENT, A MEANS ION IS ABSENT



TYPICAL COMPUTER PLOT ROUTINE USED TO MONITOR VARIATIONS OF EACH MEASURED VARIABLE FOR EACH WELL.

MINIMUM = 0.0

NITRATE CONTOUR BASED ON P. D. BIGBEE DATA COLLECTED ON
JUNE 23, 1971 REPRESENTING A COMPARISON OF EARLY SUMMER VALUES
BETWEEN THE YEARS OF 1971 AND 1973

WELLS IN ORDER: 1401, 1101, 1102, 1801, 1108, 1802

... BASED ON ALICE CORN DATA COLLECTED ON

JUNE 23, 1973 REPRESENTING A COMPARISON OF EARLY SUMMER VALUES

BETWEEN THE YEARS OF 1971 AND 1973

WELLS IN ORDER: 1401, 1101, 1102, 1201, 1109, 1202, 1502

SCALE = 4.16 MILES PER INCH

[illegible] BASED ON P. D. BIGBEE DATA COLLECTED ON [illegible] 1971 REPRESENTING A COMPARISON OF FALL VALUES BETWEEN [illegible] OF 1971 AND 1973

[illegible] IN ORDER: 1401, 1101, 1102, 1001, 1108, 1802, 1502
[illegible] = 4.16 MILES PER INCH

BAIRD 1 1 124
LAST LINE NUMBER IS 233
PURGE IF DONE WITH JOB

SYMAP

TIME = 0.0

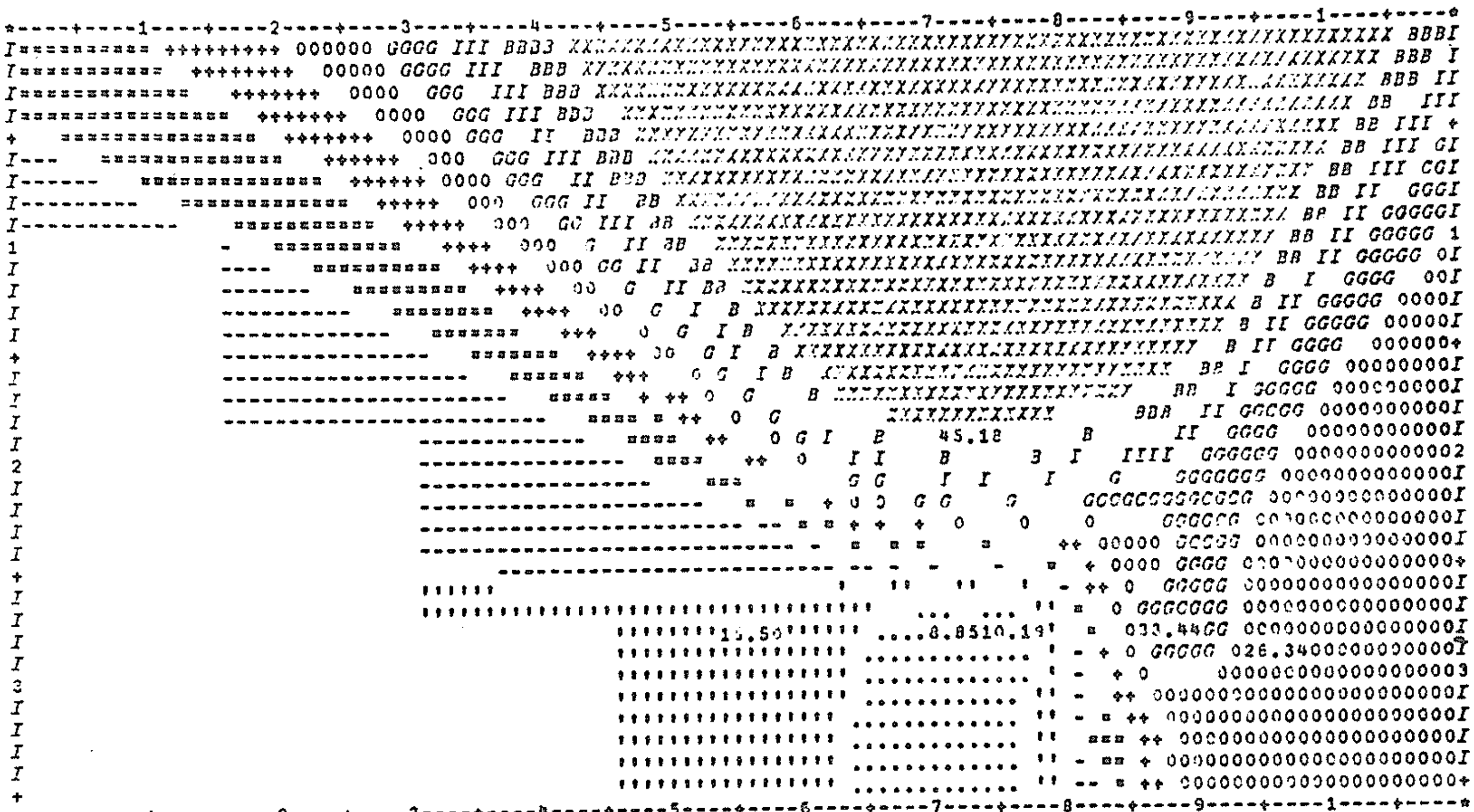
NITRATE CONTOUR BASED ON ALICE CORE DATA COLLECTED ON

SEPTEMBER 15 ,1973 REPRESENTING A COMPARISON OF FALL VALUES BETWEEN

THE YEARS OF 1971 AND 1973

WELLS IN ORDER: 1401, 1101, 1102, 1801, 1108, 1802, 1502
SCALE = 4.16 MILES PER INCH

DATA VALUE EXTREMES ARE 2.00 9.20



SYMAP

TIME = 0.0

NITRATE COUNTOUR BASED ON P. D. BIGBEE DATA COLLECTED ON

NOVEMBER 11,1971 REPRESENTING A COMPARISON OF WINTER VALUES BETWEEN

THE YEARS OF 1971 AND 1973

WELLS IN ORDER: 1401, 1101, 1102, 1801, 1103, 1802
SCALE = 4.16 MILES PER INCH

DATA VALUE EXTREMES ARE 8.86 45.19

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

SYMAP

FIND = 0.0

NITRATE CONTOURS BASED ON ALL [illegible] SOIL DATA COLLECTED ON
NOVEMBER 3, 1973 REPRESENTING A [illegible] OF WINTER VALUES BETWEEN
THE YEARS OF 1971 AND 1973

AREAS IN ORDER: 1401, 1101, 1102, 1[illegible]01, 1108, 1502
SCALE = 4.10 MILES PER INCH