ARCS

Remedial Planning Activities at Selected
Uncontrolled Hazardous Substance Disposal
Sites in the Zone of Regions IX and X

# FINAL
# 100 PERCENT DESIGN SUBMITTAL
# NEWMARK OU REMEDIAL DESIGN
# NEWMARK GROUNDWATER
# CONTAMINATION SUPERFUND SITE
# NORTH PLANT

U.S. Environmental Protection Agency
Contract No. 68-W9-0054

URS Greiner

**Team Subcontractors:**

Black & Veatch Special Projects Corp.
Shannon and Wilson, Inc.

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**Prepared For:**

**Contract No. 68-W9-0054 / WA No. 54-37-9NJ5**
**U. S. Environmental Protection Agency**
**Region IX**
**75 Hawthorne Street**
**San Francisco, CA 94105**

**Prepared By:**

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**Sacramento, CA 95833**

**September 1997**

# IDENTIFICATION FORM

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|---|---|
| **Document Title:** | **FINAL 100 PERCENT DESIGN SUBMITTAL<br>NEWMARK OU REMEDIAL DESIGN<br>NEWMARK GROUNDWATER CONTAMINATION<br>SUPERFUND SITE NORTH PLANT** |
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| **Plan Coverage:** | This document constitutes the 100 percent design submittal for the Newmark Operable Unit Remedial Design, Newmark Groundwater Contamination Superfund Site work assignment (WA) in the U.S. Environmental Protection Agency's (EPA) Region IX under EPA Contract No. 68-W9-0054. These services are provided by URS Greiner, Inc. - California as prime contractor. |

# APPROVAL FORM

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| A:W | Air-to-water ratio |
| ARARs | Applicable or relevant and appropriate requirements |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society of Testing and Materials |
| AWWA | American Water Works Association |
| BACT | Best available control technology |
| BC | Basement complex |
| bgs | Below ground surface |
| City | City of San Bernardino |
| DHS | Department of Health Services |
| DTSC | Department of Toxic Substances Control |
| ECS | Emissions control system |
| $ft^2$/day | Square feet per day |
| GAC | Granular activated carbon |
| GFCI | Ground-fault circuit interrupter |
| gpm | Gallons per minute |
| hp | Horsepower |
| LPGAC | Liquid-phase granular activated carbon |
| LWBM | Lower water-bearing member |
| MCL | Maximum contaminant level |
| MCM | Middle confining member |
| NEMA | National Electrical Manufacturers Association |
| NPL | National Priority List |
| O&M | Operation and maintenance |
| OU | Operable unit |
| P&ID | Piping and instrumentation diagram |
| PCE | Tetrachloroethene |
| PFD | Process flow diagram |
| ppb | Parts per billion |
| psi | Pounds per square inch |
| PVC | Polyvinyl chloride |
| RGS | Rigid galvanized steel |
| RI/FS | Remedial investigation/feasibility study |
| ROD | Record of decision |
| RWQCB | Regional Water Quality Control Board |
| SCADA | Supervisory Control and Data Acquisition System |
| SCAQMD | South Coast Air Quality Management District |
| SCE | Southern California Edison Company |
| TCE | Trichloroethene |
| TSS | Total suspended solids |
| URSG | URS Greiner, Inc. - California |
| USEPA | United States Environmental Protection Agency |
| UWBM | Upper water-bearing member |
| WA | Work assignment |
| $\mu$g/L | Micrograms per liter |

# 1.0 INTRODUCTION

Previous investigations have concluded that a plume of groundwater contamination (Newmark Plume) exceeding state of California maximum contaminant levels (MCLs) exists beneath the city of San Bernardino, California (Figure 1-1). The Newmark Operable Unit (OU) encompasses the area impacted by this contaminant plume. A Record of Decision (ROD), dated August 4, 1993 (USEPA 1993), outlines the requirement for two groundwater extraction and treatment systems, one system (of two components) in the southern area of the Newmark OU, designated as the South Plants, and one in the northern area, designated as the North Plant.

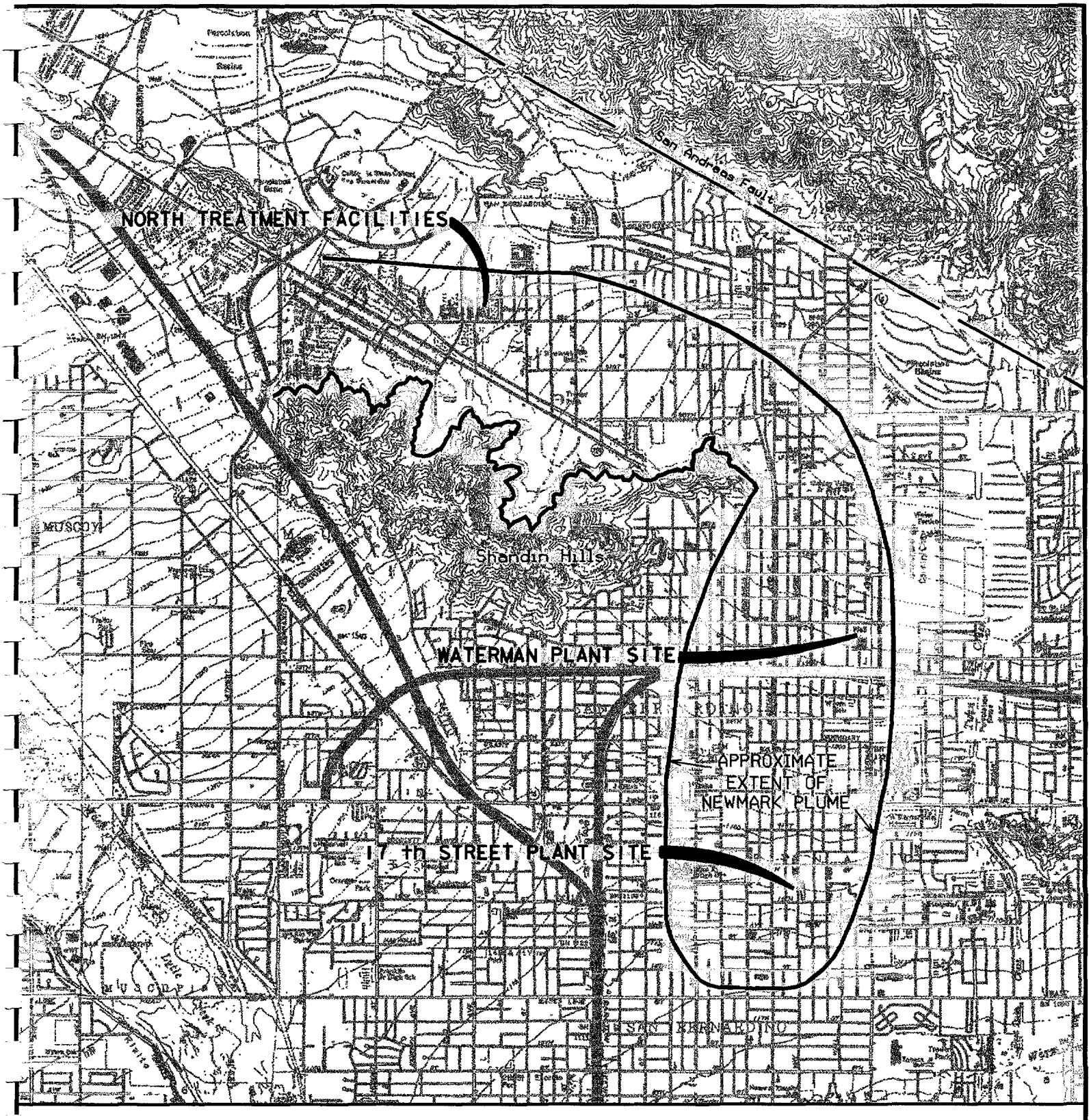
This 100 percent design submittal presents the design developed for the North Plant. While both the South Plant and North Plant technical specifications and drawings are presented in "Newmark OU Remedial Design, North and South Plants 100% Construction Specifications and Drawings" (URSG 1997b), the South Plant design is being submitted under a separate cover (URSG 1997d), concurrently with this document. This design has been prepared by URS Greiner, Inc. - California (URSG) under U.S. Environmental Protection Agency (USEPA) contract number 68-W9-0054/work assignment number 54-37-9NJ5.

This 100 percent design document addresses comments on the 30 (URS 1995b), 60 (URS 1995c), and 90 (URS 1995f) percent design documents provided by the USEPA. In addition to USEPA input, to ensure that the design reflects actual conditions and to provide a smooth connection to existing facilities, URSG met with city of San Bernardino (City) and state agencies throughout the design process. State requirements and all design comments have been incorporated, as well as City preferences for future system operation and maintenance.

The groundwater extraction and treatment systems design has been divided into two major design projects:

- Water transmission pipeline design.
- Groundwater treatment system design.

A separate deliverable was developed for the pipeline design (URS 1997a). This report covers the North Plant groundwater treatment system. The wellhead facility design will be provided by the City.




LEGEND

Approximate Extent Of Groundwater Contamination. (K. Mayer EPA)

Fault

0 ½ 1

SCALE IN MILES

N

Base Map: USGS San Bernardino Quad

| | | |
|---|---|---|
| URS Consultants, Inc. Sacramento, Ca | NEWMARK OU RD<br>NEWMARK GROUNDWATER CONTAMINATION SUPERFUND SITE | FIGURE 1-1<br>NEWMARK OU PLUME LOCATION |

GSI-1 MARK.VM USTSVPR

## 1.1 BACKGROUND

### 1.1.1 History

The California Department of Health Services (DHS) discovered chlorinated solvents in municipal water-supply wells (municipal wells) within the northern San Bernardino/Muscoy region of San Bernardino County during a 1980 groundwater investigation. Several investigations were conducted to locate the potential source(s) of contamination. On March 30, 1989, USEPA placed this region on the National Priorities List (NPL), thereby releasing federal funds for cleanup of the region, now identified as the Newmark Groundwater Contamination Superfund Site (site). These municipal wells are operated by the City of San Bernardino Water Department (Water Department).

The principal contaminants identified in site investigations were trichloroethene (TCE) and tetrachloroethene (PCE). Reported concentrations of these contaminants exceed federal and California MCLs for drinking water in several municipal wells within the San Bernardino and Muscoy areas, including the Newmark Municipal Wellfield (Newmark Wellfield).

### 1.1.2 Conceptual Hydrogeologic Model

The conceptual hydrogeologic model for this site is evolving over time as new information becomes available. It consists of data assembled from historical drillers' logs and other information supplied by the Water Department, monitoring well installations, groundwater sampling events, and shallow seismic reflection studies. A brief highlight of the conceptual model is presented here. For more details, refer to the Detailed Hydrogeologic Investigation Technical Memorandum for the North and South Facility Areas (URS 1995d).

#### General Model

The conceptual hydrogeologic model consists of four units (or members) based on interpretations of the available data. The units include two water-bearing members (upper and lower) separated by a confining member with a relatively lower permeability. The bottom unit is a basement complex (BC) composed of bedrock that is locally altered.

The upper water-bearing member (UWBM) is interpreted as unconsolidated dune and river channel deposits consisting of boulders, gravel, sand, and silt. This unit is generally unsaturated, but may contain groundwater under perched conditions. Early indications from the Source OU remedial investigation (RI) activities are that perched or seasonal saturated conditions may be present in the northeast portions of the source OU. Further data accumulation and investigation will provide information necessary to make a more detailed statement regarding perched water conditions.

The USEPA investigative studies in the Newmark North Plant area focus on a much smaller area than previous studies used in the development of the conceptual hydrogeologic models.

The middle confining member (MCM) is interpreted as poorly to moderately consolidated alluvial and fluvial deposits consisting of interbedded heterogeneous gravel, sand, silt, and clay.

The lower water-bearing member (LWBM) is interpreted as unconsolidated alluvial and fluvial deposits consisting of interbedded silty gravel; silty, clayey sand; and sandy clay lenses. This member can locally contain a massive granitic/dioritic gravel bed 300- to 400-feet-thick.

The BC is interpreted as competent igneous and metamorphic material consisting of granodiorite and schist. This unit can locally be overlain by a zone of altered material. This altered zone is typically represented by angular, schistose rock fragments and clayey silts which contain mottled clasts. Clasts commonly exhibit relict texture and are interpreted as altered bedrock.

Evaluation of five seismic lines and historical aerial photographs concluded that the area studied is crossed with a series of lineaments with corresponding conjugate sets that roughly intersect at right angles. When reviewing aerial photos through a stereoscope, these conditions give the appearance of blocks of material which have been up- and down-thrown relative to one another.

## North Area

The model consists of only one water-bearing unit north of Shandin Hills. The MCM and LWBM are not present. Lithologic records, borehole geophysics, and seismic information indicate that the alluvium/bedrock contact is relatively shallow when compared with the South Area, with altered bedrock occurring at approximately 370 feet below ground surface (bgs). Competent bedrock occurs at approximately 490 feet bgs. The water-bearing unit in the vicinity of MW09 contains relatively higher percentages of silt and clay than in monitoring wells previously installed to the north. This indicates that groundwater extraction/pumping rates from the area around MW09 may not be as great as areas further north due to implied lower transmissivity.

The analytical data indicate that groundwater contaminant concentrations are present in excess of the MCLs for PCE. Based upon the preliminary analytical data from MW09 and analytical information from an abandoned production well (at the southwest corner of Shandin Hills Drive and Kendall Drive, previously sampled by the Regional Water Quality Control Board [RWQCB]), it is concluded that migration of the contaminant plume south of the Newmark Wellfield area is inhibited by relatively shallow bedrock. Also, the plume is significantly impeded by the surface exposure of bedrock represented as Shandin Hills.

Contaminants are observed at relatively higher concentrations in MW09A (the shallow completion) than those recorded in shallow completions from previously installed monitoring wells (MW02 through MW08) (URS 1992). However, this should not significantly affect the remedial approach. Concentrations of PCE above MCL were also detected in MW09B.

## South Area

Based on the analytical results from monitoring wells near the leading edge of the contaminant plume (MW10 and MW11), it is concluded that contamination appears to be limited to the upper portions of the LWBM. The eastern boundary of the leading edge of the Newmark Plume is currently delineated by the absence of contaminants in Muni-24 (Gilbert Street well). The western edge is delineated by low levels of contaminants detected in Muni-18, 19, and 20 (27th Street, North E Street, and 23rd Street).

MW11 is located near the intersection of Genevieve Avenue and Baseline Street in an area interpreted to be a bedrock low and near the leading edge of the Newmark Plume. Altered bedrock was encountered in MW11 at approximately 1,200 feet bgs. Competent bedrock was encountered at approximately 1,254 feet bgs.

## 1.2 EXISTING AIR STRIPPER TREATMENT SYSTEM

Currently, the City operates two air strippers at the North Plant. Each stripper is rated for a hydraulic volumetric capacity of 2,000 gallons per minute (gpm). Emissions from the strippers are currently "not controlled." USEPA determined that the South Coast Air Quality Management District's (SCAQMD's) regulations are applicable or relevant and appropriate requirements (ARARs). Under the anticipated increased flow rates and contaminant concentrations of USEPA's remedial action, off-gas treatment would be required. An engineering cost analysis based on the latest contaminant concentrations indicated that liquid-phase granular activated carbon (LPGAC) is the more cost-effective means of treating the groundwater and, therefore, an LPGAC adsorption plant is being designed (URS 1994b).

Although USEPA's remedial action does not directly incorporate the existing air strippers, it does not preclude their use by the City for peak demand periods. The existing air strippers will have valves added so that they may be used for groundwater treatment in the future. Table 1-1 presents design data of the two existing air strippers and Table 1-2 presents actual air stripper operational data. Additional information on operational data is presented in Appendix A.

## 1.3 DESIGN OBJECTIVE

The primary objective of this report is to design an on-site groundwater treatment system for the North Plant. Groundwater will be extracted from one existing Newmark wellfield well located near the North Plant, Newmark OU, and two proposed wells located to the south of North Plant. As part of remedial action implementation at Newmark OU North, groundwater has to be extracted to intercept further plume migration. For further details, refer to Subsection 1.4 and URS's Remedial Investigation/Feasibility Study (RI/FS) Report (URS 1993).

Originally, it was planned to utilize the two existing air strippers to treat the groundwater, and to install an emissions control system (ECS) to treat the air stripper off-gas. A study identified the PURUS ECS as the best available control technology (BACT) (URS 1994a). However, present worth cost comparisons, which were based on more recent concentration data from the Newmark OU plume and on actual extraction data from existing treatment plants, indicated that LPGAC groundwater treatment is more cost efficient than off-gas treatment at the existing air strippers (URS 1994b). Upon direction by USEPA, URSG has designed an LPGAC groundwater treatment system. Treated water will be discharged to the City's municipal water supply system, and, therefore, drinking water standards must be met.

## Table 1-1

## DATA RELATED TO EXISTING AIR STRIPPERS AT NORTH PLANT

| Item | East Air Stripper[1] | West Air Stripper[1] |
|---|---|---|
| Diameter (ft) | 12 | 12 |
| Total Height (ft) | 42 | 42 |
| Packing Height (ft) | 25 | 25 |
| Packing Type | #2 Glitch mini rings | #2 Glitch mini rings |
| Blower Flow Rate (max. cfm) | 30,000 | 30,000 |
| Flow Rate Adjustment | Louvers | Louvers |
| Blower Motor | 40 | 40 |
| Design Water Flow Rate (gpm) | 2,917 | 2,917 |
| Effluent Design Quality (ppb) | Startup:<br>PCE: 100 to ND<br>TCE: 30 to ND<br>Routine Operation:<br>PCE: 150 to 0.5<br>TCE: 50 to 0.5 | Startup:<br>PCE: 100 to ND<br>TCE: 30 to ND<br>Routine Operation:<br>PCE: 150 to 0.5<br>TCE: 50 to 0.5 |
| Design Air: Water Ratio (A:W) | 30:1 | 30:1 |
| Design Packing Loading ($gpm/ft^2$) | 26 | 26 |
| Design Removal Efficiency | 99.7% | 99.7% |
| Inlet Pipe Diameter (in) | 16 | 16 |
| Effluent Pipe Diameter (in) | 16 | 16 |

Note: Actual operational data are listed in Table 1-2.

[1] Existing two air strippers at North Plant are designated by City of San Bernardino as East and West air strippers.

ND non detect
ft feet
cfm cubic feet per minute
gpm gallons per minute
$ft^2$ square feet
ppb parts per billion
in inches
PCE tetrachloroethene
TCE trichloroethene

## Table 1-2

## ACTUAL OPERATIONAL DATA OF EXISTING AIR STRIPPERS AT NORTH PLANT

| Item | East Air Stripper | West Air Stripper |
|---|---|---|
| Air Flow Range (cfm) | 8,700 to 18,100 | 11,200 to 19,800 |
| Water Flow Range (gpm) | 1,600 to 3,200 | 2,200 to 3,900 |
| Air:Water Ratio (A:W) | 31:1 to 85:1 | 27:1 to 61:1 |

Note: Data summarizes from monthly operational data recorded from February to August 1994.
cfm cubic feet per minute
gpm gallons per minute

## 1.4 NEWMARK WELLFIELD EXTRACTION WELL SYSTEM DESIGN

This section describes the extraction well location design of the Newmark OU. Presently, the Water Department extracts groundwater from four existing wells in the Newmark wellfield, identified as Newmark wells 1, 2, 3, and 4. The proposed extraction system includes the existing Newmark well and 3, as well as two new extraction wells. Design of the system includes the location, number, and extraction rates of the proposed new extraction wells. The physical design of the extraction wells (e.g., casing diameter, screen interval and size, packing materials) was completed using data from the pilot borings for the extraction wells. The project flow model was initially used to determine extraction well locations and flow rates. System extraction rates were refined using analytical capture zone calculations adapted from Javandel and Tsang (1986). The extraction system design was initially proposed in the Newmark Wellfield Extraction System Technical Memorandum and is attached as Appendix F.

### 1.4.1 Scope and Objective

The goal of the Newmark wellfield extraction system is to inhibit further migration of the northern portion of the Newmark groundwater contaminant plume. The proposed extraction well system is located just north of Shandin Hills. To design an effective extraction system, the following parameters were determined:

(1) Location of the Newmark wellfield extraction wells.
(2) Number of extraction wells.
(3) Pumping rate estimates for the extraction wells.

### 1.4.2 Proposed Extraction Well System

Figure 1-2 shows the locations and individual capture zones of three of the four proposed extraction wells. Newmark Well No. 1 was added to the design based on a need for additional capture during high regional groundwater flow. This decision was reached during discussions with USEPA and the Water Department after the Technical Memorandum (Appendix F) was finalized. Three extraction wells were considered pumping at the following constant rates: Newmark well no. 3 at 1,600 gpm; one new extraction well at 1,300 gpm; and a second new extraction well at 1,000 gpm. Figure 1-2 shows the overlapping capture zones covering the width of the groundwater contaminant plume. The total pumping rate for the proposed extraction system was 3,900 gpm. The proposed extraction wells will be screened over a portion of the aquifer to optimize contaminant capture (probably the lower portion of the aquifer). The new wells have been installed by the City. If Newmark Well No. 1 is required it can be treated through the air strippers.

The project flow modes were initially used to help determine extraction well locations and flow rates. Based on the uncertain results of the modeling runs and the area-specific limitations of the model, an analytical procedure was used to supplement the flow model simulations. Several pumping scenarios using various pumping rate combinations were considered. The results from the model pumping scenarios were refined mathematically, producing the final pumping scenario described below. Based on the available data, aquifer parameters used during capture zone calculations, and flow model simulations, the extraction scenario presented here is considered optimum. Inclusion of the existing Newmark wellfield in the extraction system allows for maximum flexibility in the event that additional pumpage is needed (e.g., large regional water level fluctuations) at the Newmark wellfield.

As calculated in the Newmark Wellfield Extraction System Technical Memorandum (Appendix F), the proposed capture zone is within the higher concentration areas of the contaminant plume delineated in the Newmark RI/FS Report (URS 1993). The historical groundwater sampling data (past 12 years) indicate relatively consistent contaminant levels at the Newmark Wellfield. Additionally, contaminant levels at the Newmark Wellfield are consistent with contaminant levels found in upgradient wells (MW07 and MW08). This indicates that clean water from the north (Devils Canyon area) does not significantly affect contaminant levels at the wellfield.

During operation of the extraction well system, if contaminant levels drop below cleanup standards, the flow from individual well(s) may be adjusted to minimize pumpage of "clean" water.

There are minimal data to warrant concern that runoff from the Shandin Hills will infiltrate, resulting in excess pumping of clean water. The two monitoring wells closest to Shandin Hills (MW07A, B and MW09A, B) appear to support this hypothesis because they have elevated contaminant concentrations in both the shallow and deep screen intervals. Wells further north of the Shandin Hills show decreased contaminant concentrations in the shallow groundwater. The intent is to extract groundwater from the zones of contamination and not from the zones of clean water. Hence, the proposed extraction wells are located in the vicinity of the Newmark Wellfield (area of highest historical groundwater contamination).

### 1.4.3 Proposed Extraction System Limitations

It should be noted that the proposed extraction well system design is an estimate based on the project flow model and analytical calculations of capture zones, and therefore subject to the same uncertainty and limitations as the models. The following limitations particularly affect the well system design:

- Model Grid Spacing. Project flow model uses a grid spacing of 820 feet in $x$ and $y$ directions. Because of the grid size, a minimum well spacing of 820 feet can be used in the model simulation. If smaller well spacings were used, a lower extraction rate might effectively capture the imaginary particles.

- Extraction Well Screen Lengths. The model does not allow for separate screening intervals within an aquifer or for partial penetration of an aquifer. Although the contamination was modeled over the entire aquifer, the data previously collected indicate that the contamination is limited to the lower portion. The model assumes extraction wells are fully penetrating over the entire model layer (aquifer). This difference could allow the model to predict a greater pumping rate than necessary. Conversely, the area's specific model limitations, described in Subsection 2.4 of Appendix F, tend to make the model under-predict extraction rates.

The capture zone calculations were based on several simplifying assumptions that produce uncertainty. For instance, the capture zone equations are sensitive to water table fluctuations and the resulting variable pumping rates. This example is relevant because up to 80 feet of water level change has been observed in this area within the last two years. Changing water levels result in variable aquifer thicknesses (B) and regional flow velocities (U). The changing water levels also cause pressure changes in the well pump system, inducing variable pumping rates (Q) that are directly proportional to the water level changes. The results of these water level changes, it follows, equate to variable capture zone sizes, as predicted by Equation (1) in Appendix F.

APPROXIMATE DIRECTION OF GROUNDWATER FLOW

MW06
A - ND
B - 0.6

MW03
A - ND
B - 22

MW02
A - 0.3
B - 16

MW04 A - ND B - 16

MW05 A - 0.6 B - 32

MW08
A - 0.6
B - 8

MW07
A - 9
B - 9

MW09
A - 4.3
B - 9.3

NEWMARK WELL 3 (1600 GPM)
NEW EXTRACTION WELL (1300 GPM)
NEW EXTRACTION WELL (1000 GPM)

MW-12
MW-11
MUNI-16
MUNI-14
MUNI-19
MW01
MW10
MUNI-24

San Andreas Fault

## LEGEND

- Bedrock Outcrop
- Boundary of No Flow Area
- Capture Zone
- 1000 GPM — Extraction Rate
- △ — Monitoring Wells
- ○ — Municipal Supply Wells
- A - 0.3 — PCE Concentration (ug/l) in Subunit A
- B - 6 — PCE Concentration (ug/l) in Subunit B

Note : Concentrations of PCE in Groundwater are Based on April 1993 and November 1994 Sampling Data.

Only PCE Data In The Wells Near The Newmark Wellfield are Shown

ND - Non-Detect

0' 2000' 4000'

SCALE IN FEET

N

C:\PROJ\NEWMARK\NORTH\FIGI-3.DGN

URS Consultants, Inc.
Sacramento, Ca

NEWMARK OU RD
NEWMARK GROUNDWATER CONTAMINATION SUPERFUND SITE

# FIGURE 1-2

PROPOSED EXTRACTION WELL LOCATIONS AND CAPTURE ZONES NEWMARK WELLFIELD AREA

The results of the capture zone calculations, presented in Subsection 2.5 of Appendix F, reflect high water level conditions. Calculations were also performed for low water level conditions using historical data supplied by the city of San Bernardino Water Department. It appears that the capture zones calculated for low water conditions would be smaller, possibly as much as 200 feet narrower, than those for high water conditions.

The main impact from large water level changes is a complex variation of capture zones. The capture zone changes are difficult to predict given the uncertain and unpredictable nature of the water level changes, variable regional flow velocities, and aquifer heterogeneities in this area. Considering these factors, it is possible that a third new extraction well (or more) could be necessary to maintain plume capture after the proposed extraction system has begun operation. It is not considered prudent, however, to propose a larger extraction system at this time. The system should be evaluated after operating and monitoring data become available.

The proposed extraction wells will be screened over a portion of the aquifer to optimize contaminant capture (probably the lower portion of the aquifer). Actual pumping rates will be based on pumping tests performed on the newly constructed wells. Regardless, the proposed design is considered optimum, based on currently available data.

## 1.5 BASIS FOR PROCESS DESIGN AND COMPONENT SIZING

LPGAC system design and component sizing are based on records from existing well pumping, groundwater extraction modeling, recommendations from carbon vendors, and results of pump testing conducted at wells located near the proposed new well locations. Data from other groundwater treatment plants operated by the City were also incorporated in this evaluation, i.e., Waterman facility (air strippers), existing North Plant (air strippers), 19th Street facility (LPGAC) and 17th Street facility (LPGAC). The operational parameters of these plants are comparable to the anticipated operational parameters of the proposed North Plant. Additionally, URSG's professional judgment and past experience with similar projects, plus a consensus reached during a project meeting in San Bernardino between the USEPA, the City, the Department of Toxic Substances Control (DTSC), the DHS, and URS on November 16, 1994, were also instrumental in the design (URS 1994b).

Appendix A presents operational data provided by the City. Figures A-1 through A-4 graphically present production rates of the four wells. Appendix B summarizes results from groundwater analyses at the North Plant. Figures B-1 through B-4 present graphs of influent concentrations at several city water treatment plants. Figures B-5 through B-8 present graphs of contaminant concentrations at each extraction well. Appendix C presents design calculations and graphs used during design. Appendix D presents design information submitted by LPGAC vendors for equipment sizing, and Appendix E presents design information for the chlorination system and the flowmeters. Specifications and construction drawings are presented in a separate package (URSG 1997b).

Information received by the LPGAC vendors indicates that a minimum contact time of ten minutes is required to achieve adequate removal efficiencies by the LPGAC filters. This can be achieved in a parallel i.e., single-pass, configuration at a maximum flow rate of approximately 500 gpm through each vessel. However, serial, i.e., a double-pass, configuration of LPGAC filters is recommended for the following reasons:

- Higher reliability to meet discharge requirements.
- Reduced carbon usage due to more complete carbon loading.
- Simplified breakthrough sampling. In serial configuration sampling is required between primary and secondary LPGAC filters only. For parallel configuration, however, vendors recommend collection of actual carbon samples at different depths from the vessels.

Because the maximum recommended flow rate through each LPGAC filter is limited to approximately 750 gpm, more LPGAC vessels would be necessary for treatment in serial configuration. The additional capital costs are expected to be offset by the reduced LPGAC usage over the project duration. URSG's review of this information indicates that a hydraulic contact time of fifteen minutes across two LPGAC vessels arranged in series will be required to keep the flow rate through each vessel below 750 gpm, and to minimize pressure drop. Figure C-1 graphically presents the relationship between flow rate and total contact time.

Several uncertainties impact the determination of a design flow rate at the North Plant. These issues were discussed in URSG's Technical Memorandum (URS 1995a) and the main factors are summarized below:

- Large seasonal variations in groundwater level.
- Significant influx of groundwater from the west (through the Shandin Hills, Wiggin Hill gap), which cannot be accounted for in the model runs as presently calibrated.
- Additional impact of groundwater level fluctuations as a result of state project water being spread upgradient of the North facility.

For the determination of the design flow rate, these uncertainties have to be accounted for by applying a safety factor of 25 percent, resulting in a total design flow rate of 4,875 gpm. To treat the anticipated flow rate, seven pairs of LPGAC vessels are required (Sheets P-1 through P-5, URSG 1997b).

The process components are discussed in detail in Section 2.0. The expected contaminants and their respective levels in the groundwater are also discussed in Section 2.0.