4.0 INVESTIGATION AREA CHARACTERISTICS

4.1 SUSPECTED SOURCE AREA

The field work for this remedial investigation (RI) was performed from February 21, 1992 through June 26, 1992. The activities performed during this RI are summarized in Section 3.0. This section will summarize the results of the field investigation as they pertain to the geologic and hydrogeologic parameters of the suspected source area. The information presented here has been incorporated into the FS and will support calculations made during the remedial design stage.

4.1.1 Soil and Geology

During this focused RI, core samples from the unsaturated soil were collected from monitoring well locations MW02 through MW06. These samples were used for chemical analysis and lithologic description. Due to poor soil conditions, core samples were not collected from monitoring well boring locations MW07 and MW08 (Figure 4-1).

Cuttings samples were collected from MW02 through MW08 (see Section 3.2 for mud system details and sample procedure) and used for lithologic logging purposes only. Cuttings samples were collected approximately every 10 feet below ground surface (bgs) to total depth (TD) of each well. Soil boring logs summarizing the results of the lithologic sampling and containing detailed lithologic sample descriptions are contained in Appendix A.

No well-developed, native soil horizons were observed at any of the monitoring well locations. Surface sediments consisted of younger alluvial fan deposits or alluvial deposits from modern washes. These sediments date back to the Quaternary age (geologic map of the San Bernardino, California, 1:250,000, 1986).

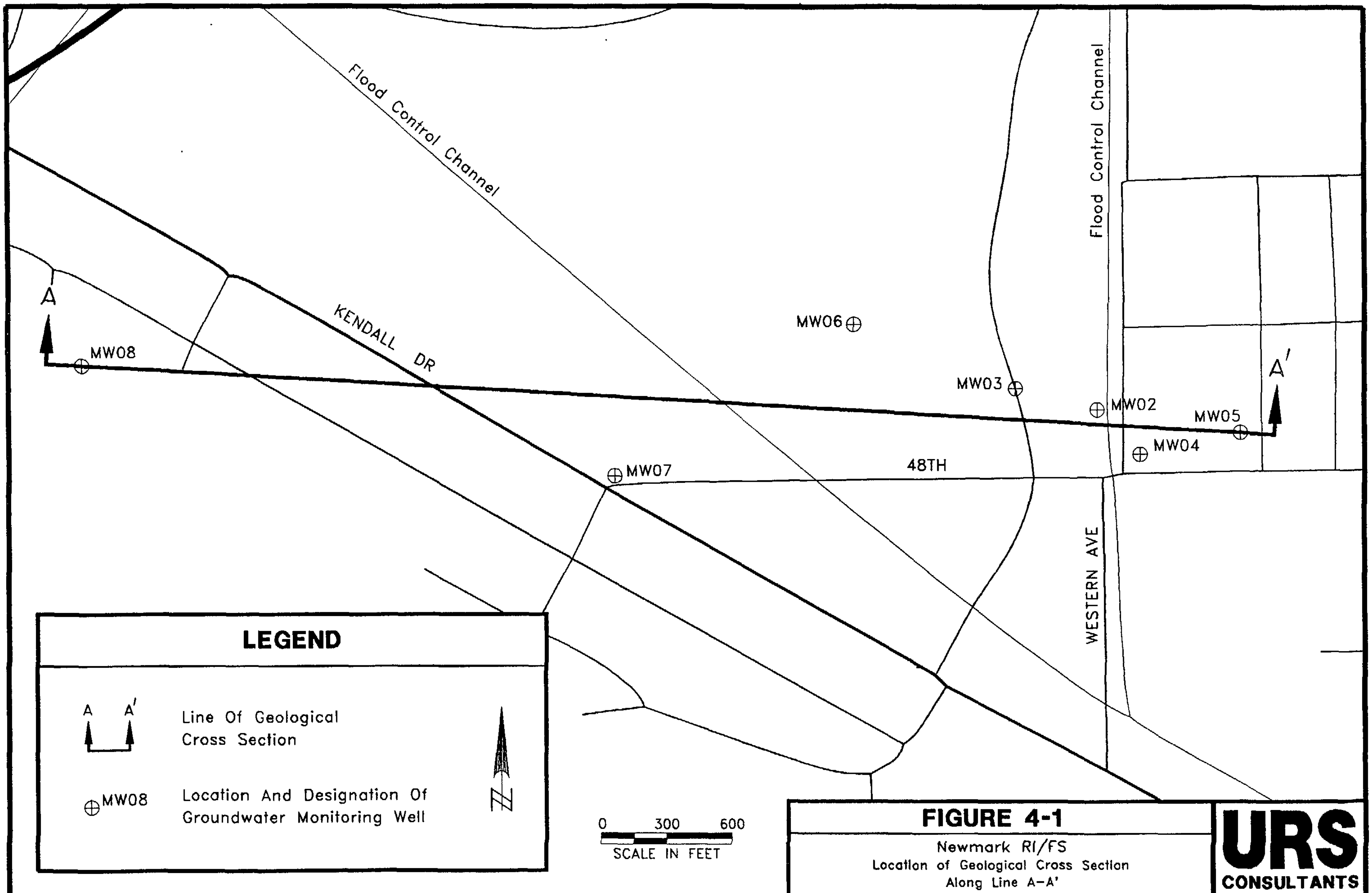

FIGURE 4-1

Newmark RI/FS
Location of Geological Cross Section Along Line A-A'

The subsurface alluvial deposits in the suspected source area were found to occur as relatively discontinuous lenses ranging in thickness from approximately 10 to 150 feet. These lenses consist of a complex mixture of gravel, sand, silt and clay. Only gradational lithologic transitions were observed in the alluvial sediments collected from core or drill cutting samples. Based on texture, the suspected source area alluvium was divided into two distinct intervals: a coarser grained upper interval and a finer grained lower interval (Figure 4-2).

In the suspected source area, the coarser grained upper interval consisted of predominantly sandy gravel and gravelly sand from ground surface to approximately 200 feet below ground surface (bgs). Sediments encountered in this interval included well-graded gravelly sand with approximately 10% cobbles and boulders, 25% coarse to fine gravel, 55% coarse to medium grained sand, and 10% fine grained sand or silt. Sand grains consisted of subangular to rounded quartz, feldspar, plagioclase, hornblend, biotite and lithic fragments. Color ranged from black and white when washed, to olive brown when not washed.

Sandy gravels were also encountered in the upper interval. These gravels consisted of approximately 10% cobbles and boulders, 65% coarse medium to fine gravel, and 25% coarse to medium grained sand. Gravel consisted of subangular to rounded quartz, feldspar, plagioclase and lithic fragments. Sediments ranged in color from black and white when washed, to dark grayish brown when not washed.

At approximately 200 feet bgs, a noticeable decrease in the percentage of boulders, cobbles and coarse to medium grained gravel occurred with a corresponding increase in the percent of fine grained sediments such as fine sand, silt, and clay. These finer grained sediments continued from a depth of approximately 200 feet bgs down to bedrock or to the total depth drilled.

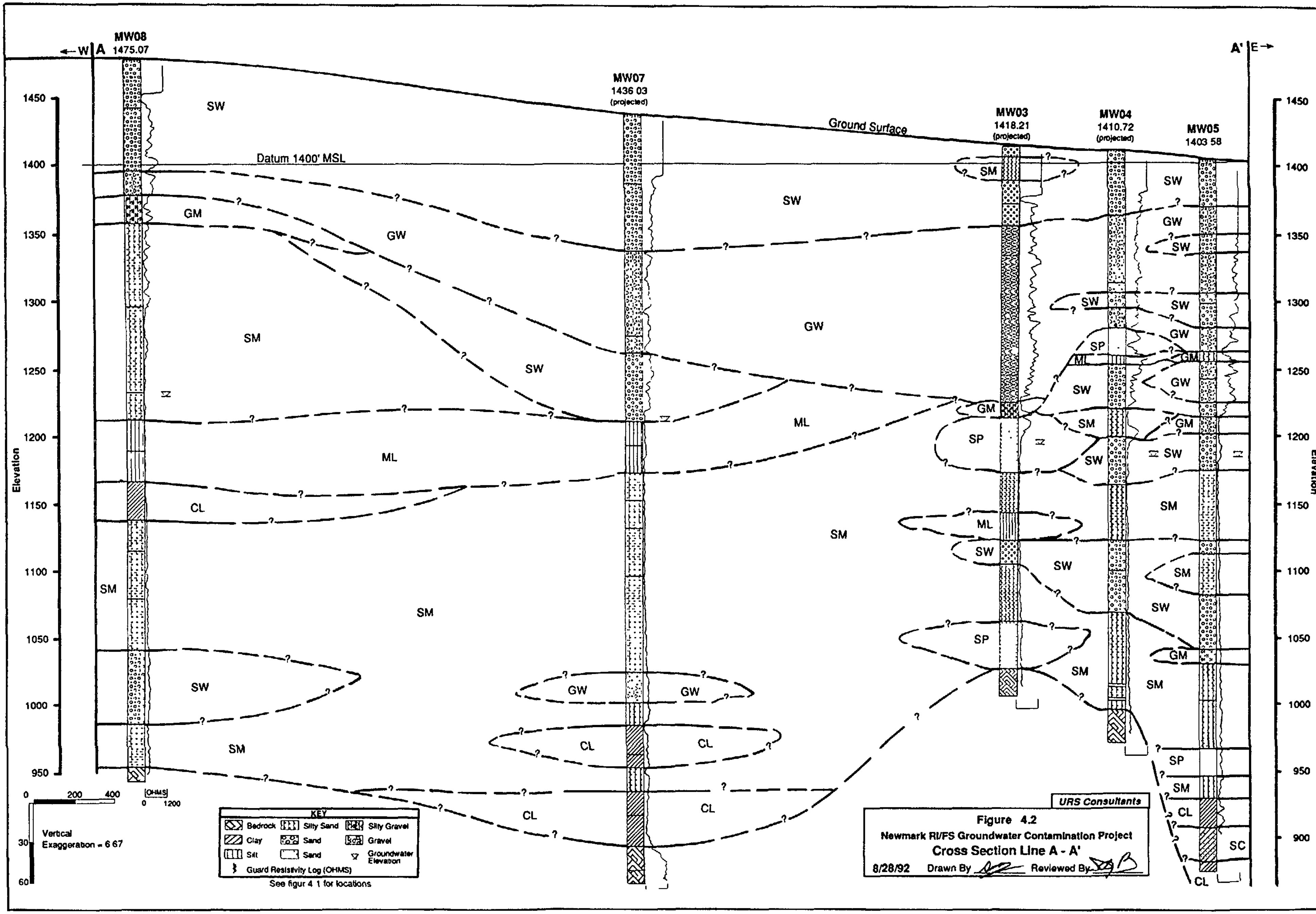

Figure 4.2

Newmark RI/FS Groundwater Contamination Project

Cross Section Line A - A'

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Alluvial sediments encountered in the lower zone consisted of predominantly silty sands and sandy silts, with occasional 2 to 25 feet thick lenses of gravel, silts and clays. The overall mineral make-up of sediments of the lower zone was very similar to the upper zone. However, the overall percentage of coarse grained sediment was much less below 200 feet bgs than it was above. Gravels and sands were well graded, angular to rounded. Individual sand grains, gravels, and cobbles consisted of quartz, K-feldspar, plagioclase, hornblend, biotite and lithic fragments. These sands and gravels ranged in color from olive brown when unwashed, to black and white when washed.

Yellowish brown to redish brown clay and silt was also interspersed among the silty sands at boring MW02, MW04, and MW05. These silt and clay lenses appeared to be discontinuous in nature, have moderate to low plasticity, and were moderately soluble in the drilling fluid.

All wells drilled in the suspected source area, with the exception of MW05, reached total depth in bedrock. Bedrock in the source area consisted of highly weathered schist or diorite with recognizable grains of quartz, K-feldspar, plagioclase, hornblend and biotite in the diorite and quartz, muscovite and feldspar in the schist. In the upper portion of the bedrock, feldspars were highly weathered and appeared as a white clay in the cuttings samples. However, as drilling penetrated deeper into the bedrock, the affects of weathering appeared to decrease and the percentage of white clay material decreased while the percent of feldspar increased. Cuttings appeared angular (fractured) in the less weathered portion of bedrock. The color of the schist basement rock in the source area was gray when unwashed, to greenish gray when washed. Diorite basement rock was gray when unwashed and black and white or black and orange when washed.

When at least two separate cutting samples (a minimum of 10 feet apart) indicated that the bit was drilling in bedrock, the field geologist informed the driller to drill approximately 20 more feet into the formation. This would allow for:

- Sufficient section to know the well had reached bedrock and was not drilling on a large boulder

- A minimum section of bedrock to generate a quality electric log signature

- Enough hole to handle any slough or backfill which might occur prior to electric logging or running casing

Monitoring well boring MW05 was the only monitoring well drilled in the suspected source area which did not encounter bedrock. The well was drilled to a total depth (TD) of 520 feet bgs and reached TD while drilling in alluvial sediments (sandy clay). Detailed mud log and electric log (E-log) information gathered from MW05 was correlated to MW02, MW03, MW04, MW06, MW07 and MW08 to assess if faulting may be present. (E-logs are presented in Appendix B.) No definite evidence of faulting was discovered in any of the well logs. Because of the complex nature of the alluvial sediments in the source area, correlation between well logs was very difficult and a fault cut may exist in any of the wells. However, without additional information, it was impossible to assess whether a variation seen in the geologic section was caused by faulting or by depositional changes.

Although no definite evidence of faulting was found on the mud logs and E-logs, it was believed that a northwest to southeast trending fault might exist to the west of MW05, and to the east of MW02 and MW04. This is based on the following:

- The radical change in depth to basement that occurred between MW04 and MW05 was not consistent with slope of bedrock in the suspected source area;

- Speculation of a groundwater barrier (Fault K) presented in literature (Hardt and Hutchinson 1986); and

- Information on file with the San Bernardino Water Department indicates that the water chemistry of wells within the eastern portion of the Newmark Wellfield is different from wells in the western portion.

None of these items provided strong enough evidence to conclude whether faulting was present in the source area or any indication as to direction of movement along the fault plane. Additional data (i.e., reflection seismic data) will be required to assess the location movement and possible affect of faulting on remedial operations in the area. No other evidence of faulting was directly observed in monitoring well logs installed in the suspected source area.

Upon completion of drilling operations, the well boring was circulated clean and E-logs (Appendix B) were run using the procedures outlined in Section 3.3. The resulting E-logs were correlated to the mud log for the same well to evaluate the accuracy of the mud log and to correlate lithology to E-log response. Overall, the mud logs and the E-logs acquired from suspected source area monitoring wells correlated very well. However, lithologic changes shown on the mud logs will often vary in depth from the same changes shown on the E-log. Occasionally, a clay or silt horizon underlying a sand or gravel which was not identified on the mud log was present on the E-log.

This discrepancy between the mud log and E-log resulted from difficulties inherent to logging mud rotary holes. The following are a few of the complications encountered during drilling and logging of source area wells:

- Sloughing formation from up the hole masked lithologic changes, especially if the subject lithologic horizon was less than 40 feet thick;

- Due to the mud system problems, cuttings were not completely removed from the mud circulated out of the hole. Cuttings were recirculated down the well and mixed with the new cuttings, which altered the sample identification;

- Caliper logs showed large wash-outs occurred in most of the holes, calculated up-times (time it takes to pump the cuttings from the bottom of the hole to the shaker screen) varied substantially due to variations in bore hole diameter causing the identified depth of the lithologic change to differ from the true depth;

- Fine grained sand, silt and clay were smaller than the shaker screen and passed through the screen without being noticed;

- Solubility of clay formation also affected logging. Clay of moderate to highly soluble was often dissolved in the drill fluid and was not seen in cuttings;

- Since groundwater in this area is fresh water, very little spontaneous potential (natural electrical current) develops at a lithologic interface as it would if formation pore space were filled with salt water. Thus, the spontaneous potential (SP) log was of little use for correlation purposes or for definition of lithologic interface;

- The gamma ray log worked poorly in suspected source area monitoring wells. The logs contained background noise which masked the true formation changes. This noise was assumed to be caused by natural minerals in the alluvium that emitted a low level radioactive signal that was picked up by the gamma ray tool's receiver.

Since soil excavation was not anticipated as a remedial action at the time, geotechnical properties (i.e., Atterberg limits, compressive strength, etc.) were not included within the scope of this investigation.

4.1.2 Hydrogeology

Field operations performed during the Newmark RI/FS included installation of seven nested pairs of groundwater monitoring wells. Each pair consisted of a shallow (A) well, which was screened in the top 25% of the water column, and a deep (B) well, which was screened in the vicinity of bedrock. Step or continuous rate pump testing was not included in the scope of this investigation so detailed hydrogeologic parameters such as transmissivity and storage were not calculated at each well location. Static water levels were measured in each of the newly installed monitoring wells and groundwater gradient was calculated for both the upper and lower portion of the aquifer.

Groundwater in the suspected source area flows through alluvial deposits consisting of a complex mixture of gravel, sand, silt, and clay. A review of mud log and E-log data from borings MW02 through MW07 indicated that sediments below the water table generally consist of coarse to fine sands with occasional gravel, sand, and clay lenses. The silt and clay lenses were observed in MW02, MW03, MW05 and

MW07. However, the lenses appeared to be laterally discontinuous in nature and probably had little or no effect on groundwater flow in the suspected source area.

On May 13, 1992, groundwater elevation data were measured from suspected source area monitoring wells MW02A/B through MW06A/B (see Table 3-1 for summary). Groundwater elevations were measured in MW07B and MW08A/B when the wells were sampled on June 7, 1992 and July 4, 1992. Figures 4-3 and Figure 4-4 present groundwater contour maps generated from the data. These two groundwater contour maps were generated in order to provide a representative summary of data acquired from the upper portion of the aquifer and compare it to data acquired from the lower portion of the aquifer.

Findings indicated that groundwater elevations in the B wells range from 0.02 to 8.46 feet lower than groundwater elevations measured in the A wells. MW07 is the one exception to this finding and results indicate that the groundwater elevation at MW07B is 5.35 feet higher in elevation than MW07A. Groundwater elevations acquired from the A wells and the B wells indicate that groundwater flow direction in the suspected source area is generally east-southeast.

As indicated in Figure 4-3 and Figure 4-4, groundwater flow direction varied across the site in both the A wells and the B wells. The calculated groundwater gradient between MW08B and MW07B was approximately 0.0039 feet vertical per horizontal foot (ft/ft) in a southeasterly direction. However, between MW06B and MW04B, the gradient increased to 0.0132 ft/ft and the flow direction changed to a more easterly direction (toward the Newmark Wellfield).

A similar gradient change occurred in the shallower A wells. The calculated groundwater gradient between MW08A and MW07A was 0.0094 ft/ft in a southeasterly direction. Farther east, the gradient between MW06A and MW04A increased to approximately 0.0138 ft/ft and the flow direction again moved to a more easterly direction (toward the Newmark Wellfield). The change in groundwater flow direction and gradient seen across the suspected source area was believed to result from the influence

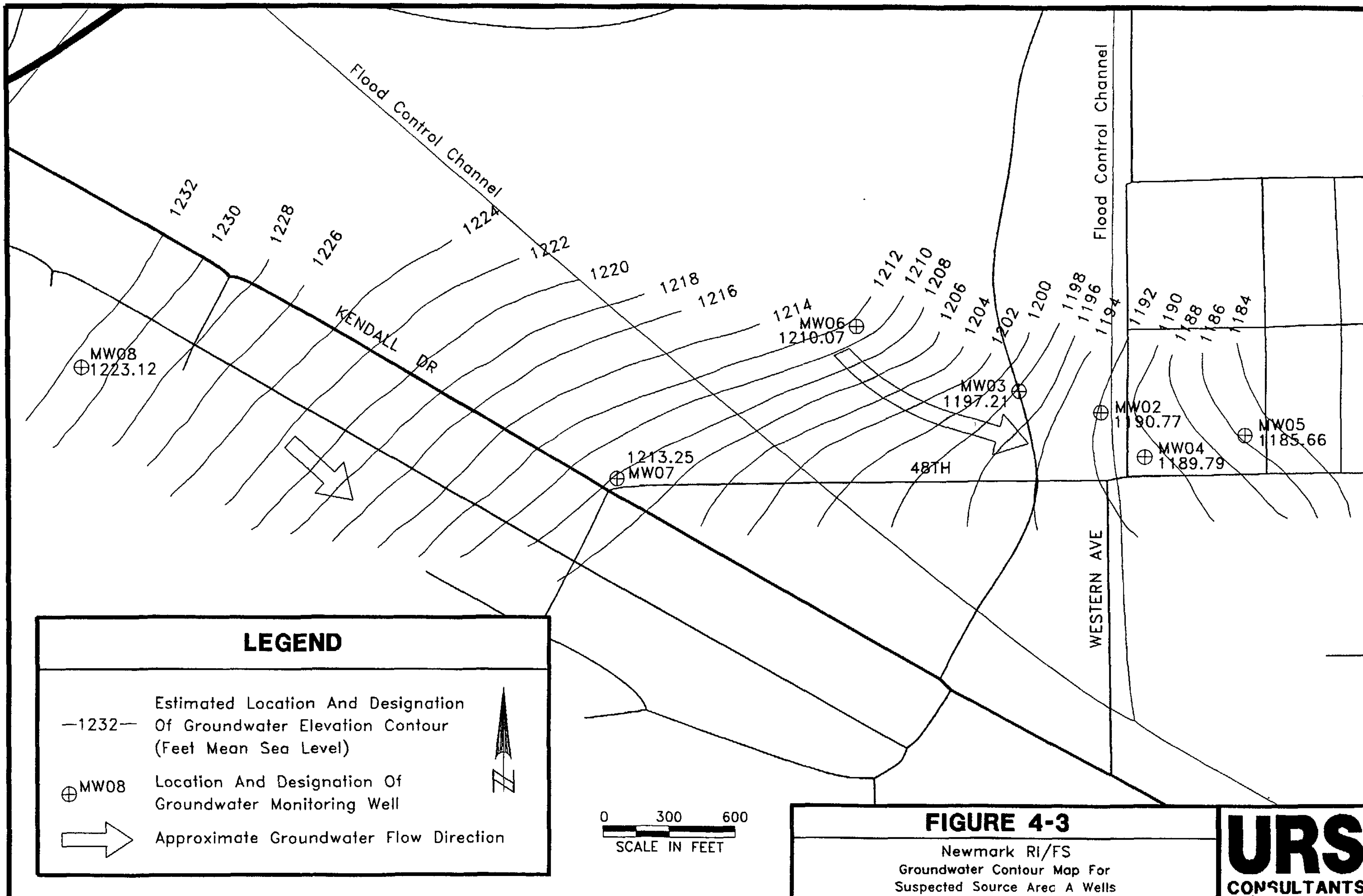

FIGURE 4-3

Newmark RI/FS

Groundwater Contour Map For Suspected Source Area A Wells

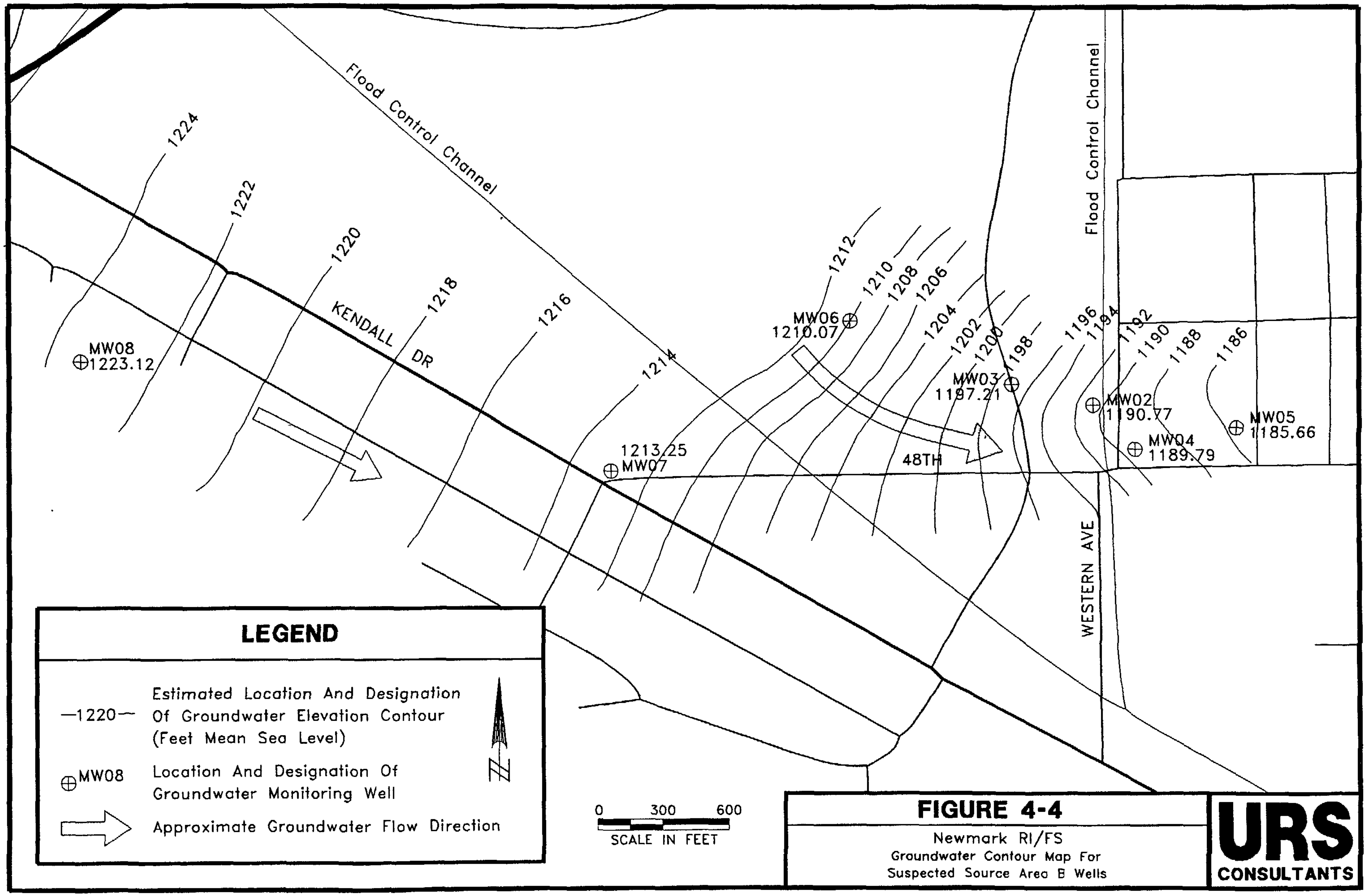

FIGURE 4-4

Newmark RI/FS
Groundwater Contour Map For
Suspected Source Area B Wells

of pumping at the Newmark Wellfield. Although the wells do not pump continuously, a cone of depression appears to have formed in the area of the wellfield, altering the natural groundwater flow patterns in the area. It is not certain whether pumping at the Newmark Wellfield was in progress when groundwater elevations were measured in source area wells.

The information available indicates that the aquifer in the suspected source area is one continuous unconfined aquifer which extends from the top of first groundwater to bedrock. No continuous clay or silt horizon was observed which could provide sufficient flow restriction to allow for a multiple aquifer scenario. The variation in groundwater elevation between the A wells and the B wells is believed to be caused by the natural increase in hydraulic potential (which increases with depth) and not due to a vertical gradient between separate aquifers. All hydrogeologic parameters in the suspected source area were consistent with findings of previous reports.

4.2 PLUME AREA

Field work associated with the plume monitoring well, MW01, was performed between February 21, 1992 and June 26, 1992. Subsection 4.2.1 summarizes the results of the field activities as they pertain to the geologic and hydrogeologic parameters of the plume area, and integrates these results with information from well logs for municipal production wells in the plume area.

4.2.1 Soils and Geology

Soil investigation in the plume area was limited to boring log and geophysical log data acquired from one monitoring well boring (MW01) drilled to a total depth of 1,000 feet bgs. The location of MW01 and all municipal wells in the plume area are shown in Plate 1; boring and geophysical log data from MW01 are contained in Appendix A.

Cutting samples were collected during drilling of MW01 approximately every 10 feet from ground surface to the total depth of the well. These samples were used for lithologic logging only. Due to poor soil composition, core samples were not collected from monitoring well boring MW01.

Soils encountered in monitoring well MW01 were very similar to those found in the source area wells and were generally comprised of alluvial deposits, derived from igneous and metamorphic bedrock of the San Bernardino and San Gabriel Mountains. The sediments were identified as quaternary in age (geologic map of San Bernardino, scale, 1:250,000 1986). Alluvial deposits found at MW01 occurred as a complex mixture of boulders, gravel, sand, silt and clay. Based on texture, the alluvial deposits found in MW01 were divided into three intervals.

The first interval consisted of coarse grained sand, gravel and boulders, and extended from ground surface (gs) to approximately 178 feet bgs. This interval included well-graded coarse to fine gravel (50%), coarse to fine sand (40%) and cobbles to boulders (5%). Individual sand grains were angular to subrounded and consist of quartz, feldspar, plagioclase, hornblend, biotite and lithic fragments.

Very little clay was seen in the interval from gs to 178 feet bgs but occasional 2 to 10 feet thick lenses of grayish brown to yellowish brown soluble clay were observed.

The second interval consisted predominantly of finer grained clay, silt and sand, and extended from approximately 178 to 554 feet bgs. The interval included yellowish brown sandy clay with moderate plasticity; clay (50%), fine sand (40%), and silt (10%). These clays were interbedded with a well graded grayish brown, silty sand consisting of angular to subrounded grains of coarse to fine sand (60%) and silt (40%). Occasional clay-like sand intervals were also noted in this interval. These consisted of coarse to medium grain sands (60%) in a clay matrix (30%).

The third interval consisted of coarse grain sand and gravel with interbedded clay and silt and extended from 554 to 974 feet bgs. Alluvial sediments in this interval include clayey sand, well-graded, fine to coarse sand (65%), clay (25%), and silt (10%). The clay had a moderate plasticity and ranged from olive brown to yellowish brown in color. The sands and clays appeared to be highly interbedded throughout the interval and ranged in thickness from 2 to 20 feet thick. Overall percent of sand appeared to be higher (75% sand vs. 25% clay) in the upper portion of the interval 554 to 721 feet bgs than in the lower portion (55% sand vs. 45% clay) of the interval 721 feet bedrock at 974 feet bgs.

Bedrock was encountered in monitoring well MW01 at 974 feet bgs. Cutting samples of the bedrock consisted of angular fragments of quartz, K-feldspar, plagioclase, hornblend and biotite. Bedrock appeared highly weathered from alluvium/bedrock contact to total depth drilled.

Since there was no evidence to suggest soil contamination at this drilling location, undisturbed soil samples were not collected during the drilling of MW01. Only gradational lithologic transitions were identified during analyses of drill cuttings. Actual contacts between differing lithologic formations were identified utilizing the electrical logging data. An attempt was made to correlate the boring log and the electric log signature from MW01 with information from various municipal wells within approximately 3,000 feet of MW01. Drillers sample logs from the 23rd Street, North E Street, and Mountain View Cemetery #2 and #3 wells were reviewed. These four wells were located to the west and east of MW01 and penetrated approximately the same thickness of alluvium. No direct correlation of individual horizons were made because of the lateral and vertical gradational changes characteristic of alluvial deposits. Correlation was also complicated by the very generalized drill cutting descriptions of the offsetting wells. These generalized descriptions are common for the municipal wells in the area. Descriptions of cuttings were usually based on observations made by the drilling crew and not a trained geologist. The lack of electrical logs on previously drilled municipal wells also hampered correlation of lithologic zones between wells in the area. Despite these complications, one correlation was made in a zone of "cobbles/boulders" identified at approximately 320 feet in the MW01, 23rd Street, and Mountain View Cemetery #2 wells.

4.2.2 <u>Hydrogeology</u>

The groundwater in both the Newmark source area and the Newmark plume area originates from surface-water runoff in the San Bernardino Mountains. Surface water flows in the study area across the San Andreas Fault through the outlets of Devils, Badger, Sycamore and Waterman Canyon (Hardt and Hutchinson 1980). At the mouth of Waterman and Devils Canyons, surface runoff is collected in large percolation basins to recharge the area aquifer.

In the Newmark plume area, the groundwater flow direction is south-southeast around the northeast edge of Shandin Hills. Once the groundwater passes around the northeast edge of Shandin Hills, the groundwater flows southerly toward the Santa Ana River.

The alluvial deposits in the Newmark plume area consist mostly of sand, gravel, boulders, and occasional discontinuous clay lenses. These clay lenses increase in thickness and number toward the south and the central portion of the basin. Based on boring log and E-log data collected from monitoring well MW01 and data available from municipal wells in the vicinity, the alluvium in the Newmark plume area was divided into three depositional sequences:

- The northern depositional sequence (located north of Shandin Hills) which forms a single unconfined aquifer consisting of predominantly coarse grained sediments;

- The middle or transition depositional sequence (located from the northeast edge of Shandin Hills and extending south to approximately west of Perris Hill) which forms a single unconfined aquifer consisting of primarily coarse grained sediments with minor discontinuous fine grains (silt and clay) lenses;

- The southern depositional sequence (starting near the 16th Street well and extending south) which form to separate aquifers, an upper unconfined aquifer and a lower confined aquifer.

The northern depositional sequence encompassed both the suspected source area and the northwestern portion of the plume area. Sediments consisted predominantly of sand, gravel and boulders with little or no clay. This is evident in drillers' and electric logs for the Newmark Wellfield wells, DHS monitoring wells and the Waterman Avenue well. The alluvium in this area behaves as one unconfined aquifer. Depth to water ranged from approximately 100 to 220 feet bgs in this area.

The middle depositional sequence consisted mostly of sand and silt with significant intervals of gravel and boulders. Based on the drillers' and electric logs of MW01, 25th and E Street well, 23rd and E Street well and 17th Street well, some thin clay lenses were found in this area and were concentrated between 185 to 550 feet bgs. Sediments in this area appeared to be in the transition zone between the single unconfined aquifer to the north/northwest and the two aquifers to the south/southeast. However, these clay lenses did not seem to form a significant confining zone to the coarse alluvium below. This was evident from the consistency of water levels taken at four different depths in MW01. Based on this data, the alluvium in this area appeared as one unconfined aquifer. Depth to water ranged from approximately 100 to 300 feet bgs.

The southern depositional sequence consisted of silt, sand and gravel with many clay lenses. In this area, the alluvium divided into two major aquifers. The upper aquifer remained an unconfined aquifer; but the lower aquifer was confined by the overlying zone of interfingered clay lenses. The identification of two aquifers at the Newmark plume edge was based on the recorded water levels, the placement of the well perforations during the installation of wells in the area, and interpretation of the alluvium described in the drillers' logs for wells in the area. In this area, the zone of interfingering clay lenses was approximately 200 feet thick and located approximately 75 feet bgs at the Newmark plume edge. The zone of interfingering clay lenses increased to approximately 300 feet thick near the 7th Street well. Depth to water ranged from approximately 50 to 180 feet bgs in the southern depositional sequence of the Newmark plume area. The wells located in the area of the Newmark plume edge, which provided the above information, were 16th Street well, Gilbert Street well, and 7th Street well.

Transmissivity values were calculated for the alluvium in the Newmark plume area using specific-capacity test data for the municipal wells that were drilled in the area. The transmissivities ranged from 173,200 to 415,400 gal/day/ft. The average transmissivity equaled 236,360 gal/day/ft.