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HYDROGEOLOGIC STUDY OF NORTH RICHLAND WELL FIELD AND GROUNDWATER RECHARGE BASINS

A Report

Prepared For

The City of Richland, Washington

Prepared By

ICF Northwest

November 1987

EXECUTIVE SUMMARY

ICF Northwest conducted investigation and testing of the City of Richland's North Richland Well Field and Recharge Basin System. This study involved the quantitative evaluation of the surface infiltration rate and particle size distribution of the recharge basin floors; performance of aquifer pumping tests; geologic evaluation of the available well logs for the well field; and evaluation of past and present operational strategies.

Recommendations for the recharge basins include the following:

- Line the basins with sand;
- Repair the dike separating the basins; and
- Repair the perimeter fence around the basins.

Recommendations for operation of the well field include the following:

- Relocate the largest pumps in the field into the wells with the highest yield potential (based on well log data and operational experience); and
- Operate the well field under recharge only when production exceeds 3.0 million gallons per day (75 % of the estimated aquifer capacity).

By relocating the high capacity pumps to the best producing wells, it should be possible to limit recharge to 150 % of production during periods when recharge is required (estimated 5 months per year). This strategy could result in saving the operational costs of pumping up to 1.6 billion gallons of recharge water per year which are not currently recovered by the production wells.

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[illegible] STUDY OF

NORTH RICHLAND

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GROUNDWATER

RECHARGE BASINS

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1.0 INTRODUCTION

ICF Northwest, under subcontract to HDR/CWC, Inc., has conducted a hydrogeological study of the City of Richland's North Richland Well Field and Groundwater Recharge Basin System. This study includes evaluation of current and historical operations of the system, on-site evaluation of the condition of the recharge basins, and aquifer evaluations through pumping tests using the pumps in place in the system.

The North Richland Well Field has been a significant historic source of drinking water for the City of Richland and continues to provide the largest portion of product water not processed through the city's filtration plant. In addition, the North Richland Well Field is the primary source of water during the annual winter shut-down of the filtration plant for maintenance.

Since the well field continues to be an important water source, the objectives of this study were two-fold:

1) evaluate the physical condition of the recharge basins and recommend maintenance procedures; and
2) evaluate the productive capacity of the native aquifer at the well field and recommend efficient pumping strategies accordingly.

The methods used to evaluate the condition of the recharge basins include the following:

1) observation of near-surface sediments in cores and hand-dug pits;
2) measurement of surface infiltration rates using a concentric ring infiltrometer at locations of observed extremes in surface conditions;
3) collection of samples in three-inch increments from the top foot of sediments in the basins and analysis of particle size distribution of the samples.

Evaluation of the aquifer at the well field was done through application of the following methods:

1) constant rate pumping tests of two wells using pumps in place and using nearby wells as monitoring wells;

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2) calculation of coefficients of storage and transmissivity based on conditions observed during pumping;
3) evaluation of geologic strata as indicated in well logs of individual wells.

2.0 HISTORIC OPERATIONS

Since construction of the Richland Water Filtration Plant, the North Richland Well Field has been used to produce a daily average ranging from 0.5 to 7.8 million gallons of water per day. Water is pumped from the well field for 10 to 12 months of the year with the highest production occurring during the summer months of June through August and an additional peak in production during January and February when the filtration plant is shut down for maintenance.

The aquifer at the well field is recharged via a system of settling and recharge basins centrally located at the well field. Figure 1 indicates the location of the recharge basins and the production wells in the North Richland Well Field. Water from the Columbia River is pumped from the City's intake structure near the filtration plant to the settling basin through a 27 inch line. The recharge water enters the south end of the settling basin and flows to the extreme north end of the settling basin before discharging through a concrete weir and flow divider into the two recharge basins. Recharge flows into this system range from zero during low production periods to as high as 16.0 million gallons per day during July. Figure 2 illustrates the monthly totals for recharge and production for the years 1985 through 1987. The relationships between recharge and production are discussed in more detail in the section dealing with pumping strategies and recommendations.

The product water from the well field is treated with chlorine by a chlorinator system at the well field and then discharged directly into the city's supply system. No additional filtration or chemical treatment is applied.

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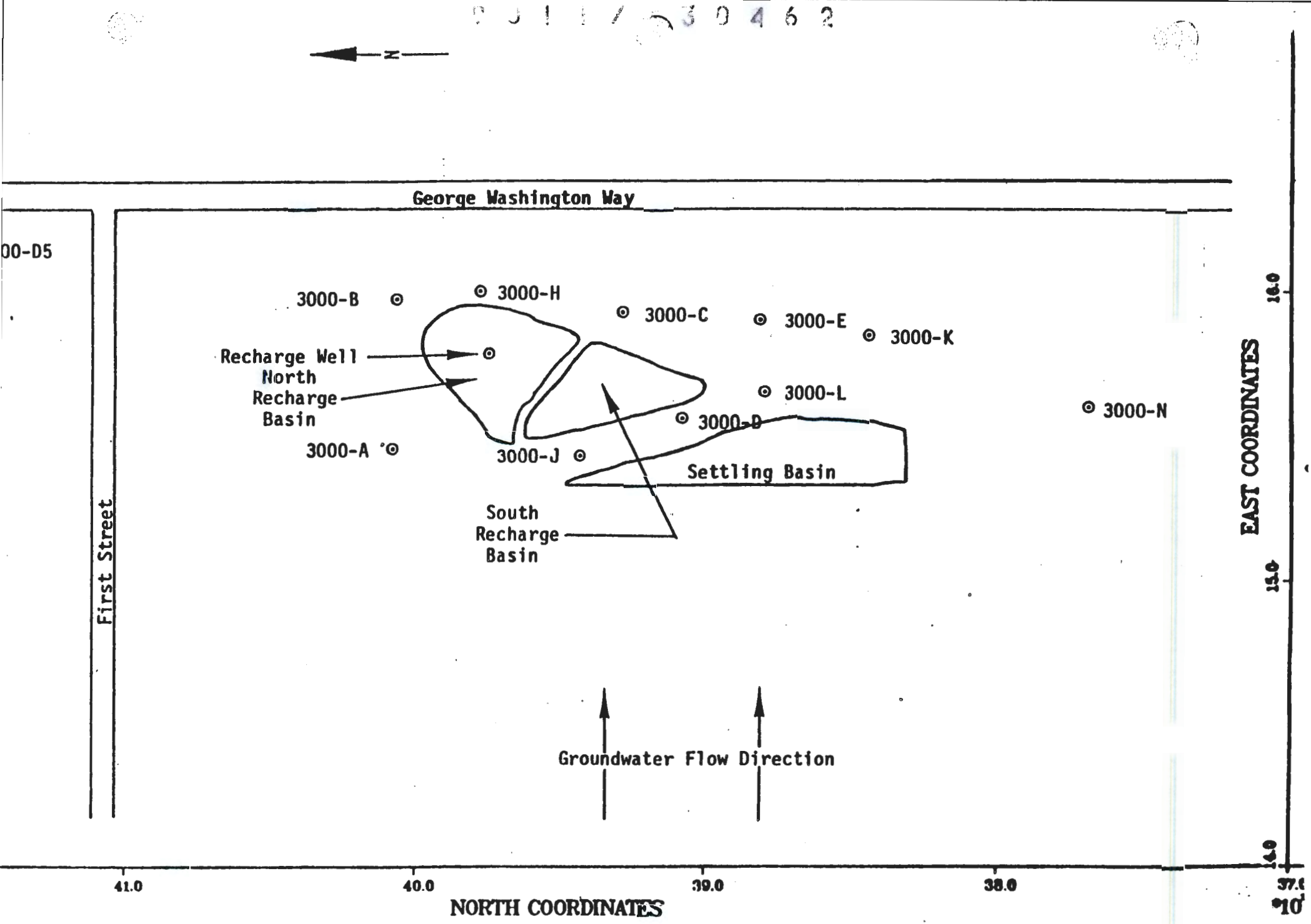

Figure 1. Location and Layout of North Richland Well Field and Recharge Basins.

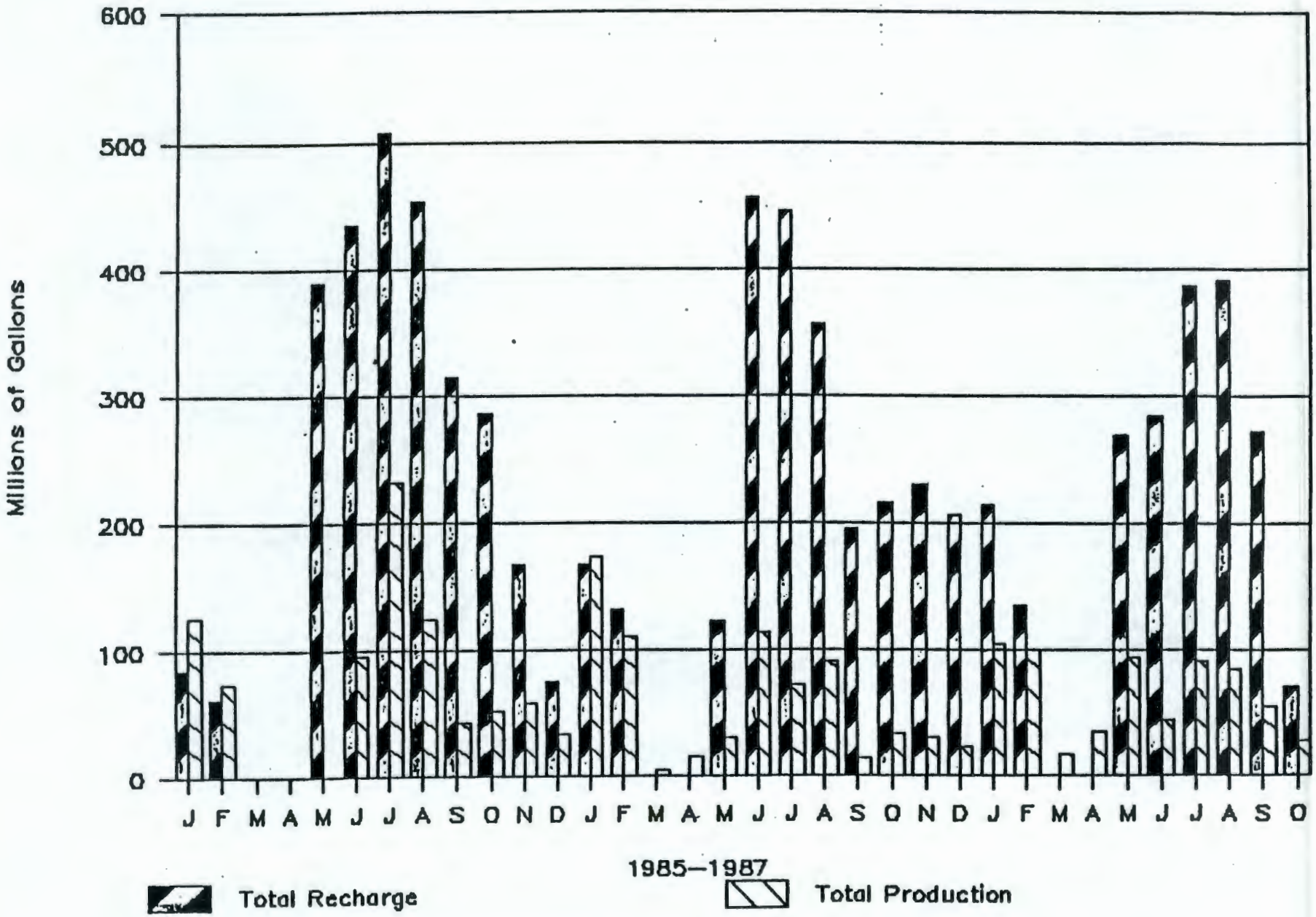

Figure 2. Total Recharge and Production for North Richland Well Field 1985 - 1987.

3.0 HYDROGEOLOGY

There are eleven production wells in the North Richland Well Field and the productive capacities of each varies widely from neighboring wells. A general description of the hydrogeology of the Richland area is given by Deju and Gephart (1976).

The surface layer of the North Richland Well Field area consists of approximately 25 feet of geologically young glaciofluvial deposits informally known as the Hanford Formation. This material consists of a heterogeneous mixture of boulders, rocks, gravels and sands. This layer is underlain by 100 to 150 feet of a much older alluvial deposit known as the Ringold Formation. The Ringold Formation is much finer textured than the overlying Hanford Formation and includes local deposits of fine silts and clays. The water table in the North Richland area occurs near the interface between the Ringold and Hanford deposits.

The groundwater in the North Richland area flows eastward from the recharge of the Yakima River in the west to discharge into the Columbia River. A groundwater contour map of the North Richland area compiled in 1985 is shown in Figure 3. This map indicates a notable depression in the aquifer in the vicinity of the North Richland Well Field, with two well levels measured at 340 feet above Mean Sea Level (MSL). This level was fourteen feet lower than levels observed during the current study where water levels near 354 feet MSL occurred in all wells in the field. During the two weeks of field work, the water level in all wells decreased approximately two feet. This trend is illustrated in Figures 4, 5, and 6, which show the observed water levels in upgradient, downgradient, and one distant well respectively. This trend most likely reflects some degree flattening of a groundwater mound beneath the recharge basins created by the recharge immediately prior to the field studies.

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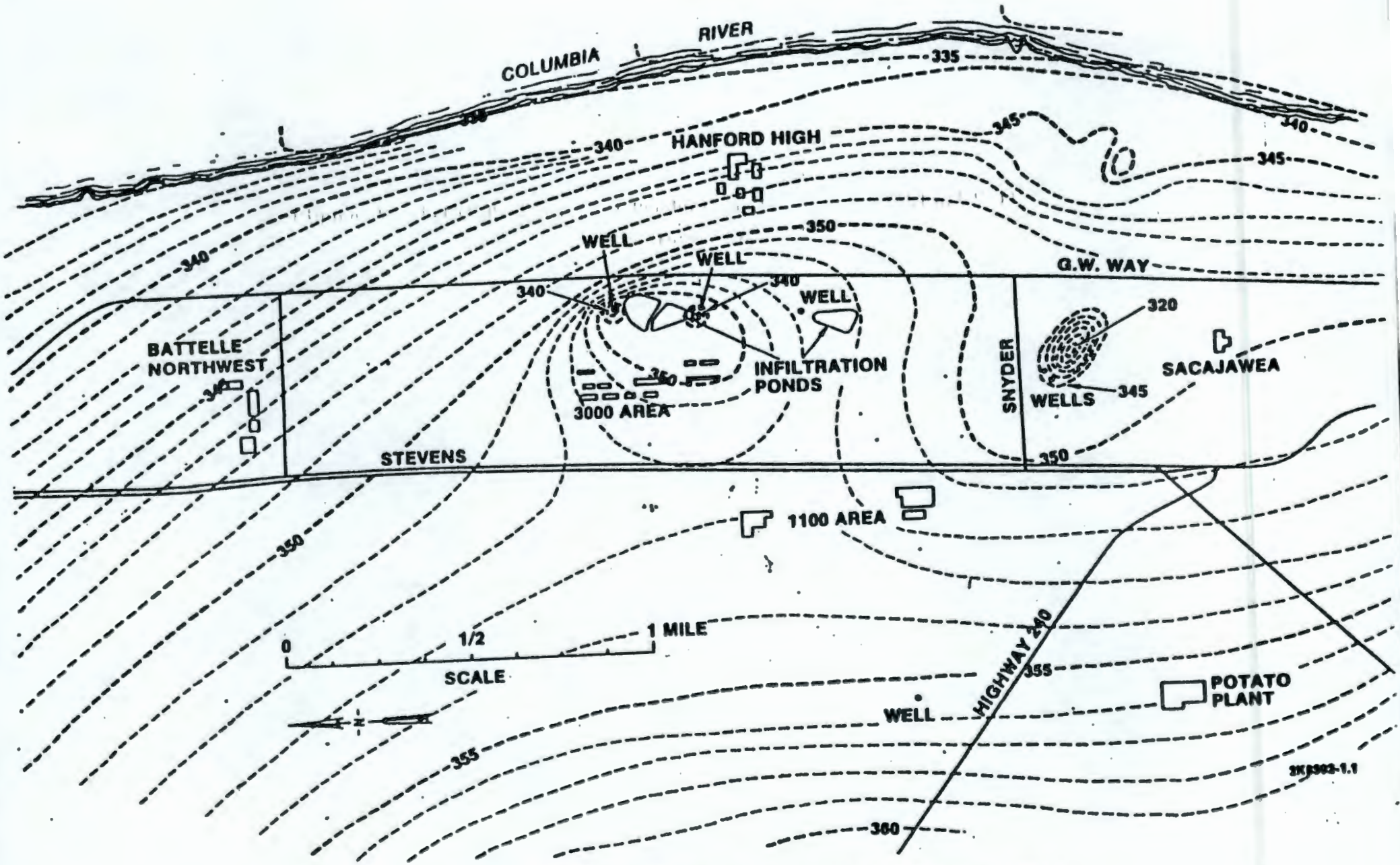

Figure 3. Ground Water Contour Map, North Richland Area, 1985.
(Source: Gerton, 1985)

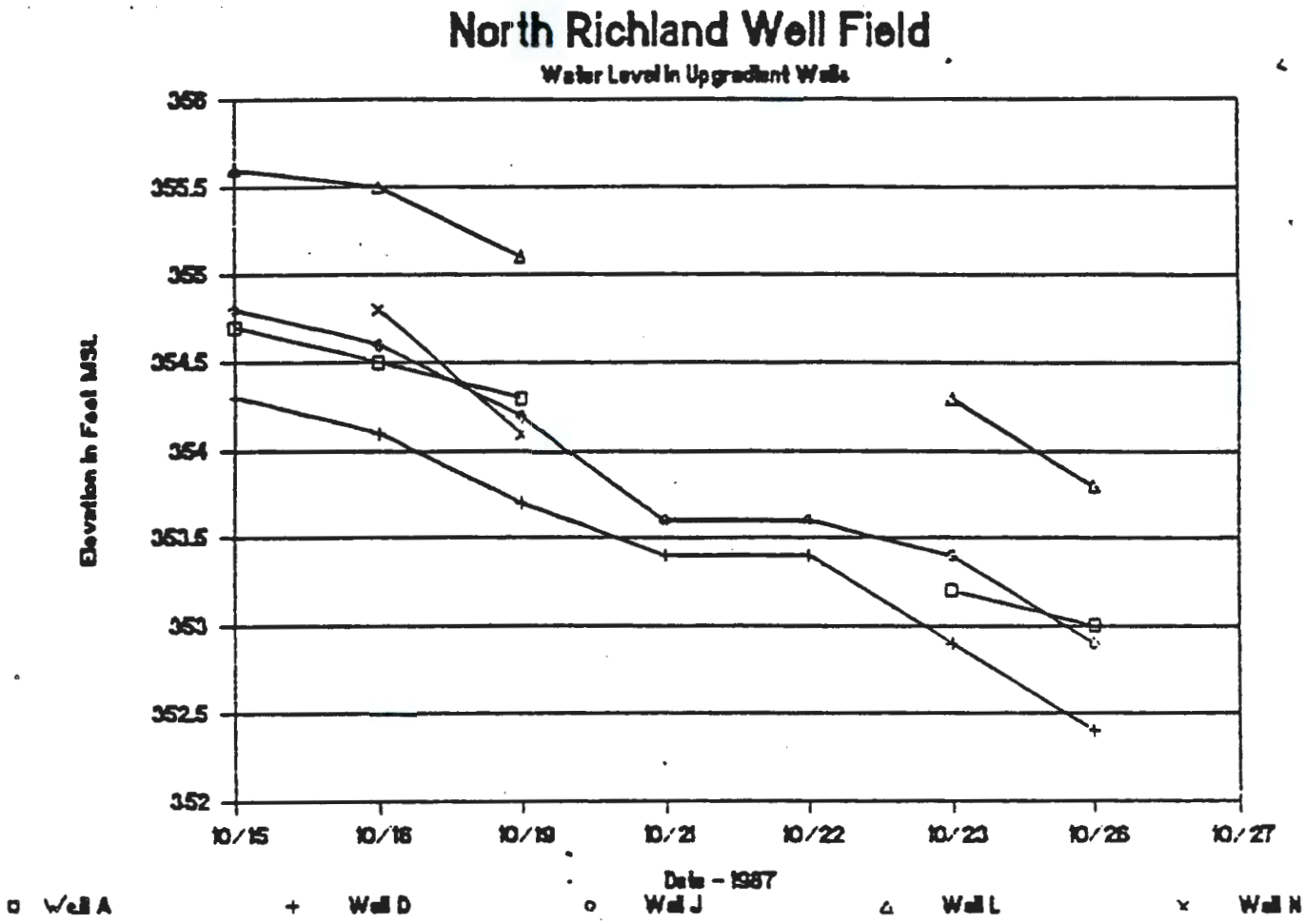

Figure 4. Water Levels Observed in Upgradient Wells, 1987.

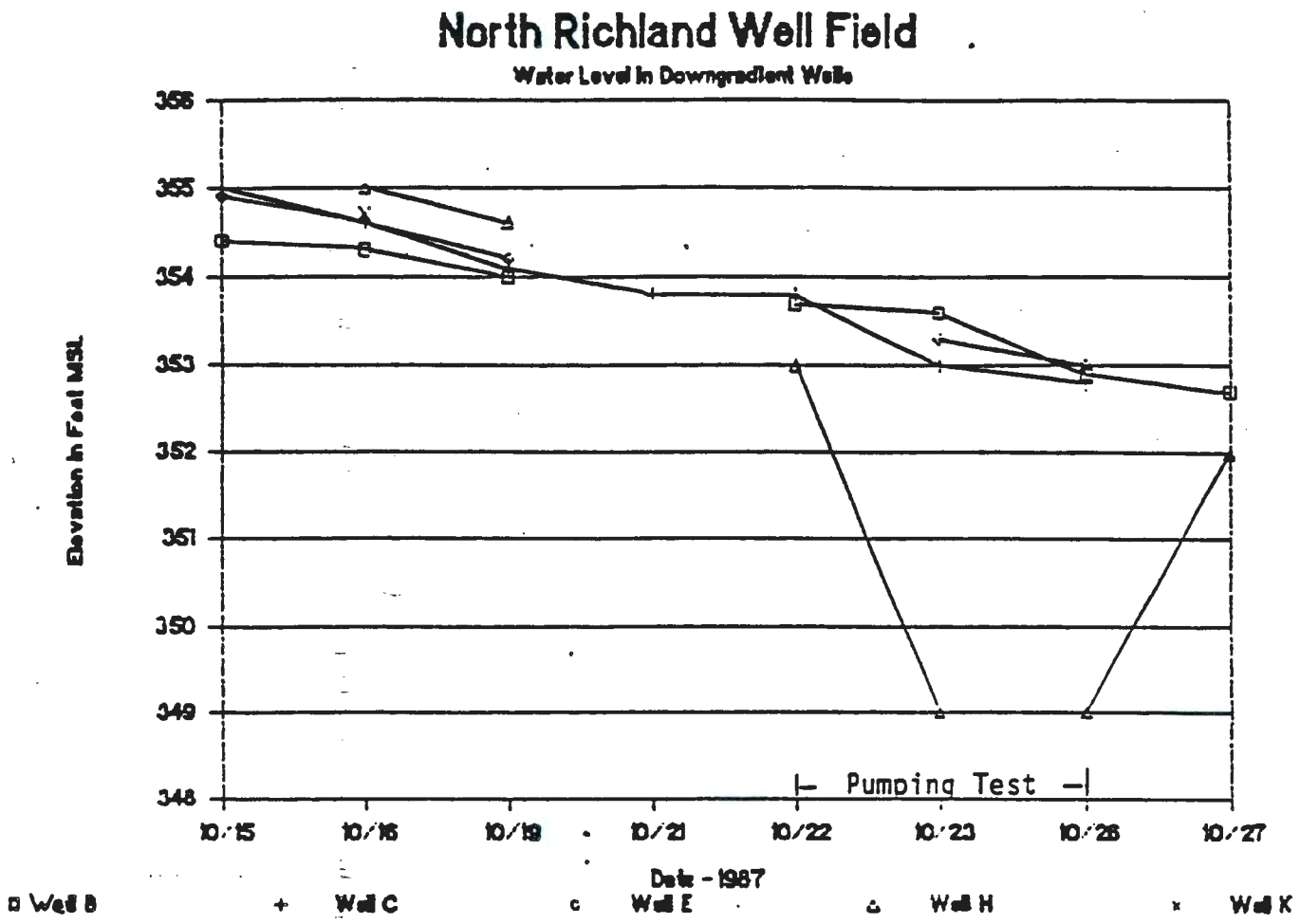

Figure 5. Water Levels Observed in Downgradient Wells, 1987.

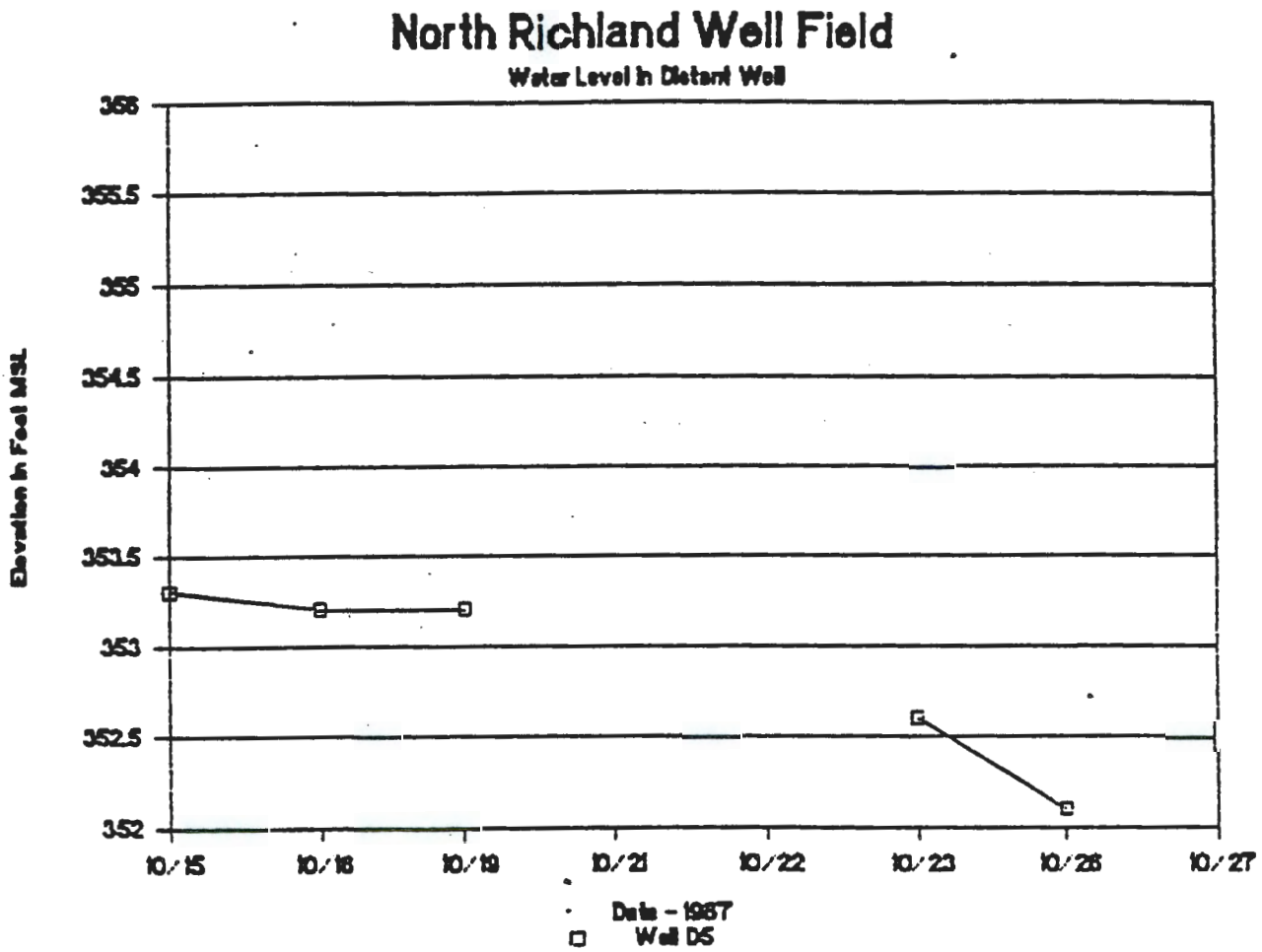

Figure 6. Water Levels Observed in Distant Well (3000-D5), 1987.

4.0 EVALUATION OF WELL LOGS

A study of the existing well logs of the North Richland Well Field was performed to evaluate the yield potential of the wells based on observed strata. Available well logs indicate that the aquifer is very complex. Subsurface strata differ substantially between neighboring wells. Geologic evaluation of the well logs indicates that individual well stratigraphy is primarily responsible for the different production characteristics of the wells.

For the purposes of this report, the subject wells have been divided into three major groupings, those with the best, moderate, and lowest yield potential, based on rock characteristics identified in the well logs and their positions relative to natural aquifer flow. The age of the well logs (most over 40 years) and lack of precise definition of some strata prevent detailed evaluation, however, the following general descriptions are consistent with the operational history of the well field.

Appendix A contains copies of the well logs for the North Richland Well Field. For the purposes of this interpretation, well log references to "clay", "silt", "rock", "cemented", or "tight" materials were assumed to be less permeable to water than those described as "gravel", "sand", "stones", and "boulders."

The wells of the highest yield potential, based on hydrogeologic interpretations, are wells 3000-J, D, B, and C. Wells 3000-J and 3000-D penetrate favorable rocks and probably receive water from the aquifer and from the south recharge basin and the settling pond. These wells should have high yields. They may benefit from installation of more casing perforations, particularly well 3000-D which indicates seventeen feet of native static water level head above the screen. The lower static water level in 3000-J may somewhat limit its yield during low recharge periods.

Wells 3000-B and C are completed in excellent rocks and have static water level fifteen feet or greater above the casing perforations. Upgradient wells A, J, and D may be extracting some aquifer water, however, B and C should receive ample recharge from both the north and south basins.

Wells 3000-K, D-5, and N show moderate yield potential. Well K terminates in a clayey horizon and is capped by a cemented gravel and sand. It has a thirty-five foot perforated interval in rocks with favorable permeability. Well K may recharge from the settling pond assuming the cemented gravel and sand cap do not extend beneath the pond, or the cap is permeable. The well has good potential and has no directly competing upgradient well.

Well D-5 penetrates rocks with favorable yield properties, however, its static water level is only three feet above the perforations and it is far removed from the recharge basins. It probably produces primarily from the aquifer through seventy feet of perforations.

Well 3000-N is similar to well K although located some distance from the recharge basins. It penetrates a slightly clayey layer from 351 to 346 feet MSL elevation, just below the static water level, but shows good potential.

Four wells, 3000-E, L, A, and H, have the lowest yield potential due to completion in poor quality rock units within the perforated interval. Logs of all four of these wells indicate less permeable sediments in 44% or more of the perforated interval and contain either overlying aquitards or low static water level.

Well A is completed in rocks with poor permeability characteristics. Most of A's production probably comes from an eleven foot confined sand and gravel interval overlain by two clayey units. It may produce from the aquifer more than from the recharge basin water.

Some data are missing from the log of well E. A sixteen-foot section of the perforated zone from elevation 311 to 327 feet MSL is not described in the log. It was assumed for this evaluation that this sixteen-foot zone is permeable to water. Well E has poor quality rocks in the upper part of the perforated interval and penetrates poor rocks higher in the well. We assume that "stone" means "cemented sediments" and therefore is less permeable. Well E is also constrained by an upgradient well, 3000-L.

Well L's poor yield may be improved by perforating the casing higher in the well. The perforated interval has no overlying clay beds so it should easily recharge from above. Its production without recharge will be limited, however, because static water level is only six feet above the perforations.

The perforated interval in well 3000-H includes some less permeable rocks. Only the upper fourteen feet are in excellent rocks and the top of the perforated interval is at the static water level. In addition, a cemented gravel layer occurs about five feet above the static water level. If the cemented gravel layer is extensive and indeed less permeable, it may inhibit recharge from above.

Figures 7 and 8 indicate the significant features of the well log interpretations. The positions of screened intervals in the wells relative to the currently observed water level is shown in Figure 9. The screened intervals of all wells except 3000-H are below the water level of 352 feet MSL. Figure 10, however, indicates that at water levels of 340 feet MSL, as observed in the 1985 study (see Figure 3), significant portions of the screened intervals of eight of the eleven wells would be above the water level.

The Recharge Well, located in the approximate center of the north recharge basin, is blocked, apparently filled in with silty material at a depth of approximately five feet below the surface of the basin floor. This well should not be used for any water level measurements unless the well is first cleaned out and rehabilitated.

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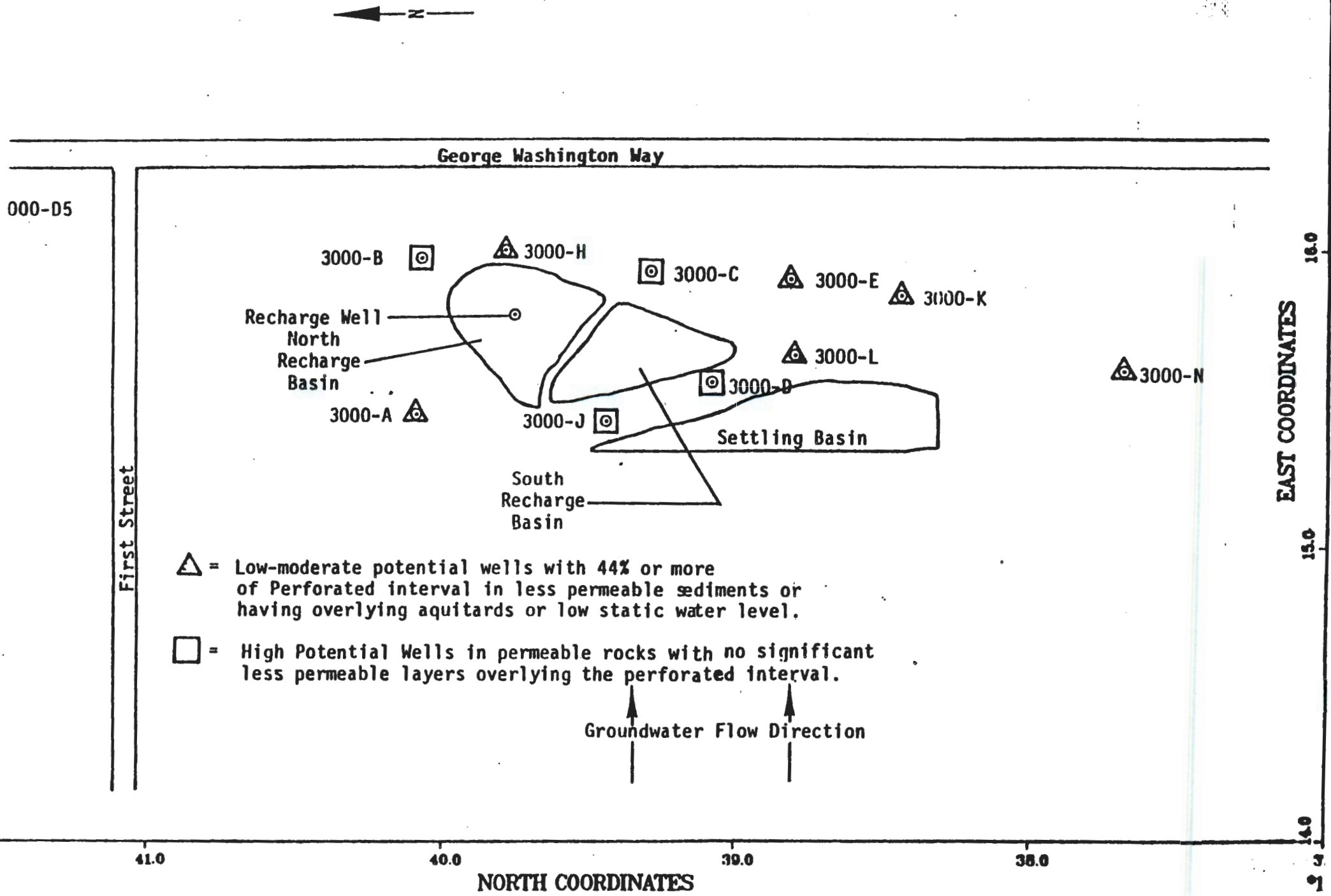

Figure 7. Relative Permeability of Strata Based on Well Log Data.

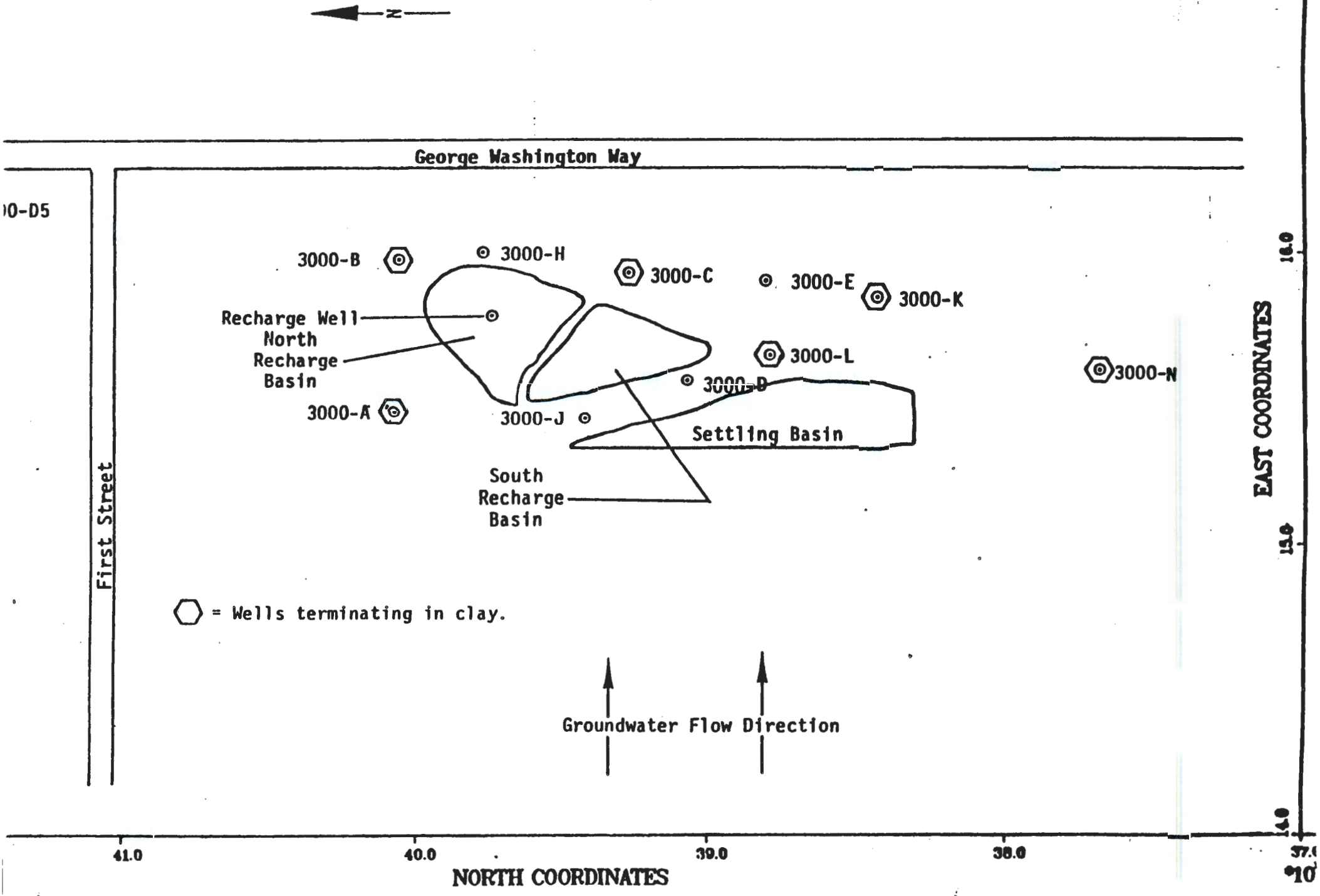

Figure 8. Wells Terminating in Clay Based on Well Log Data.

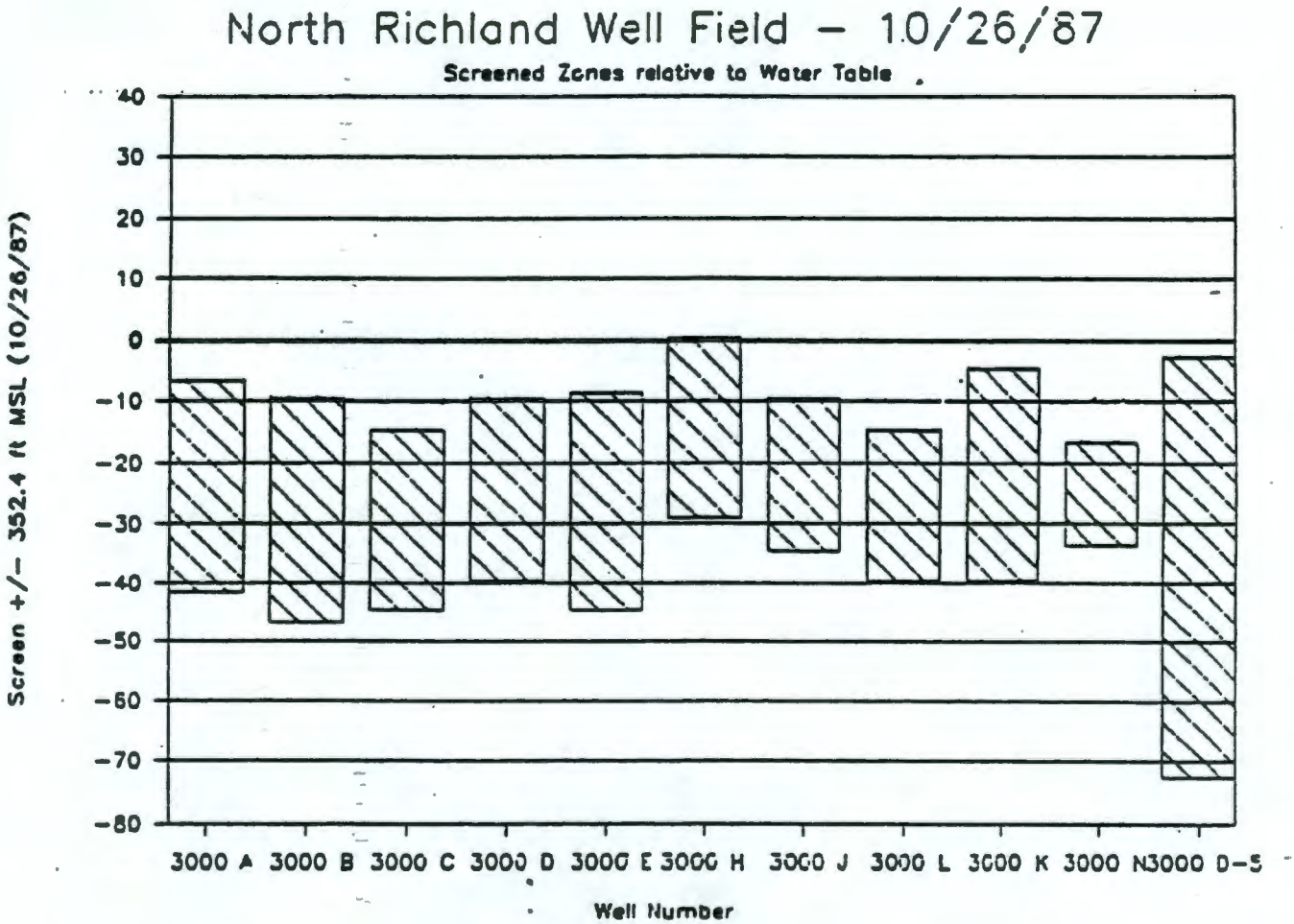

Figure 9. Location of Perforated Intervals Relative to Water Levels observed, 1987.

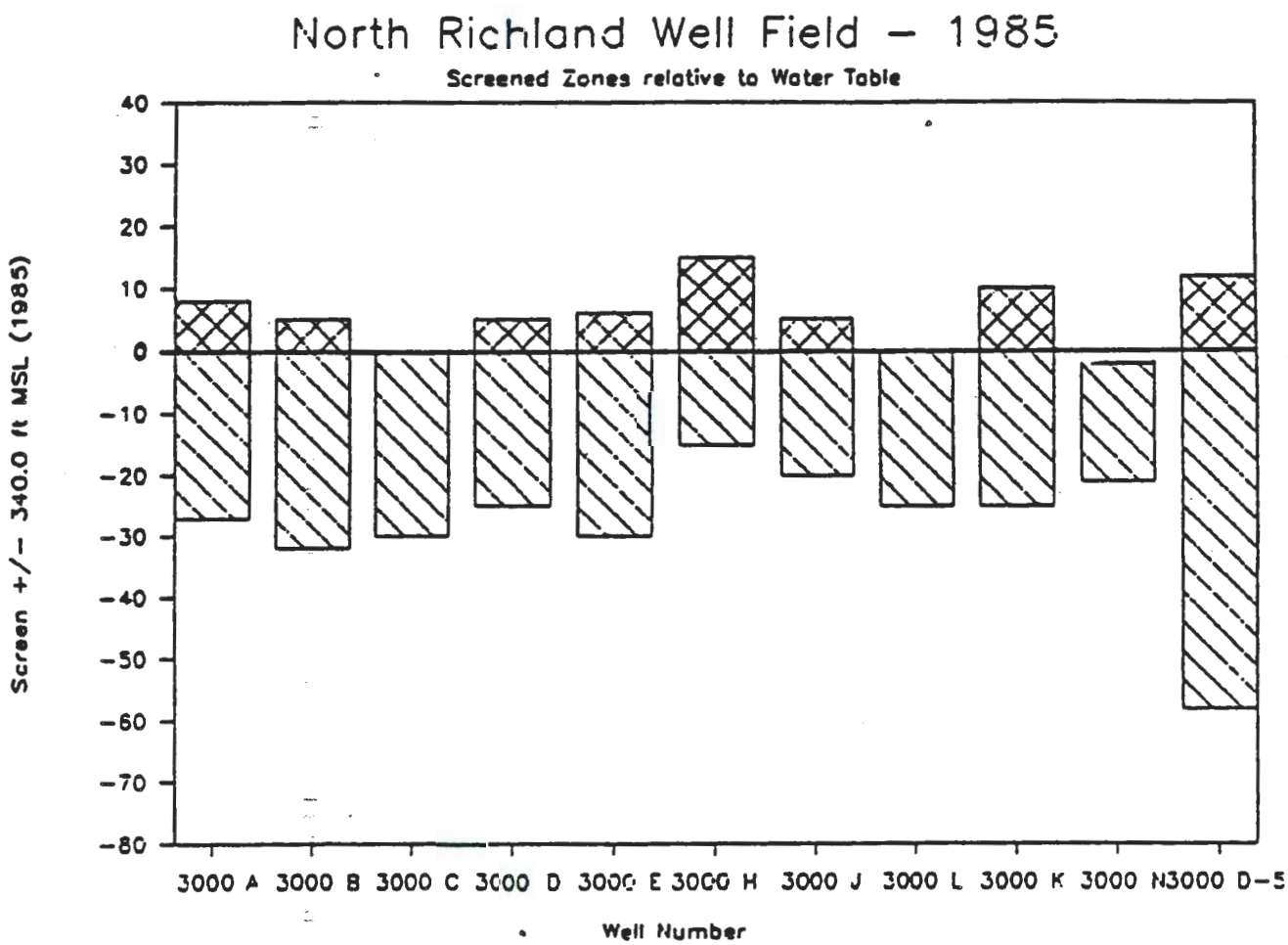

Figure 10. Location of Perforated Intervals Relative to Water Levels Observed, 1985.

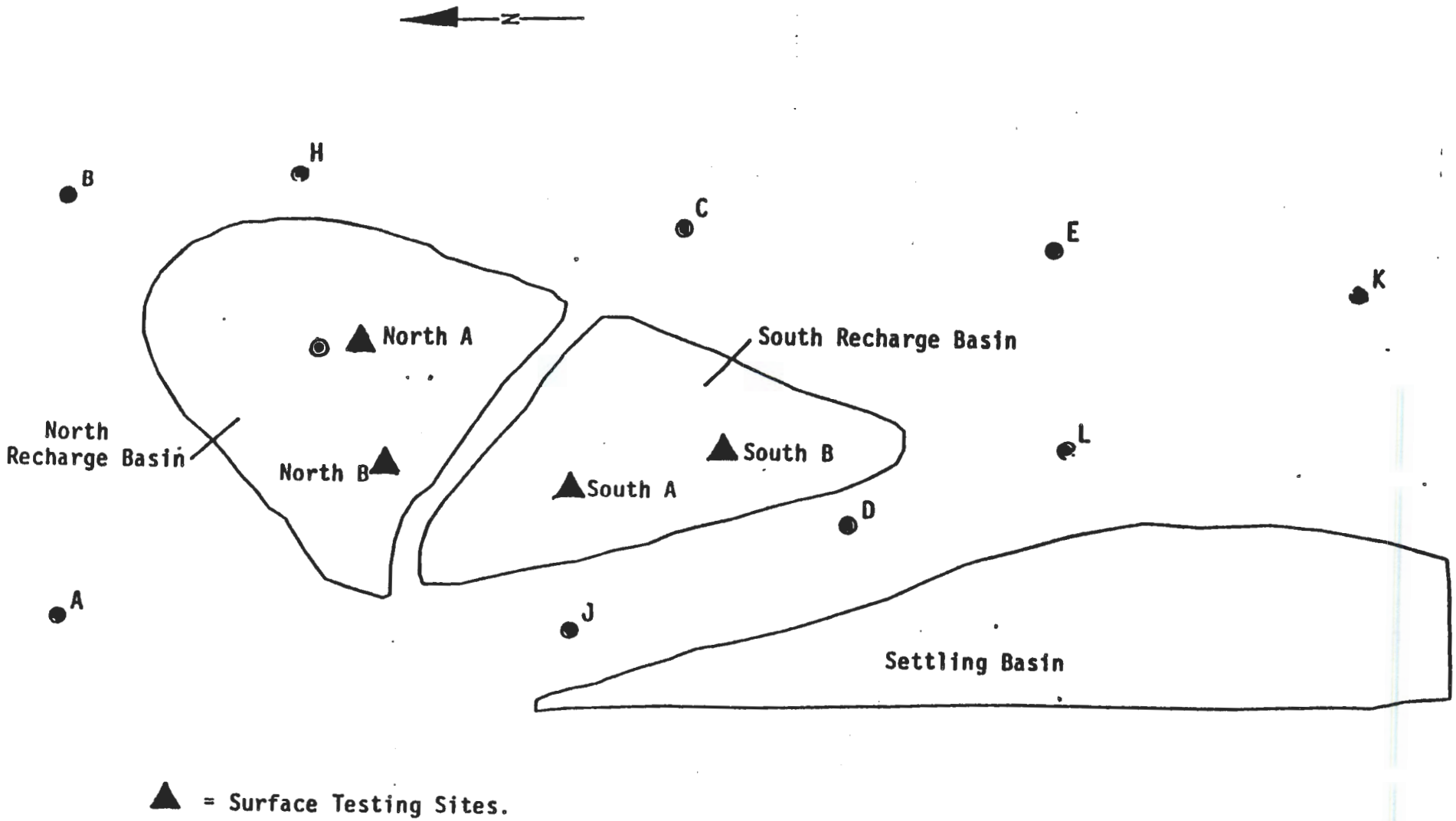

Figure 11. Location of Recharge Basin Sample Sites.

5.0 TEST RESULTS

5.1 North Richland Recharge Basins -- Particle Size Analysis

The recharge basins are centrally located within the North Richland Well Field. Evaluation of the basins was conducted after recharge waters had percolated and the basin floors were dry enough for vehicle access. Field evaluation of the north basin was performed on October 14, 1987 and in the south basin on October 22, 1987. The last recharge pumping prior to this study was completed October 11. Figure 11 indicates the approximate location of sample sites within the recharge basins.

Visual inspection of the north recharge basin floor indicates that approximately 60 % of the surface consists of a relatively deep (10 inches +) layer of coarse sand and small pebbles. Another 20 % of the area displays cobbles of 2 to 4-inch diameter at the surface. The remaining 20 % of the surface area, particularly near the basin inlet structure, exhibits a thin silt layer (less than 1.0 cm) at the surface. Approximately 60 % of the basin floor is host to a stand of aquatic plants, tentatively identified as Water Smartweed.

Two locations within the north basin were selected for detailed examination. Site A is located approximately 50 feet south east of the recharge well and is an area of coarse sand at the surface representative of the major portion of the basin area. Visual evaluation of the near-surface material at this site indicates a light brown, medium to very coarse sand from the surface to 6"; a black, medium to very coarse sand from 6" to 17" depth; and sandy gravel with cobbles from 17" down to 24" and beyond.

Site B in the north basin is located approximately 120 feet south west of the recharge well and 150 feet east of the basin inlet. The surface at Site B was covered with a uniform layer of silty material approximately 1.0 millimeter thick.

From the surface to a depth of 4", the profile is a black, medium to very coarse sand with some gravels; the next strata, from 4" to 10", is a similar black sand with a few gravels and cobbles; and the strata from 10" to beyond 24" in depth is primarily gravel and cobbles with some light brown, medium sand.

Samples were collected in three-inch increments from the top foot of material at each site for determination of particle size distribution by dry sieving. The results of the testing of individual samples is found in Appendix B. Since the top foot at all locations was generally homogeneous, a graphic presentation of the average distribution for each site is included here. Size fractions are based on particle diameters and are outlined in Table 1.

Table 1. Particle Size Diameters

Particle	Diameter (millimeters)
Gravel	>4.00
Pebble	2.00-4.00
Very Coarse Sand	1.00-2.00
Coarse Sand	0.50-1.00
Medium Sand	0.25-0.50
Fine Sand	0.106-0.25
Very Fine Sand	0.063-0.106
Silts and Clays	<.063

The particle size distribution for the top foot at Site A in the north basin is shown in Figure 12. The material is predominantly coarse sand to pebble-sized particles. Data for Site B indicate a less uniform material dominated by gravels as shown in Figure 13.

The surface of the south basin consists almost entirely of exposed cobbles and gravels with sands dominating the surface over only about 10% of the area. An area of aquatic plants coincides with the sandy surface area. The basin floor was covered almost entirely with an algae mat approximately 1-2 mm thick. Site A in the south basin was located near the center of the basin in an area of coarse sand with few gravels at the surface.

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The profile at Site A consists of coarse sand with few gravels from the surface to 5"; coarse sand with some gravels and cobbles from 5" to 15"; and coarse sand with about 50% gravels and cobbles from 15" to beyond 24". Figure 14 shows the particle distribution for the top 12" at Site A in the south basin.

Site B in the south basin was located in the southern lobe of the basin and was dominated by gravels at the surface. The profile from the surface to 6" consisted of gravel and coarse sand; coarse sand with gravel from 6" to 11" and; coarse to very coarse sand from 11" to 48" and beyond. The particle distribution for Site B is shown in Figure 15.

5.2 North Richland Recharge Basins -- Surface Infiltration Rates

Surface infiltration rates were determined at each site using a concentric ring infiltrometer. The moisture content of surface sediments at all locations was at or near field capacity and was, therefore, favorable for rapid equilibration to a saturated flow condition.

The surface deposits in the recharge basins are generally highly permeable to water. The results of the infiltration tests are found in Figure 16. The results of infiltrometer testing provide a good basis for evaluation of the relative infiltration rates of various individual sites or surface conditions, but do not necessarily reflect the rate of percolation of the entire basin.

The infiltration rate of the entire basin is most likely less than the individual test sites due to the presence of restricting layers deeper within the profile that are not encountered during the infiltrometer testing.

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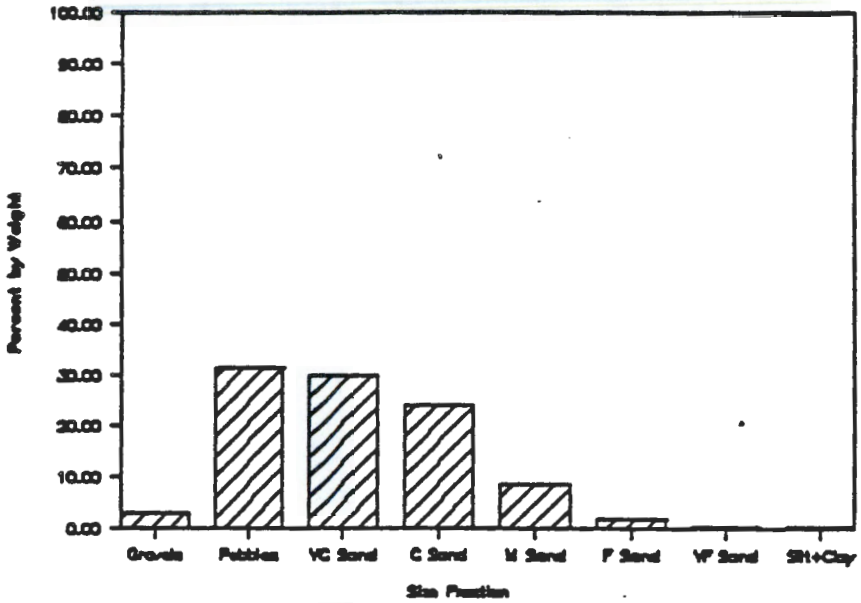

Figure 12. Particle Size Distribution, North Basin - Site A.

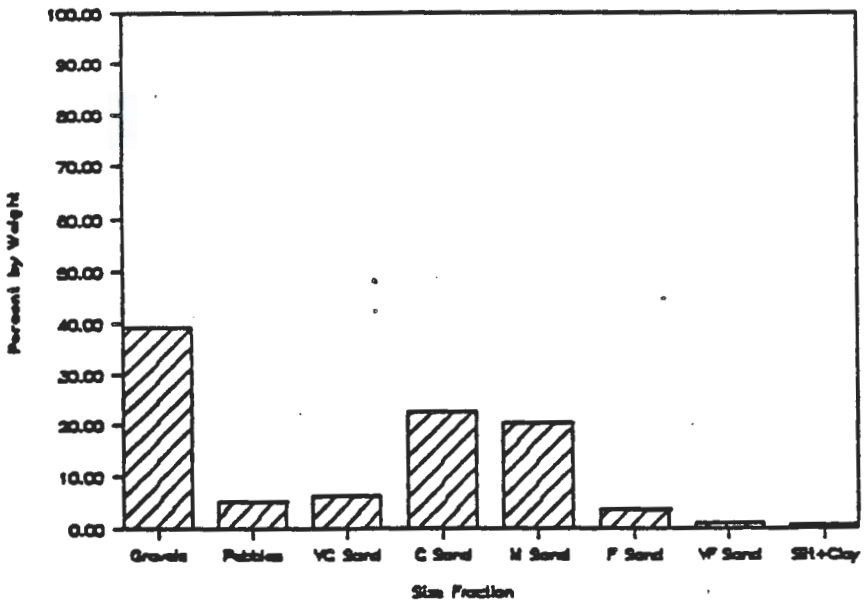

Figure 13. Particle Size Distribution, North Basin - Site B.

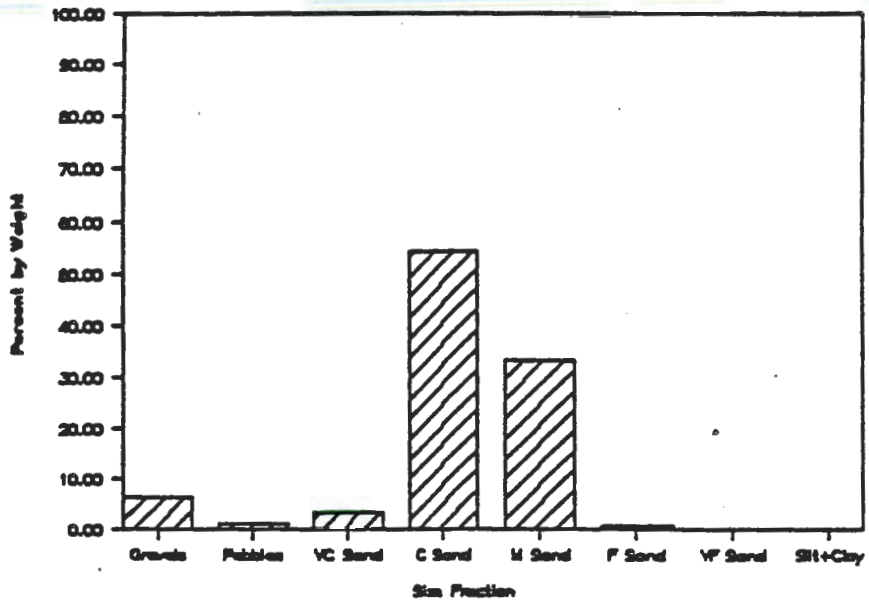

Figure 14. Particle Size Distribution, South Basin - Site A.

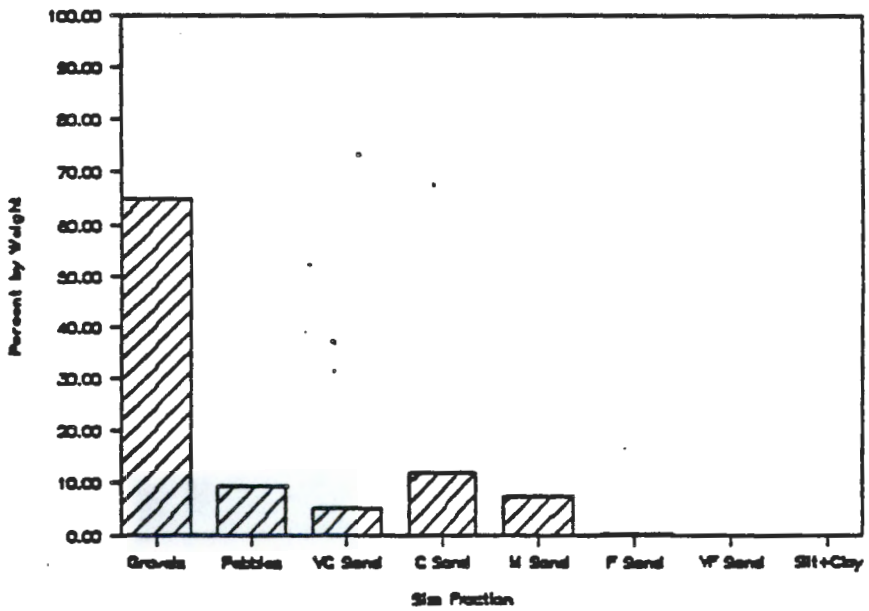

Figure 15. Particle Size Distribution, South Basin - Site B.

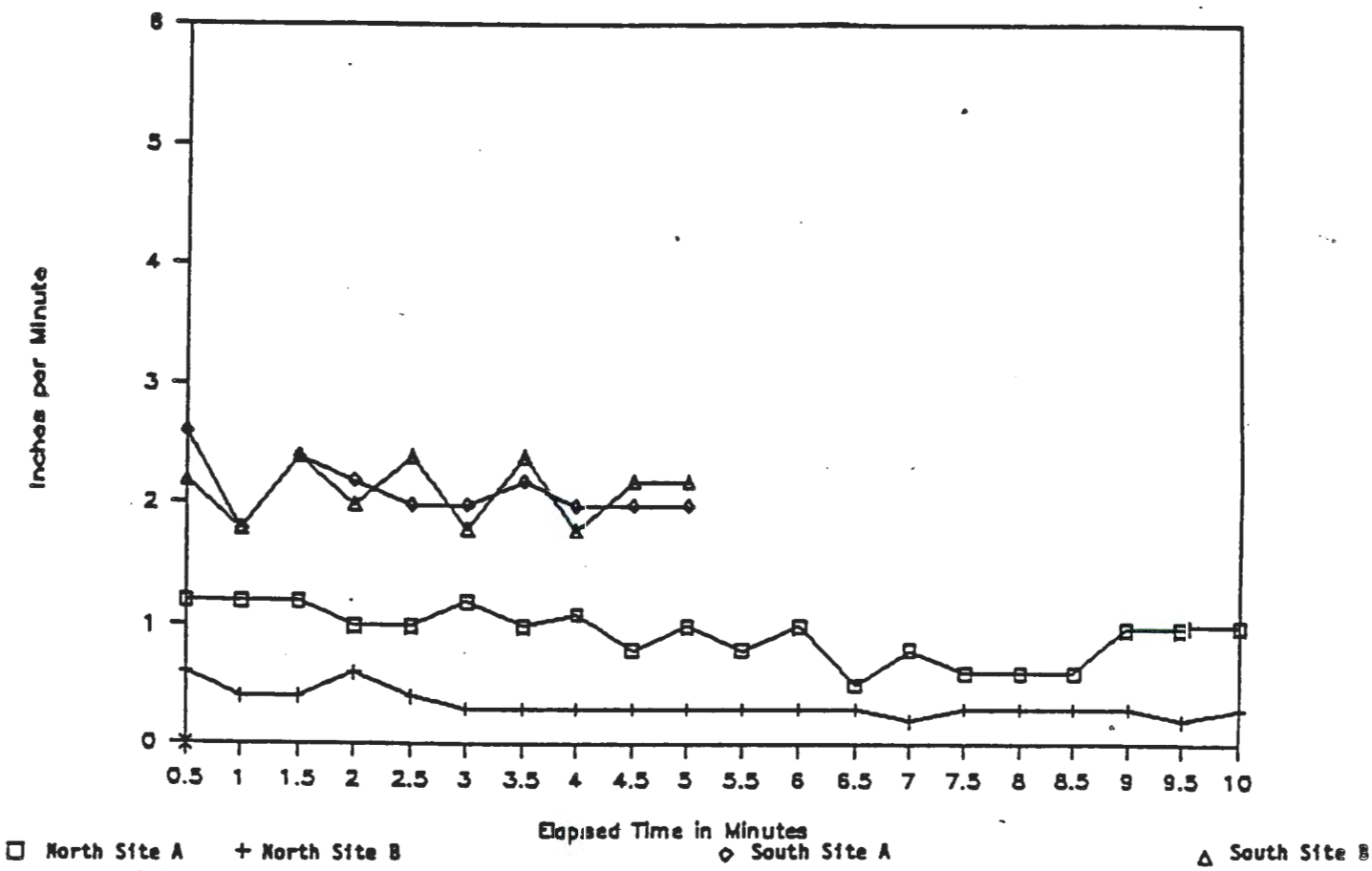

Figure 16. Surface Infiltration Rates Observed in North and South Basins.

As shown in Figure 16, the infiltration rate for Site A in the north basin was approximately 1.0 inch per minute over the period of the test. At Site B, where the thin silt layer was observed at the surface, the infiltration rate was still quite rapid (approximately 0.3 inches per minute) but was less than half that of Site A. This indicates that while siltation of the basins does not occur over large areas during the course of a season, small amounts of silt that could potentially cover the entire basin could have a dramatic effect on the rate at which recharge water ultimately enters the aquifer.

The infiltration rates observed at Sites A and B in the south basin are very similar (approximately 2.0 inches per minute) and about double the rates observed in the north basin. This reflects the generally coarser surface materials in the south basin.

5.3 North Richland Well Field -- Aquifer Pumping Tests

Constant rate pumping tests were performed on two wells in the North Richland Well Field. The first test was performed by pumping well 3000-J (a 125 hp pump) at a rate of 300 gallons per minute for 24 hours on October 21 and 22, 1987. Wells 3000-D and C were used as monitoring wells observe aquifer drawdown. After 24 hours, no drawdown was observed in either of the monitoring wells or in well J.

The second pumping test utilized well 3000-H with its 200 horsepower pump and well B as the monitoring well. Well H was pumped at a rate of 1340 gallons per minute for a 98 hour period from October 22 to 26, 1987. Total drawdown observed in well H was 4.0 feet. This level of drawdown was achieved within 60 minutes of the start of the test and the level in the well remained constant at a 4.0 foot drawdown throughout the remainder of the test. The maximum drawdown observed in the monitoring well, well 3000-B, was 0.66 feet which occurred after 24 hours of pumping and then remained constant at that level for the remainder of the test.

Twenty-four hours after completion of the pumping test, the water level in well H had recovered to within one foot of the pre-test level, and well B was unchanged.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 North Richland Recharge Basins -- Recommendations

Overall, no restrictions to infiltration were observed in the basins with the exception of the silted area near the inlet of the north basin. The generally rocky surface conditions of the basins, however, makes management of any silt deposits quite difficult. Tillage of the basin floors has minimal effect due to the implement's bouncing over rocks. For this reason, placement of a uniform layer of coarse sand approximately 10 to 12 inches deep over the floor areas of both north and south basins is recommended. The basins should be prepared for this application by removing remaining aquatic vegetation and mixing or removing existing silt layers by mechanical means such as use of a suction dredge. After installation of the sand layer, the basin floors may be easily maintained with periodic mechanical cultivation.

A possible source of sand for lining the basin floors is an excavation at the City of Richland's municipal landfill. A sample was collected from a horizon of black sand approximately eight feet thick and occurring 15 feet below the surface in a large excavation on the east side of the landfill. The results of dry sieving analysis of this material are shown in Figure 17. This material is dominated by coarse sand and has very few fines and no materials larger than very coarse sand. This sand is physically well-suited for use in the basins.

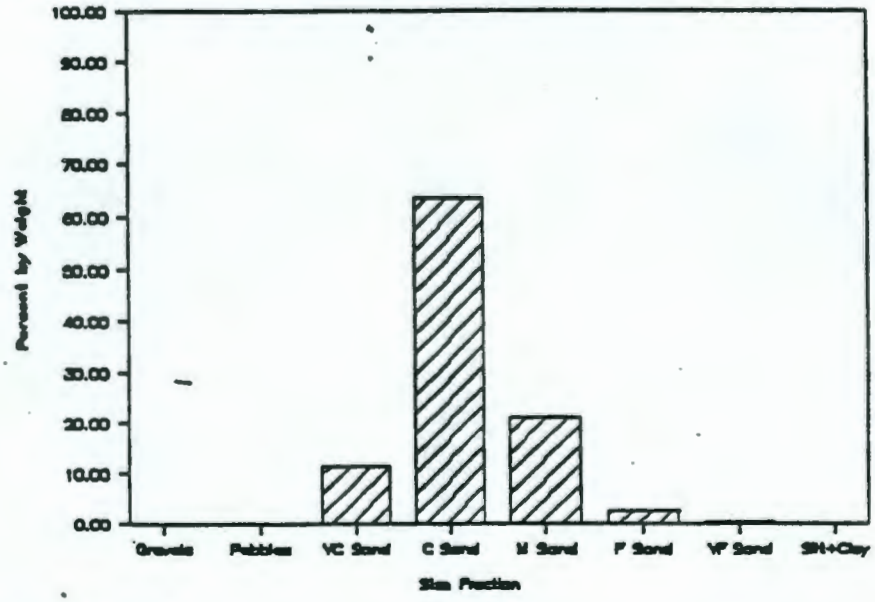

Figure 17. Particle Size Distribution, Landfill Sand Sample

Additional recommendations for maintenance of the North Richland Recharge Basins include repair of the dike separating the basins and repair of the basin perimeter fencing. Some erosion has occurred on both sides of the dike at the location of the two steel pipes that serve as overflow weirs between the basins and may eventually result in a breach of the dike. Repair of the existing perimeter fence will minimize unauthorized access to the basins both during recharge when a water hazard exists, and when the basins are dry.

6.2 Well Field Evaluation and Pumping Strategy Recommendations

Since there was no drawdown of the water level during pumping of Well J, no conclusions can be drawn from that test other than the capacity of the well to supply a sustained 300 gallons per minute with no measurable drawdown. The pumping test of Well H, however, supplied sufficient data to perform evaluation of aquifer storage and transmissivity. Total yield from this pumping test was 7.9 million gallons for the 98 hour period or approximately 1.9 million gallons per day (mgd). Utilizing the drawdown and pumping rate information, and the lateral distance between the wells H and B, coefficients of transmissivity and storage were calculated. The Coefficient of Transmissivity, T, was calculated using the following equation:

$$T = \frac{264\ Q}{s}$$

Where T = the Coefficient of Transmissivity
Q = the constant pumping rate
s = the slope of the observed drawdown curve

For this test, Q = 1343 gallons per minute
and s = 0.55 foot

For this pumping test, the Coefficient of Transmissivity, T, was calculated to be 644,600 gallons per day/foot, a very high level.

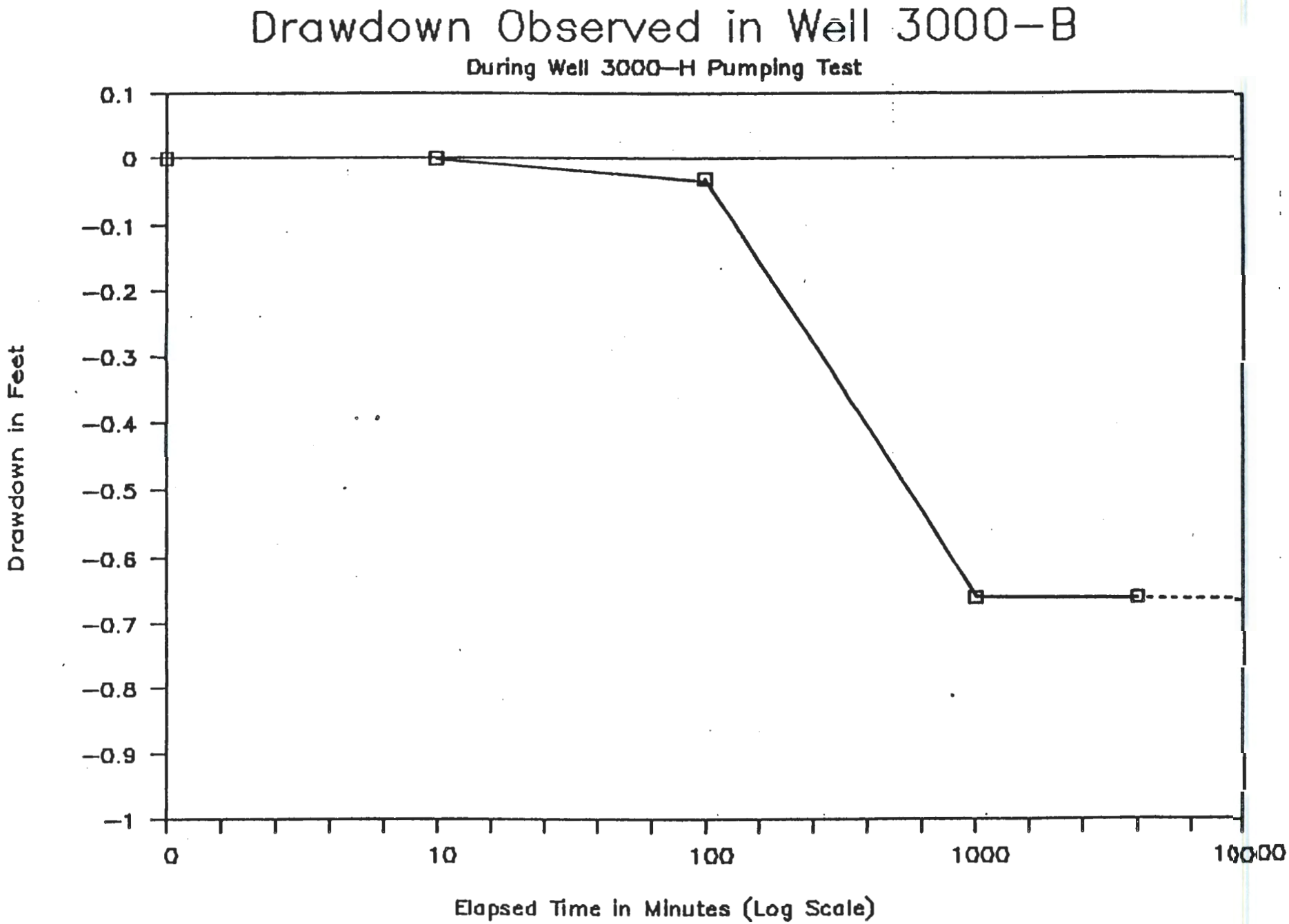

Figure 18. Drawdown Measured in Well 3000-B During Pumping Test.

The aquifer Storage Coefficient, S, is calculated by the following equation:

$$S = \frac{0.3\ T\ t_0}{r^2}$$

Where T = the Coefficient of Transmissivity
t_0 = the zero drawdown intercept of a straight line projected through the observed drawdown curve, in days
r = the distance in feet from the pumped well to the monitoring well

for this test, T = 644,600 gallons per day/foot
t_0 = .07 days
r = 350 feet

The Aquifer Storage Coefficient, S, calculated for this pumping test is 0.11, which is consistent with expected values for the types of sediments observed in the wells. Figure 18 is a semi-logarithmic graph of the water level drawdown measured in Well B during the pumping of Well H. Values of "s" and "t_0" used in the previous calculations were extrapolated from this curve.

We believe the aquifer at the North Richland Well Field to be capable of supplying a sustained 4.0 to 5.0 million gallons per day. This conclusion is based on the results of the pumping tests performed by ICF personnel and evaluation of previous pumping test results from Cornell, Howland, Hayes, and Merryfield (1961) (the previously mentioned 1961 report estimated the supply under unrecharged conditions to be 4.0 to 6.0 mgd).

Based on this information, four basic operating strategies for the system can be considered:

1. Continued operations of the well field using current pumping strategies.
   Advantages:
   - No additional costs or changes from normal maintenance and operations.

   Disadvantages:
   - Inefficient use of aquifer.
   - High cost of product water due to high volumes of recharge water pumped.

2. Use of the aquifer supply only, with no recharge operations.
   Advantages:
   - High efficiency of aquifer utilization.
   - Eliminates costs of recharge pumping.

   Disadvantages:
   - Reduces production capacity of the well field to about 4.0 mgd maximum.
   - May increase hardness of product water.*

3. Use of aquifer supply exclusively during periods when production demand is less than 4.0 mgd and supplying recharge water to meet the aquifer supply deficit during periods of high demand.
   Advantages:
   - Permits efficient aquifer utilization.
   - Reduces overall cost of product water while maintaining peak period productive capacity.

   Disadvantages:
   - May increase hardness of product water during low production periods.
   - Requires capital expenditure for placement of largest pumps in most productive wells.

4. Continued use of coinciding recharge and production, but reduce recharge volume to more closely match production.
   Advantages:
   - Reduces overall cost of product water while maintaining peak period productive capacity.
   - Maintain present water quality.

   Disadvantages:
   - Requires capital expenditure for placement of largest pumps in most productive wells.

Of these four options, the most practical appear to be options 3 and 4 because both strategies reduce the cost of product water associated with high levels of recharge, yet still maintain the high potential capacity of the well field through recharge.

An analysis of production records from the well field over the last three years, 1985 through October 1987, indicates that only four times during the last three years, and only once in the last two years, has average daily production (averaged over the month) exceeded 4.0 mgd.

* Information on the specific water quality of the aquifer in North Richland is beyond the scope of this study.

9 J 1 1 7 4 3 0 4 8 8

This analysis is illustrated in Figure 19, and indicates that the production requirements of the well field can be met in most instances by the conservative estimate of the natural aquifer capacity (4.0 mgd). This, of course, raises the question of quality (ie. hardness, possible chemical contamination from upgradient sources) of the natural aquifer water versus the recharge water from the Columbia River. The water quality question is beyond the scope of this report, but should be addressed in conjunction with consideration of minimum recharge operations.

The most efficient use of the North Richland Well Field involves use of the natural aquifer supply to the greatest extent possible and closely matching recharge flow to production during periods when production demand exceeds the aquifer capacity.
Applying this strategy and referring to the average daily production data in Figure 19, recharge of the aquifer would be needed during January and February (when the filter plant is down), and during the summer months of June, July, and August, when production typically exceeds 75 % of the estimated aquifer capacity. For the remainder of the year, recharge of the aquifer is probably not necessary. This strategy could result in saving the City the operational costs of pumping up to 1.6 billion gallons of recharge water per year.

Verbal information supplied by system operators indicates that wells 3000-K, L, N, and H display problems with drawing air when the system is operated at low recharge flows. This is consistent with the evaluation of the well logs that shows well K to have a moderate potential, yet it is equipped with one of the largest pumps in the well field (200 hp). Well N shows moderate production potential, but is quite distant from the primary recharge basins and thus would not be expected to show a significant response to low to moderate recharge of the north and south basins. Wells L and H both fall into the low yield potential category based on well log data. This is again consistent with operating experience. In addition, well H is equipped with a large, 200 hp, pump.

9 0 1 1 7 4 3 0 4 8 9

9 0 1 1 7 4 3 0 4 9 0

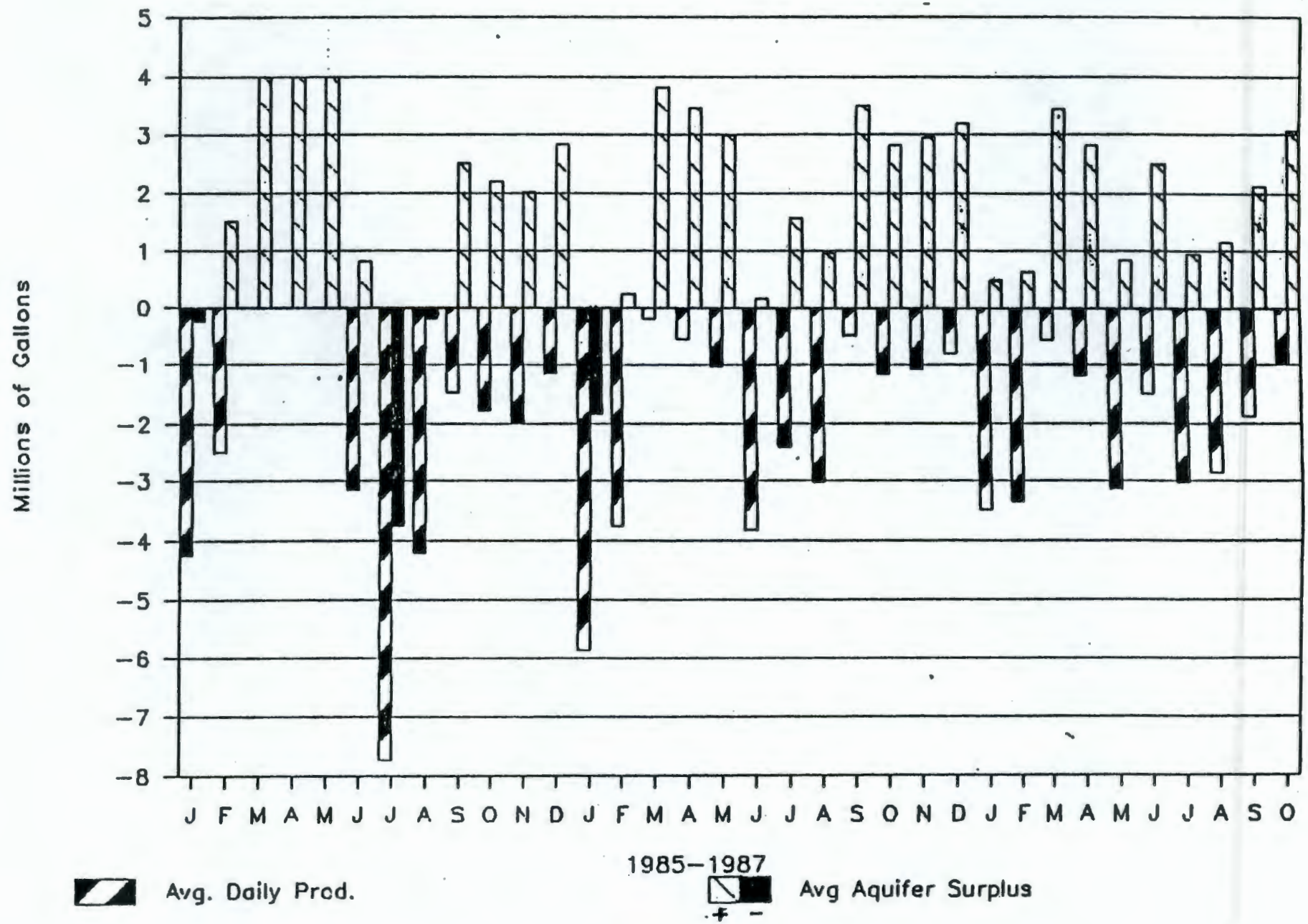

Figure 19. North Richland Well Field Production vs. Estimated Aquifer Supply Capacity of 4.0 mgd.

The pumps installed in the North Richland Well Field are outlined in Table 2. As previously stated, for optimum production under reduced recharge, the largest pumps should be located in good wells on the upgradient side of the field. As shown in Table 3, the situation is nearly reversed from the optimum.

Table 2. Pump Sizes and Locations.

Well	Pump Size (hp)
A	75
B	75
C	100
D	125
E	250
H	200
J	125
K	200
L	125
N	100
D-5	75

Table 3. Current Pump Distribution vs. Well Location.

Upgradient Wells	Downgradient Wells
A (75 hp)[3]	B (75 hp)[1]
J (125 hp)[1]	H (200 hp)[3]
D (125 hp)[1]	C (100 hp)[1]
L (125 hp)[3]	E (250 hp)[3]
	K (200 hp)[2]

Note: Wells N and D-5 appear to be too far from the central well field to be affected by upgradient wells.
1 = Wells identified as best yield potential.
2 = Wells identified as moderate potential.
3 = Wells identified as low potential.

A scheme that would bring pump placement more into line with optimum conditions is shown in Table 4, and would involve moving the two 200 horsepower pumps from wells 3000-K and 3000-H to wells 3000-J and 3000-D and replace them with the 125 horsepower pumps from J and D. An additional replacement would move the 125 hp pump from well 3000-L (which, while upgradient, is completed in low permeability rocks) to well 3000-B and replace it with B well's 75 hp pump.

Table 4. Recommended Pump Locations.

Well	Pump Size (hp)
A	75
B	125
C	100
D	200
E	250
H	125
J	200
K	125
L	75
N	100
D-5	75

6.3 Conclusions

An overview of the recommendations for the well field and recharge basins is outlined below:

A. Recharge Basins
   1. Line basins with 12 inches of coarse sand.
   2. Repair the dike separating the north and south basins.
   3. Repair the perimeter fence surrounding the basins.

The first two items, lining the basins with sand and reparing the dike, are maintenance items that will improve operation of the basins and prolong their useful life. The sand layer at the City's landfill is a possible source of material for the basin floors. While the sand was found to be physically suited for that use (ie. has desireable particle size distribution), the material should be chemically characterized to identify possible contamination from landfill operations prior to its use in the basins.

B. Well Field

1. Move the 200 hp pumps from wells 3000-K and H to wells 3000-J and D.
2. Move the 125 hp pumps from wells 3000-J and D to wells 3000-K and H.
3. Move the 125 hp pump from well 3000-L to well 3000-B and replace it with the 75 hp pump from well 3000-B.
4. Operate the well field based on a 4.0 mgd aquifer supply with recharge only during aquifer deficit periods, or;
5. Supply recharge water during production at a rate very close to the production rate.
6. After completion of the recommended pump changes (and given the high transmissivity of the aquifer), recharge should not have to exceed 150 percent of production during any production period.

Moving the large capacity pumps into the wells with the highest production potential should improve operation of the well field under conditions of low or no recharge or under high recharge. In order to maintain water quality at a level similar to current operations, particularly with respect to hardness, continuing the system of aquifer recharge during production is desireable. The greatest improvement in operational efficiency of the recharge basin/well field system is to match the recharge volume more closely to the production volume. The recommended changes should allow recharge to approach 150 % of production instead of the historic 300 to 400 %.

No technical problems were discovered in the course of this study that indicate the North Richland Well Field should not continue to supply a significant portion of Richland's municipal water needs. Based on the information available, we believe that the changes outlined above should permit a much more efficient operation of the North Richland Well Field than is now possible through more efficient capture of aquifer water and better utilization of recharge water.

7.0 REFERENCES

City of Richland. Daily Water Production and Consumption Reports, 1985-1987.

City of Richland. Water Maintenance Manual -- Wells, Pump Stations, and Misc.

City of Richland, 1987. Water System Plan.

Cornell, Howland, Hayes, and Merryfield, 1961. A Report on an Engineering Investigation of the Water Supply System. Prepared for the City of Richland, Washington.

Raul A. Deju and Roy E. Gephart, 1976. Evaluation of Current Water Problems of the City of Richland Using System Analysis.

Fletcher G. Driscoll, 1986. Groundwater and Wells, Second Edition.

Ronald E. Gerton. Letter to William R. Gilbert, Public Works Director City of Richland, Washington, Feb. 12, 1985 (with enclosures).

U.S. Department of the Interior, 1971. Ground-Water Hydraulics. Geological Survey Professional Paper 708.