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A JOINT POWERS AGREEMENT BETWEEN THE CITY OF SOUTH LAKE TAHOE, CALIFORNIA AND DOUGLAS COUNTY, NEVADA CONCERNING CITY PARTICIPATION IN THE COST OF CLOSURE OF THE DOUGLAS COUNTY LANDFILL.

RECITALS

1. WHEREAS, the City of South Lake Tahoe, California (hereinafter City) and the County of Douglas, Nevada (hereinafter County) have a mutual public and governmental interest in the use and closure of that certain facility commonly known as the Douglas County Landfill operated by County;

2. AND WHEREAS, both City and County desire to agree upon the terms and conditions upon which the landfill will continue to operate during City participation and to insure that the costs of operation and closure are equitably shared betweeen all users of the facility;

3. AND WHEREAS, the distribution of such costs and assurance of continued use and operation of the facility until closure requires that an agreement be entered into between the parties which will have a duration sufficient to allow for continued monitoring of the facility in accordance with applicable federal and state law;

4. AND WHEREAS, both entities have met and determined that entry into a joint powers agreement will provide an appropriate vehicle for insuring that the expenditures of both parties are made in a manner consistent with their mutual interests while protecting the interests of their constituents;

For and in consideration of the mutual promises herein set forth, it is agreed as follows:

SECTION 1

LEGAL AUTHORITY

This agreement is made and entered into under the legal authority provided by California Government Code Section 6500 et seq. and Nevada Revised Statutes 277.080 - 277.180 authorizing bi-state local governments to jointly exercise any powers common to the contracting parties.

SECTION 2

PURPOSE

The express purpose of this agreement shall be to provide for the following joint activities:

1. City and County shall participate in the landfill closing costs based upon the formula and estimated costs showing on Exhibit A attached hereto and incorporated by reference herein as if fully set forth.

It is understood and agreed by the parties that the costs set forth in Exhibit A are estimates and not fixed figures. However, all parties will utilize their best good faith efforts to insure that the estimated costs are not exceeded.

2. The activities undertaken as described in Exhibit A, and payment thereof, shall commence on or about October 1, 1990 and shall conclude September 30, 1992. If, due to the provisions of state or federal law, or other causes beyond the reasonable control of either party, the closure is not complete by that date, this agreement shall be automatically reviewed by the City Rate Review Committee for recommendation to the City for extension for an additional year or such time as necessary to raise funding, but shall in any event conclude as to closure activities on September 30, 1993 or as soon as practical thereafter. As to continuing monitoring activities, see Section 3.

3. All costs of closure as estimated in Exhibit A shall be subject to semi-annual audit by the Auditors of City and County, or their designees. Audits shall occur on or about April 1 and October 1 of any year within the contract term. If audits indicate increases in the costs contained in Exhibit A, the City, upon recommendation of the Rate Review Committee may, at its discretion, agree to further extensions of the term of this agreement sufficient to cover any such additional costs. If audits show a decrease in cost, the duration of the rate increase may be shortened upon review of the Rate Review Committee and recommendation to the City Council.

4. It is understood and agreed by the parties that the estimated costs for the $3/ton state surcharge are not contained in the closure costs outlined in Exhibit A, but will be based on the assumption that, of the waste now entering the landfill from the Tahoe Basin via South Tahoe Refuse, seventy (70) percent is from the California portion of the basin, and thirty (30) percent comes from the Nevada portion of the basin. Out-of-state refuse coming to Nevada is subject to a charge of three (3) dollars per ton, which is paid to the State of Nevada.

Waste stream analyses will be conducted by City on or about August 1, 1990 and December 1, 1990 to determine the validity of the assumed division. Additional studies may be undertaken as deemed necessary and as agreed to by the parties.

If the analyses reveal a different proportionate waste stream, the costs will be appropriately recalculated and debited or credited appropriately by the Chief Executive Officers of the parties. Any such recalculation shall be deemed to have become effective on July 1, 1990.

All monies collected by South Tahoe Refuse for the $3/ton fee shall be held by South Tahoe Refuse for quarterly payment to the State of Nevada.

SECTION 3

ONGOING MONITORING

In accordance with applicable federal and Nevada law, monitoring of the landfill upon closure will be required to continue for a period of thirty (30) years from October 1, 1990 to September 30, 2020.

The monitoring program proposed by the parties is attached hereto in Exhibit B and delineated for cost participation in Exhibit A, together with the estimated costs of the program. The parties shall utilize their governmental and regulatory authority to insure a refuse collection rate sufficient for that period to pay the costs of such monitoring.

Ongoing monitoring costs shall also be subject to the semi-annual audit procedure outlined in Section 2.3. Should audits reveal applicable additional costs, those costs shall be paid conditional upon approval by City for increased refuse rates. Any reduction in costs of ongoing monitoring shall also be reflected in a downward adjustment.

SECTION 4

SERVICE CONTINUATION

The existing County landfill shall not be closed to City refuse until the date of official closure by Douglas County or until such time as a substitute landfill or other disposal facility satisfactory to City has been located. Such facility must have all the permits and operating authority required by local, state, and federal law, and be prepared to receive refuse from City on terms and conditions satisfactory to City. The determination of what is satisfactory to City shall be made by the City Council of City in the exercise of its sole discretion.

It is anticipated by the parties that such a substitute landfill will be available and legally operational on or before September 30, 1992. However, the right of City to continue depositing waste in the existing Douglas County landfill shall continue unimpeded until a satisfactory substitute has been procured or until September of 1993, as referenced in Section 2 paragraph 2 of this agreement.

Nothing in this agreement is intended to preclude the possible future participation of the parties in a new landfill.

SECTION 5

EXISTING LANDFILL CONDITIONS

All parties agree that the known existing condition of the landfill site with regard to soil and water contamination are as depicted in the reports attached as Exhibit C and incorporated by reference herein as if fully set forth.

It is these conditions which this agreement is intended to remediate prior to closure of the landfill. In the event that, during closure activities, there are further conditions or new information discovered regarding contamination of any type, this agreement shall be deemed suspended by operation of law and the parties will use their best efforts to reach in good faith, and consistent with this agreement, an amendment as to how to further proceed.

SECTION 6

CONDITIONS

Payment of all costs incurred as a result of this agreement shall be subject to approval and implementation of appropriate refuse rate increase. Under no circumstance shall this agreement obligate the general fund of either party.

SECTION 7

HOLD HARMLESS AND INDEMNIFICATION

City hereby agrees to hold harmless, indemnify, and defend County from any actual or alleged liability which arises from any intentional tort or negligent acts of City in performing the terms and conditions of this agreement.

County hereby agrees to hold harmless, indemnify, and defend City from any actual or alleged liablity which arises from any intentional tort or negligent act of County in performing the terms and conditions of this agreement.

SECTION 8

AMENDMENTS

This agreement may only be amended in writing. Any amendment shall be approved by a majority vote of the governing board of both parties.

SECTION 9

ENTIRE AGREEMENT

This agreement constitutes the entire agreement between the parties and supercedes any and all previous agreements, understandings, verbal or written, and actions of the signators relating to the subject matter hereof.

Executed this 4th day of September, 1990.

Approved as to Form:

J. Dennis Crabb

J. DENNIS CRABB
City Attorney
City of South Lake Tahoe

Approved as to Form:

Brent Kolvet

BRENT KOLVET
County Counsel
Douglas County

Approved By:

FRANK HEMBROW
Mayor Pro Tem
City of South Lake Tahoe

MICHAEL E. FISCHER
Chairman
Douglas County Board of
Commissioners

ATTESTED BY:

Angela Peterson
ANGELA PETERSON
City Clerk

ATTESTED BY:

Barbara Reed
BARBARA REED
County Clerk

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Exhibit A

DOUGLAS COUNTY LANDFILL RATE INCREASE ATTRIBUTABLE TO SHARED LANDFILL CLOSURE COSTS

SHARED COST	AMOUNT	74%
Existing Landfill Closure	$2,045,000	$1,513,300
New Landfill		
Preliminary Evaluation	$30,000	$22,200
Reno/Storey Alternative	$20,000	$14,800
Phase II	$150,000	$111,000
Liquid Waste		
Pilot Program	$75,000	$55,500
Treatment Program	$50,000	$37,000
Prior Payments	($150,000)	($111,000)
Totals:	$2,220,000	$1,642,800
Divided by 2 Years	$1,110,000	$821,400
Annual Operating Cost	$450,000	$333,000
Continued Annual Costs	$280,000	$207,200
Credit for prior rate increase and payment of operating cost $12/ton x 72,212 tons		($866,544)
Required Increase		$494,456
Current Revenue		$4,435,842
Increase per ton	$6.86	
Percentage Increase		11.2%

Exhibit D

DOUGLAS COUNTY SOLID AND LIQUID WASTE MANAGEMENT PROGRAM
FUNDING REQUIREMENTS

COMPONENT	PURPOSE	COST
Solid Waste Management Program		
EXISTING LANDFILL CLOSURE		
• Landfill Surveying	Aerial mapping of landfill for design purposes and survey of boundaries.	$20,000 *
• Mining Plan for Cover Material	Plan required by BLM for free use of cover materials and closure cover material.	$5,000 *
• Closure Bid Documents	Preparation of contract documents and specifications for closure.	$50,000 *
• Contract Administration	Management activity required for orderly closure of landfill.	$25,000 *
• Construction Supervision	Inspection of construction, construction stake-out, and materials testing for closure.	$95,000 *
• Construction	Cost of regrading landfill slopes, providing drainage control, and capping landfill.	$1,750,000 *
• Drainage Mitigation Basin	Drainage control including drainage basin	$350,000 *
		SUBTOTAL $2,295,000
• Solid Waste Program Administration	On-going involvement of staff in landfill closure program, transfer station siting implementation, continuing financial review, and general management function.	$40,000/yr
• On-going Operation Related to Closure	Operation and maintenance of roads and drainage structures.	$50,000/yr
• Ground Water and Gas Monitoring	Ground water monitoring and gas control and monitoring.	$150,000/yr
• Regulatory and Landfill Compliance	On-going involvement of staff in developing and enforcing performance standards at landfill and other waste management activities.	$40,000/yr
		SUBTOTAL $280,000

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* Approved by the Board on February 15, 1990

EXHIBIT 6

DOUGLAS COUNTY SOLID AND LIQUID WASTE MANAGEMENT PROGRAM
FUNDING REQUIREMENTS

COMPONENT	PURPOSE	COST
NEW LANDFILL		
• Phase I Preliminary Evaluation and Screening	Identification of preferred site.	$30,000 *
• Evaluation of Reno/Storey County Alternative	Determination of legal liability and technical merit.	$20,000 *
• ~~Evaluation of Douglas County/Calif. Volume~~	~~Documentation of Calif. contribution as the basis for allocating costs.~~	~~$40,000.~~
• Phase II Final Evaluation and Screening	Refinement of merits of preferred site at feasibility level.	$150,000
• Phase III Final Design and Bid Documents	Final design and preparation of contract document and specifications.	$300,000
• Phase IV Construction, Contract Administration, Construction Supervision	Construction of new landfill.	UNDETERMINED $3,000,000 - $5,000,000 (est.)
	SUBTOTAL	$3,540,000 - $5,540 mm (est.)

NOTE: For purposes of calculations, use 70% Calif. contribution 96,000 tons/yr total.

* Approved by the Board February 15, 1990

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DOUGLAS COUNTY SOLID AND LIQUID WASTE MANAGEMENT PROGRAM
FUNDING REQUIREMENTS

COMPONENT	PURPOSE	COST
Liquid Waste Management Program GREASE MANAGEMENT		
• Pilot Program	Testing program to ensure performance of bio-stem treatment and compatibility with conventional wastewater treatment administration of grease disposal.	$75,000 •
• Ordinance and Regulations		DA's Office •
• Treatment Program		
Agreements	Preparation of contracts with generator treatment agencies.	$10,000 •
Preliminary Design	Preliminary layout of program features and components.	$15,000 •
Final Design	Final layout or program features and components.	$25,000 •
• Septage Management		
Co-Disposal at Reno-Sparks	Exploration of disposal at Reno-Sparks WWTP as a permanent solution.	DA's Office •
Ordinance and Regulations	Administration of septic tank disposal.	DA's Office •
Regional Treatment Facility Design and Construction Management	Design of facilities within Douglas County in the event Reno-Sparks is not a permanent solution.	$50,000
Regional Treatment Facility Construction	Construction of septic tank sludge disposal facilities at the site of the North Valley Waste Water Treatment Plant.	$250,000
• Recycling Program Administration	Management of solid waste recycling program; informational materials and part-time program coordinator.	$25,000
• Sludge Management		
Interim Program	Program to dispose of wastewater treatment plant sludge as a soil amendment.	$10,000
• Household Hazardous Wastes Small Quantity Generator Program	Provide means of diverting household and small quantity generator hazardous wastes from the landfill to environmentally suitable disposal or refuse sites.	$40,000 •
		SUBTOTAL $500,000

• Approved by the Board February 15, 1990

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EXHIBIT D

DOUGLAS COUNTY SOLID AND LIQUID WASTE MANAGEMENT PROGRAM
FUNDING REQUIREMENTS

COMPONENT	PURPOSE	COST
TRANSFER STATION - VALLEY		
• Phase I Preliminary Siting	Identity and screen potential transfer station sites.	$50,000
• Phase II Final Site Selection	Evaluate preferred transfer station site.	$60,000
• Phase III Final Design and Bid Documents	Final Design and preparation of contract documents and specifications.	$150,000 - $300,000
• Phase IV Construction, Contract Administration, Construction Supervision	Construction of transfer station.	$1,000,000 - $2,000,000
	SUBTOTAL	$1,270,000- $3,420,000 (est.)

Exhibit C

2.0 INTRODUCTION

This report presents the results of the Phase I ground-water investigation conducted by Hydro-Search, Inc. (HSI) at the Douglas County Landfill near Gardnerville, Nevada. Work was conducted pursuant to a request by Mr. John Marchini, Vice President, South Tahoe Refuse Company (STRCo), in response to the Finding of Alleged Violation and Order issued to STRCo by the Nevada Division of Environmental Protection (NDEP) on January 6, 1988.

Objectives of the Phase I investigation are to: 1) satisfy the intent of the NDEP Order (Appendix A); and 2) determine the probable source, occurrence, and potential extent of tetrachloroethylene (or perchloroethylene, PCE) detected in ground water from the landfill water-supply well. These objectives have been achieved based on:

1. off-site ground-water sampling from three private domestic wells,
2. sampling and analysis of soils from two shallow soil borings in the vicinity of a leach field near the landfill supply well,
3. on-site ground-water sampling from the landfill supply well (LSW) and monitor well E-1,
4. construction, development, and sampling of two additional ground-water monitor wells, and
5. evaluation of hydrogeologic and water-chemistry data.

HSI personnel who participated in the investigation include Mr. Mark Hudson, hydrogeologist; Mr. David King, hydrogeologist; and Mr. Mark Cross, senior hydrogeologist and project manager. Monitor well drilling, construction, and development were conducted by Sargent Drilling Company, Reno, Nevada. Laboratory analyses for organic constituents were conducted by Alpha Analytical, Inc., Sparks, Nevada, and analyses for inorganic constituents by

CHEMAX Laboratories, Inc., Sparks, Nevada. Duplicate laboratory analyses for organic constituents were performed by Brown and Caldwell Laboratories, Emeryville, California.

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3.0 REGIONAL HYDROGEOLOGIC CONDITIONS

The Douglas County Landfill is located on the southeastern edge of the Carson Valley. The valley is underlain by a sequence of water-bearing alluvial deposits and is surrounded by consolidated rocks. The landfill is directly underlain by partially consolidated older alluvium. Consolidated rocks crop out to the east of the landfill (Figure 1).

Three major hydrogeologic units occur in Carson Valley. In ascending order, these include: 1) consolidated rocks, 2) older alluvium, and 3) younger alluvium. The consolidated rocks form the upland areas surrounding the valley, and underlie the alluvium which fills the basin. The alluvial deposits generally consist of a sequence of interbedded fine- and coarse-grained valley-fill alluvium which thickens toward the center of the valley. These deposits include the regional aquifer system which supplies water for domestic, irrigation, and industrial uses. Ground water in the regional aquifer system is produced primarily from two relatively coarse-grained sand and gravel aquifers. An intervening fine-grained silt and clay unit impedes ground-water movement between the two aquifers, and acts as a confining unit to ground water in the lower aquifer (Glancy and Katzer, 1975).

The younger alluvium occupies the central portions of the valley, and consists of unconsolidated silt, sand, gravel, and boulders deposited primarily by streams. The older alluvium, exposed near the margins of the valley, is relatively more consolidated and contains a higher proportion of fine-grained material than the younger alluvium. The landfill is directly underlain by the older alluvium. These sediments are generally poorly sorted. However, a

4.0 LANDFILL SITE CONDITIONS

The Douglas County Landfill is situated on the southeastern edge of the Carson Valley near the western flank of the Pine Nut Mountains. The landfill site is mildly sloping with elevations ranging from 5060 feet to 5220 feet (Figure 2). Annual precipitation is approximately 8.6 inches with the majority occurring during the winter months.

The landfill is underlain by deposits of clay, silt, sand, and gravel of the older alluvium. Depth to the aquifer system beneath the site is on the order of 250 to 300 feet. Static water levels in wells penetrating the aquifer are at a higher level than the top of the aquifer, indicating an artesian system under confining pressures. The confining unit is composed of sandy silt, silty gravel and clayey gravel. Thickness of the confining unit is about 50 to 100 feet.

Tetrachloroethylene (perchloroethylene, PCE) has been detected at low concentrations, on the order of 10 micrograms per liter (ug/l), in water samples from the landfill supply well. PCE is listed by the U.S. Environmental Protection Agency (EPA) as a volatile organic priority pollutant. Currently, there are no federal or State of Nevada standards for PCE. The maximum contaminant level (MCL) for PCE in drinking water will be proposed by EPA at 5.0 ug/l (verbal communication, EPA, August 1988).

The occurrence of PCE in ground-water samples from the landfill supply well may have resulted from one or both of the following possibilities:

1. PCE may have originated from past disposal at the landfill and migrated vertically downward to ground water beneath the landfill. PCE could then migrate laterally to the supply well with ground water in the aquifer.

2. The landfill supply well may provide a conduit for migration of surface water or perched ground water down the wellbore. A well driller's report for the landfill supply well was not filed with the Nevada Division of Water Resources, and the depth and construction of the surface seal are not known. A faulty seal could allow downward migration, to the aquifer, of any contaminated surface water or shallow perched ground water. Also, even a properly constructed surface seal to the minimum required depth of 50 feet would not prevent migration down the wellbore of perched ground water from depths greater than 50 feet.

The investigative methods used in this study were designed to evaluate the likelihood that PCE may have entered the aquifer by either of the two scenarios discussed above. Below is a discussion of the methods of investigation.

4.1 SITE INVESTIGATION

To investigate the source and occurrence of PCE in ground water at the landfill supply well, shallow soil sampling was conducted in the vicinity of the supply well, and two monitor wells were constructed and sampled down-gradient (in the direction of ground-water movement) from the landfill.

4.1.1 Soils Investigation

Solvents have been used in the maintenance garage near the supply well. A septic tank and leach field also occur near the supply well. It is possible that any spillage of used solvents to the ground near the maintenance garage or disposal to the leach field could result in migration of PCE to the landfill supply well.

Two soil borings were drilled on March 22, 1988 to investigate the possibility of migration of PCE to the landfill supply well from the surface. Both borings were located between the landfill supply well and the landfill septic tank. Boring AH-1 was drilled adjacent to the landfill supply well, and boring AH-2 was drilled adjacent to the septic tank. The borings were drilled to a depth of 25 feet using a 24-inch diameter auger and a Texoma auger drilling rig. Soil samples were collected every five feet, placed in mason jars, chilled, and transported under chain-of-custody to the laboratory for analysis.

As a preliminary field check for the presence of PCE and other volatile organic compounds (VOCs), soil samples were tested for trace gases using a portable HNU photionization meter. The borings penetrated unconsolidated and loosely consolidated silty gravel to a depth of 25 feet. No clay or silt units were encountered which could act as a perching layer, and no ground water was encountered in the borings.

The results of the field testing with the HNU meter indicated no detectable concentrations of VOCs in the soil samples. Two soil samples were analyzed (one from each boring) for the presence of VOCs using EPA method 8024. No VOCs were detected in these samples (Appendix D).

The results of the shallow borings suggest that, to a depth of 25 feet: 1) no PCE occurs in soils near the supply well, and 2) no shallow, perched ground-water zones are present to transmit contaminants from the leach field to the landfill supply well. These findings do not preclude the possibility that the landfill supply well provides an avenue for contaminants to enter the aquifer from deep, perched water zones.

4.1.2 Monitor Well Drilling, Construction, and Development

Two ground-water monitor wells were installed to sample water from the aquifer. Both wells are located down-gradient from the landfill (Figures 2 and 5).

Well M-1 is located up-gradient of the landfill supply well. This location was selected to detect any ground-water contaminants migrating from beneath the landfill, while minimizing the possibility of detecting any ground-water contaminants which might occur due to migration down the gravel pack of the landfill supply well. The presence of VOCs in the ground water from well M-1 would diminish the likelihood that the landfill supply well is providing the only conduit for migration of VOCs to the aquifer. In contrast, the absence of VOCs in ground water from well M-1 would suggest that the landfill supply well is providing a conduit for the migration of VOCs to the aquifer.

Well M-2 is located 1300 feet west of and down-gradient from well M-1. This location was selected to determine if ground-water contaminants have migrated an appreciable distance from the landfill.

The monitor wells were drilled, constructed, and developed by Sargent Drilling Company with supervision by HSI hydrogeologists. The drilling rig used was a Speedstar 70K, capable of reverse circulation air, water, and conventional rotary drilling.

The monitor wells are constructed with 2-inch stainless steel and 2-inch low-carbon steel casing (Appendix C). The stainless steel portion of the casing extends from total depth to above the static water level. Low carbon steel casing extends to the surface. The two casing strings are connected with an insulating couple, which prevents the development of a galvanic cell between the two dissimilar metals. This precaution minimizes the risk of future corrosion of the casing.

Each well was airlift developed for approximately six hours. Airlift discharge rates ranged from less than 1 gpm to approximately 4 gpm. Each well was then pumped a minimum of 24 hours at approximately 1 gpm using a submersible piston pump (Bennett pump, model 1800).

Monitor Well M-1

Monitor well M-1 is completed to a depth of 312 feet below ground surface. Perched ground water was not detected to a depth of 240 feet during drilling of the pilot hole, utilizing dual-tube reverse air circulation. Nevertheless, nominal 8-inch conductor casing was cemented to a depth of 230 feet, to prevent any future perched ground water from entering the well.

The borehole penetrated sand, silt, and gravel with local interbedded volcanic rocks (Appendix C). A poorly permeable unit consisting of 50 feet of sandy silt and clayey gravel was encountered in the interval 220 to 270 feet. This unit would tend to restrict vertical ground-water movement and is considered to be an aquitard and confining layer. The aquifer was encountered at 270 feet, and consists of clean sand and gravel (Figures 3 and 4).

Monitor Well M-2

Monitor well M-2 is completed to a depth of 360 feet below ground surface with nominal 8-inch conductor casing cemented to a depth of 95 feet, and the 2-inch casing cemented to a depth of 290 feet. The borehole penetrated similar materials to those at M-1, although no volcanic rocks were encountered. The aquitard and confining layer, comprised of clayey and silty gravel, was encountered in the interval 210 to 310 feet. The aquifer, comprised of sand and gravel, was encountered at a depth of 310 feet.

4.1.3 Ground-water Sampling

Ground-water samples have been collected for analysis of organic and inorganic constituents from three off-site domestic wells and four on-site wells. Off-site wells located nearest the landfill were sampled once in February, and included the Roberson well, the Geary well, and the Johnson well (Figure 2). Results of off-site ground-water sampling are summarized in Tables 1 and 2, Appendix E. No volatile organic priority pollutants were detected, and the water meets applicable Federal and State drinking water standards for inorganic constituents.

Ground water in the vicinity of the landfill has been sampled monthly since February 1988. During the period February through June, sampling was conducted at the landfill supply well and the Emcon well (E-1) (Figures 2 and 5). The supply well is located in the landfill maintenance yard, directly down-gradient from the landfill. Well E-1 is located west of the southern portion of the landfill. Ground-water sampling has also included monitor wells M-1 and M-2 since completion of these wells in July 1988. All of these wells are completed in the aquifer. Samples have been analyzed in the laboratory for volatile organic EPA priority pollutants (EPA Method 624), common ions, and selected trace metals. Results of analyses of samples from all on-site wells are summarized in Tables 3 through 10, Appendix E, and discussed in Section 4.3.

4.2 OCCURRENCE AND MOVEMENT OF GROUND WATER

The principal water-bearing unit beneath the landfill is a sequence of sand and gravel in the older alluvium. This aquifer occurs at a depth of about 300 feet, and is separated from the surface by a sequence of moderate to low permeability materials. Water levels measured in wells are in the range of 200 to 250 feet below land surface. Ground water occurs under confined conditions. Recharge to the aquifer is primarily from infiltration of precipitation and runoff from the surrounding uplands, and adjacent alluvial slopes.

Water level data from wells in the vicinity of the landfill indicate a direction of ground-water movement of about N 85° W under a hydraulic gradient of about 10 feet per mile. This direction of ground-water movement is consistent with the direction of movement indicated on regional water level contour maps (Maurer, 1986).

4.3 RESULTS OF GROUND-WATER SAMPLING

Ground water samples were taken from three off-site domestic wells, the landfill supply well, monitor well E-1, and two newly constructed monitoring wells (M-1 and M-2). Ground water samples were also taken from the landfill supply well in a previous site evaluation by an EPA field investigation team on September 28, 1980.

Analyses for Volatile Organic Priority Pollutants

Results of on-site ground-water sampling indicate the occurrence of tetrachloroethylene (or perchloroethylene, PCE) at the landfill supply well. Concentrations have ranged from 9 to 19 ug/l (Table 3, Appendix E). A second organic substance, Trichloroethylene (TCE), was also detected at the landfill supply well at very low concentrations. TCE concentrations at the landfill supply well were reported as nondetectable (ND) in the December, 1987, March, April, and June, 1988 samplings, and as 1 ug/l in the May, August, and September samples. One ug/l concentration is the lower detection limit of the chemical analysis method used, and is well below the proposed EPA maximum concentration for this constituent in drinking water.

Results of a 1980 water quality sampling from the landfill supply well by the EPA indicated the occurrence of PCE in ground water at a concentration of 12 ug/l, approximately the same concentration as measured for this study (EPA Field Investigation Report, 1980). The EPA investigation was conducted in response to an unsubstantiated complaint that PCE had been disposed of in the landfill.

Initial ground-water sampling in July, 1988 at monitor well M-1, up-gradient of the landfill supply well, did not indicate the occurrence of PCE. Toluene and xylenes, which were detected at or near the detection limit, are believed to represent contamination of the samples in the field, in transit to the laboratory, or in the laboratory. Toluene and xylenes are common in motor vehicle fuels, and may have been present as vehicle exhaust fumes from nearby vehicle traffic at the time of sampling.

Results of the second and third sampling episodes at monitor well M-1 indicate 4 ug/l and 8 ug/l, respectively, of PCE. Results of soil sampling (Section 4.1.1) did not indicate the occurrence of PCE in soils in the area of the maintenance yard and leach field where well M-1 is located. These combined results of soil and ground-water sampling suggest that PCE has migrated in the aquifer from beneath the landfill to the area of well M-1. The occurrence of PCE in ground water is probably a result of past disposal of used solvents at the landfill.

No volatile organic priority pollutants have been detected above the detection limit of 1 ug/l at either monitor well E-1 or M-2. These results, in conjunction with the very low concentrations of PCE detected at the landfill supply well and monitor well M-1, suggest that the extent of PCE in ground water is probably limited to the immediate area of the landfill.

The presence of organic constituents in well M-1, up-gradient from the landfill supply well indicate that VOCs may be following a pathway that begins up-gradient of both wells. However, this does not unequivocally dismiss the landfill supply well as a potential avenue for contaminants to enter the aquifer.

Analyses for Inorganic Constituents

Results of on-site ground-water sampling indicate that water quality meets applicable Federal and State drinking water standards for inorganic constituents (Tables 2 through 10, Appendix E). Ground water is generally a sodium-bicarbonate type. Concentrations of total dissolved solids are in the range of 200 to 400 mg/l. No elevated concentrations of common ions, trace metals, or nitrate occur which would be attributable to operation of the landfill.

The high pH of water from well M-2 is believed to be a result of contact of the water sample with cement. The cement seal at well M-2 extends to a depth of 290 feet (Appendix C) in the aquitard, and is underlain by bentonite in the interval 290 to 300 feet. The aquifer occurs below about 310 feet, and the well screen is in the interval 320 to 360 feet. Because the cement seal was placed above the aquifer, and opposite the aquitard, ground water in the aquifer should not be affected by the presence of the cement seal. It is possible some vertical downward leakage of cement slurry may have occurred at the time of placement of the cement seal. It is expected that any residual effects of cement placement will decrease with time, and the pH of subsequent water samples is expected to eventually decrease to background conditions.

5.0 CONCLUSIONS

Ground water in the vicinity of the landfill supply well and monitor well M-1 contains low concentrations of PCE. PCE is an industrial solvent widely used in the manufacturing of electronics, automotive and engine repair, dry cleaning and asphalt operations. It also has domestic applications in paint thinners and as a septic tank degreaser. The occurrence of PCE in ground water from both wells, directly down-gradient from the landfill, and the absence of other potential up-gradient sources indicates that the landfill is the probable source of PCE detected in ground water. The extent of PCE in the ground water is probably limited to the immediate area of the landfill as indicated by the absence of any PCE, or other organic chemicals, in wells M-2 and E-1, which are located downgradient from the landfill supply well and well M-1.

It is possible that at some time during the history of the landfill, disposal of solvents has occurred. Industrial sludges have been disposed of in the landfill in unlined evaporation ponds (EPA Field Investigation Team, 1980). At least some of these sludges probably contained industrial solvents, which over a period of years, could have migrated downward by gaseous diffusion and/or liquid transport to the aquifer.

In accordance with current landfill operation practices, no solvents are presently disposed of in the landfill to the best of the operators knowledge. However, residual concentrations of PCE and possibly other solvents may occur in soils above the aquifer. These residual concentrations comprise a potential source of contamination to the aquifer.

Exhibit C

Douglas County Landfill
Expansion and Closure Plan

Design Report

REGISTERED PROFESSIONAL ENGINEER STATE OF NEVADA
RONALD J. OWES
CIVIL
No. 8307

For

Douglas County Department of Public Works

by

Harper-Owes Consulting Engineers

Vasey Engineering Co., Inc.

June, 1989

THIS DOCUMENT PRINTED ON
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CHAPTER 3

EXISTING SITE CONDITIONS

The Douglas County Landfill is located at the base of the foothills, approximately five miles southeast of Gardnerville, Nevada (NW 1/4, SW 1/4, Sec. 18, T12N, R21E). A topographic map showing the major physical features at the site is shown in Figure 3.1.

The Douglas County Landfill is owned by the U.S. Bureau of Land Management (US BLM). The site has been in operation since the 1960's. Prior to 1971, the facility was operated as a small municipal open dump by Douglas County. Since 1971, South Tahoe Refuse Company has operated the landfill for the County and established a Nevada Class I Sanitary Landfill.

The total site area is approximately 155 acres with 30 acres of this parcel serving as the existing refuse area. Forty acres of the above total has been recently acquired by Douglas County from the US BLM and is owned in fee title. It is planned to expand future filling operations into this new parcel.

In the past, approximately 60,000 gallons per month or more of septic tank pumpings and industrial sludges were disposed of in the landfill. This practice is now in the process of being curtailed.

3.1 Surrounding Property

The site is generally bordered by open land, however, in the vicinity to the west are the Douglas County Fairgrounds (approximately 1,320 feet), to the southwest a residential area known as Ruhenstroth with several hundred homes served by individual private wells (approximately 2,000 feet) and to the northwest a residential area known as Pinenut with more than 50 homes also served by individual private wells (approximately 6,000 feet). The nearest structure to the site is the Douglas County Animal Shelter located 1,000 feet west of the gate house. The animal shelter, which employs approximately five people, used to receive water from a well on the landfill adjacent to the gate house, but now receives water from the well south of the landfill in Ruhenstroth which serves the fairgrounds (Fairground Supply Well). Further west of the site (approximately 1 1/4 miles) is the Allerman Canal, the closest perennial body of surface water, which flows north to several irrigation reservoirs and then is distributed on agricultural fields with runoff ultimately reaching the Carson River.

3.2 Geology

The project site is located 5,000 to 5,200 feet above sea level in foothills along the southeastern edge of the Carson Valley. The valley is approximately 20 miles from north to south and 8 miles wide, and is incised between two parallel mountain ranges: the Pine Nut Mountains to the east and the Carson Range to the west. The valley floor slopes gently northwards from an altitude of 5,000 feet above sea level in the south to 4,600 feet in the north. In contrast, the mountains rise steeply from the valley to a maximum altitude of about 10,000 feet for the Carson Range and 9,000 feet for the Pine Nut Range.

The mountains are predominately granitic, west-tilting structural units as is the bedrock beneath the Carson Valley which is presumed to be the down-faulted edge of the Pine Nut block (Maurer 1986). Faulting continues in the region due to different uplift rates between the Sierra Nevada block and the lower Great Basin region (Wahler Associates 1982). A result has been a number of earthquakes. Between the years 1900 and 1974, three earthquakes with Richter Magnitude greater than 7.0 occurred about 100 miles east of the project site and five earthquakes greater than 6.0 occurred within a 50-mile radius. A second result is that the Pine Nut and Carson Range have been subdivided into smaller units. These breaks are visibly evident in the exposed mountain ranges, but also extend beneath the floor of the Carson Valley.

Granitic bedrock is exposed in the mountains, but thick alluvial deposits overlie the granitic bedrock within the Carson Valley. The Carson River and its forks have transported most of this material in from the Carson Range, but other creeks have been locally important. Pine Nut Creek, for example, in the vicinity of the project site, has transported course-grained sediment from the Pine Nut Range. The transported alluvium has been derived from a wide variety of igneous rocks and some metamorphous rocks, mainly granite, tuff, tuff breccia, andesite, basalt, rhyolite, slate, gneiss, sandstone and conglomerate (Langan 1971). These are the parent materials of soils in the Carson Valley. The various parent materials have created a patchwork of soils with varying physical and chemical properties. Most importantly, some soils are weakly cemented by silica or lime precipitates while others are unconsolidated and some soils exhibit pH greater than 10 due to high sodium levels while others are circumneutral.

The alluvial deposits generally consist of a sequence of interbedded fine and coarse-grained material which thicken towards the center of the valley. Younger alluvium occupies the central portions of the valley. Older alluvium, which contains a higher percentage of fine-grained material, underlies the younger material and is exposed at the surface along the valley perimeter.

Surficial soils in the immediate vicinity of the project site are composed primarily of Indian Creek gravelly fine sandy loam (4 to 16 percent slopes) with Reno gravelly sandy loam (2 to 8 percent slopes) and McFaul sand (2 to 8 percent slopes) also present (Langan 1971). These soils are similar in that they tend to be deep, moderately to well-drained and fine-grained. These soils are typically mildly alkaline, some lime is present in the Indian Creek soils, but the Reno and McFaul series are noncalcarious and soil pH generally ranges from 6.0 to 8.6. Some strata are weakly cemented with silica or lime and local concentrations of lime in the Indian Creek soils may be violently effervescent and strongly alkaline (Langan 1971). Corrosivity to uncoated steel is characterized as low for McFaul soils but moderate to high for Indian Creek and Reno soils.

The sequence of these alluvial deposits beneath the proposed project site can be evaluated based on drillers' logs from three monitoring wells at the existing Douglas County Landfill. One well, E-1, was drilled by EMCON in 1984 and two others, M-1 and M-2, by Hydro-Search, Inc. in 1988. Well logs are presented in Appendix A and vertical sequence of soils is presented in Figures 3.2 and 3.3. The sequence is similar for the three wells. Surficial soils were found to extend 90 to 106 feet deep and were sporadically interbedded with thin bands of volcanic rock and gravel conglomerate. An 80 to 125 feet thick layer of poorly sorted silty sandy gravel exists. This layer contains cobble and boulders, is partially consolidated and is interbedded by sand lenses. The next layer down is 55 to 105 feet thick and is composed of silty to very silty sand and gravel. The layer is poorly sorted, is partially consolidated, and is interbedded with volcanic rock, mud and conglomerate. The high silt content reduces permeability and this layer is considered to be an aquitard. Beneath the aquitard is fine to coarse-grained sand and sandstone which contains some gravel and extends to the depth explored, 360 feet. This sand layer contains an aquifer.

3.3 Groundwater

3.3.1 Groundwater Flow

Bore logs for monitoring wells at the existing Douglas County Landfill indicate that a 55 to 105 feet thick silty layer, an aquitard, exists 180 to 220 feet beneath the proposed project site. Above the aquitard, soils are moderately permeable and are dry or slightly moist but do not seem to contain an aquifer (Hydro-Search, Inc. 1988). Beneath the aquitard, sandy soils contain a confined aquifer with pressure head of 25 to 120 feet.

The general direction of groundwater flow near the project site has been determined from data for 23 wells (Berger 1987). Average groundwater surface elevations for these wells during the period 1983-1986 was computed and mapped (Figure 3.4). The results indicate that flow near the proposed landfill is west south west (WSW), which is in general accord with the assessment of Maurer (1986). The groundwater slope as determined from the three landfill monitoring wells on a single date in September, 1988 also revealed a WSW flow direction (Hydro-Search, Inc. 1988). The data evaluation performed by Maurer (1986) indicates that only very slight seasonal fluctuations in groundwater levels occur on the eastern flanks of the Carson Valley. Thus, the results from a single sampling at the landfill monitoring wells can be considered to be representative for the entire year. The horizontal flow rate in the confined aquifer can be estimated based on Darcy's Law:

$$Q = KIA$$

where Q is flow in cubic feet per hour, K is hydraulic conductivity in feet per hour, I is the hydraulic gradient in feet per foot and A is area in square feet. K is estimated based on grain size characteristics (Rawls et al. 1981) and is expected to be approximately 0.5 feet per hour. I is determined from well data (Figure 3.4 and Hydro-Search, Inc. 1988) and has been measured to range from 0.0016 feet per foot to 0.018 feet per foot. Thus, for each square foot of area under the project site, 0.0008 to 0.009 cubic feet per hour is expected to flow horizontally through the confined aquifer system. If the existing landfill plus the proposed landfill are 2,800 feet wide perpendicular to the groundwater flow direction and the confined aquifer is 100 feet thick, then 224 to 2,520 cubic feet per hour of water will pass beneath the landfill.

In summary, a confined aquifer exists 260 to 320 feet beneath the proposed project area and flows in a WSW direction. A low permeability aquiclude prevents this pressurized groundwater from migrating upwards as indicated by predominantly dry soils above and, similarly, may be expected to inhibit to a large degree the downward migration of leachate into the aquifer. Any leachate generated would be more likely to remain perched on top of the aquiclude and could be subjected to episodic flushing during wet years if a perched groundwater table were to develop. An estimated 224 to 2,520 cubic feet of water per hour passes beneath the landfill within the confined aquifer, but there is no data to support the contention that a perched water table exists in the vicinity of the project site.

3.3.2 Groundwater Quality

Groundwater chemical composition from monitoring wells at the existing landfill site have been compared with monitoring data from off-site locations and with data describing typical landfill leachate in an attempt to quantify the possible extent of leachate contamination. Off-site monitoring locations included three domestic drinking water wells and the Fairground Supply Well (Figure 3.5). These wells are located generally down-gradient and 2,100 feet to 6,700 feet from the perimeter of the existing landfill. Despite this proximity to the landfill, these off-site monitoring locations are used to represent background water quality because other, more appropriate, data was unavailable. "Typical" leachate characterizations are estimated based on a large, nationwide data set developed by Harper-Owes. Leachate is characterized by high levels of specific conductance, chemical oxygen demand, chloride, sulfate, heavy metals (especially iron, manganese and zinc) and some organic compounds (especially acetone, 2-butanone, methylene chloride, toluene, phenol and some phthalates) (Table 3.1).

The chemical composition in the background wells indicated good quality (Table 3.2). No primary or secondary drinking water criteria (40 CFR 141) were violated in any of the five samples. Volatile organic compounds were not detected in the Johnson, Geary or Robertson wells but have been detected in two of the four samples collected from the holding tank of the Fairground Supply Well (Table 3.3). Detected organic compounds included trihalomethanes (chloroform, bromoform, chlorodibromomethane and bromodichloromethane), toluene, ethylbenzene, xylenes and 4-methyl 2-pentanone. Trihalomethanes likely result from chlorination of the well. Toluene, ethylbenzene and xylenes are compounds present in gasoline as well as in landfill leachate, and 4-methyl 2-pentanone (also called methyl isobutyl ketone) is used as a degreaser and is also present in leachate. Thus, based on the organic constituents, it is possible that some leachate contamination has occurred in the Fairground Supply Well. However, other constituents which are typically used as landfill leachate tracers and are early indicators of leachate migration were not present at elevated levels.
Additionally, 4-methyl 2-pentanone was not detected in any of the on-site monitoring wells despite the fact that 50 samples have been collected (Table 3.3).

In summary, dangerous concentrations of contaminants have not been found in the Fairground Supply Well, but the presence of four solvents indicate that

Table 3.1. The chemical composition of "typical" full-strength landfill leachate is presented. Values were obtained from data collected from landfills throughout the Pacific Northwest, Alaska and the East Coast and, due to the similarity of municipal refuse throughout the U.S., are thought to be representative of undiluted leachate from Douglas County, Nevada.

PARAMETER (units)	"TYPICAL" FULL-STRENGTH LEACHATE
pH (standard units; field)	6.3
Specific Conductance (umhos/cm @ 25 C)	7,300
Chemical Oxygen Demand (mg/L)	16,300
Chloride (mg/L as Cl)	570
Sulfate (mg/L as SO4)	2,500
Total Alkalinity (mg/L as CaCO3)	-
Nitrate + Nitrite (mg/L as N)	0.63
Ammonia (mg/L as N)	260
METALS (ug/L):	
Cadmium	15
Chromium	190
Copper	37
Iron	860,000
Lead	720
Manganese	24,000
Mercury	1.0
Nickel	350
Zinc	22,000
VOLATILE ORGANICS (ug/L):	
Acetone	7,900
Benzene	54
2-Butanone	6,100
Chloroethane	190
1,1-Dichloroethane	93
1,1-Dichloroethylene	40
1,2-trans-Dichloroethylene	66
Ethylbenzene	49
4-Methyl 2-pentanone	2,200
Methylene chloride	4,900
Tetrachloroethylene	39
Trichloroethane	69
Toluene	1,000
Total Phenol	2,600

Table 3.2. The chemical composition of groundwater collected from off-site wells is tabulated and the average and standard deviation are presented. This data is used to characterize background conditions against which on-site monitoring wells are contrasted. The < indicates that values are below the given detection limits and a value of one half of the detection limit is used to calculate average and standard deviation.

Douglas County Landfill Groundwater Quality Monitoring	OFF-SITE DOMESTIC WELLS						
PARAMETER (units)	JOHNSON 26-Feb-88	GEARY 26-Feb-88	ROBERTSON 26-Feb-88	FSW 22-Jul-86	FSW 23-Sep-87	AVERAGE	STANDARD DEVIATION
pH (standard units; field)	7.9	7.5	8.0	8.5	8.3	7.9	
Specific Conductance (umhos/cm @25C)				354	367	360.5	6.5
Total Dissolved Solids (mg/L)	412	190	220	238	235	259.0	78.4
Chloride (mg/L as Cl)	36.0	6.1	8.6	6.0	7.0	12.7	11.7
Nitrate (mg/L)				7.8	9.8	8.8	1.0
Sulfate (mg/L as SO4)	63	18	28	50	48	41.4	16.2
Carbonate (mg/L)	0	0	0	5.0	5.0	2.0	2.4
Bicarbonate (mg/L)	168	117	117	127	127	131.2	18.9
Sodium (mg/L)	23	15	17	34	35	24.8	8.4
Potassium (mg/L)	3.9	4.1	3.3	2.0	2.0	3.1	0.9
Calcium (mg/L)	69	24	32	32	33	38.0	15.8
Magnesium (mg/L)	8.9	5.4	7.2	4.0	4.0	5.9	1.9
Silica (mg/L as SiO2)							
Total Organic Carbon (mg/L)							
DISSOLVED METALS (ug/l):							
Cadmium	< 10	< 10	< 10	< 1	< 1	< 10	
Chromium	< 25	< 25	< 25	< 5	< 5	< 25	
Copper	< 25	< 25	< 25	0	30	< 25	
Iron	< 50	50	< 50	0	20	19	10
Lead	< 20	< 100	< 100	< 5	< 5	< 20	
Manganese	< 25	< 25	< 25	0	0	< 25	
Zinc	< 50	60	70	20	110	57	33
Arsenic				5.0	5.0	5	0
Barium				80.0	80.0	80	0
Mercury				< 0.5	< 0.5	< 0.5	
Selinium				< 1	1	1	
Silver				< 5	< 5	< 5	

Table 3.3 The detection frequency and the average concentration when detected for all organic compounds which have been found in groundwater near the Douglas County Landfill.

	LSW		E-1		M-1		M-2		FSW		DOMESTIC	
Number of Samples -->	16		16		9		9		4		3	
Organic Compound	Detect. Freq.	Avg. Conc.	Detect. Freq.	Avg. Conc.	Detect. Freq.	Avg. Conc.	Detect. Freq.	Avg. Conc.	Detect. Freq.	Avg. Conc.	Detect. Freq.	Avg. Conc.
Tetrachloroethylene	100 %	13.6	0	-	89 %	16.0	0	-	0	-	0	-
Trichloroethane	38 %	1.5	0	-	67 %	2.3	0	-	0	-	0	-
1,1 dichloroethane	6 %	0.2	0	-	0	-	0	-	0	-	0	-
Dichlorodifloromethane	6 %	2.0	0	-	0	-	0	-	0	-	0	-
Methyl chloride	6 %	2.5	0	-	0	-	0	-	0	-	0	-
Toluene	0	-	0	-	11 %	2.0	11 %	1.5	50 %	11.5	0	-
Ethylbenzene	0	-	0	-	0	-	0	-	50 %	6.0	0	-
Chloroform	0	-	0	-	0	-	11 %	2.7	50 %	8.0	0	-
Bromoform	0	-	0	-	0	-	0	-	25 %	11.0	0	-
Bromodichloromethane	0	-	0	-	0	-	0	-	50 %	24.0	0	-
Chlorodibromomethane	0	-	0	-	0	-	0	-	50 %	13.0	0	-
Total xylenes	0	-	0	-	11 %	1.0	0	-	50 %	23.0	0	-
4-methyl 2-pentanone	0	-	0	-	0	-	0	-	50 %	45.0	0	-
Acetone	0	-	0	-	11 %	65.0	0	-	0	-	0	-

leachate contamination has possibly occurred. If alternate sources for these compounds can be identified, such as an automobile repair shop or an equipment maintenance area near the well head, then leachate contamination may be considered unlikely because other early warning constituents present in leachate (including metals) were not present at elevated levels. One such alternate source, recent painting of the interior of the water holding tank, could be a source of the detected organic compounds (not including the trihalomethanes). Organic constituents were first detected in December 1987 and were not present in a September 1987 sample; if the painting occurred between September and December 1987, then the paint may be considered a most likely source of the organic contamination. In addition, on-site wells, which are presumably more contaminated with leachate, did not contain the particular suite of organic compounds that were present in the Fairground Supply Well and, thus, leachate contamination is considered unlikely.

The three other off-site domestic wells, Johnson, Geary and Robertson, were similar in that metal levels were very low, volatile organic compounds were not detectable and pH levels ranged from 7.5 to 8.5 (Table 3.2). The Johnson well differed in that it had slightly elevated levels of total dissolved solids, particularly chloride, bicarbonate, calcium and magnesium. This is considered to be part of the normal range of these constituents in uncontaminated groundwater and is not likely attributed to leachate contamination.

To make full use of the data set, data from the four off-site wells are accepted as representative of background chemical composition (Table 3.2). This data is contrasted with that from each of the on-site wells to determine if statistically significant differences exist as determined by the student's t-test at the 95% confidence interval. These results are discussed briefly, well by well:

<u>Landfill Supply Well:</u> Sampling has occurred intermittently since 1984 in the Landfill Supply Well, but no long-term trends were detectable; there is no apparent increase over time in the concentration of any constituent

(Table 3.4). Primary and secondary drinking water criteria have not been violated. This well has contained significantly more sodium than off-site wells but not more of other constituents. Leachate tracer constituents, iron, manganese, zinc, chloride and specific conductance, were not present at significantly greater levels than in background wells. Organic compounds present included tetrachloroethylene, which has been present on each of 16 sampling occasions at an average concentration of 13.6 mg/L (Table 3.3). This concentration is in excess of an EPA proposed federal standard of 5 mg/L, but no criteria currently exist.

As suggested by Hydro-Search, Inc. (1988), the most likely source of this tetrachloroethylene contamination is the landfill and may be a result of used solvent disposal at the landfill. They also propose that the contamination is migrating down the well casing rather than percolating through the soils. Tetrachloroethylene is known to occur only at relatively low concentrations in "typical" landfill leachate (Table 3.1). Four other organic compounds were detected at lower concentrations and with less frequency in the well, and all are known to occur in typical landfill leachate as well as in solvents. Thus, it appears that groundwater in the vicinity of the Landfill Supply Well has become contaminated with tetrachloroethylene, but is not contaminated with compounds more typically found at high concentration in leachate. The conclusion which may be drawn is that the disposal of industrial byproducts, rather than municipal refuse, in the vicinity of the Landfill Supply Well has caused the observed contamination.

<u>E-1:</u> Well E-1 contained significantly more iron and zinc than did the background wells (Table 3.5). Taken alone, this is compelling evidence of leachate contamination since these metals exist at high concentration in leachate. Sodium also existed at levels significantly greater than background. Organic compounds, however, have never been detected in E-1 and chloride and specific conductance, which are good leachate tracers, were present at low levels. Thus, there is some possibility that contamination by leachate derived from municipal waste has occurred in this vicinity, but there is no indication of contamination by solvents or other industrial waste.

Table 3.4. Chemical composition in the Landfill Supply Well at the Douglas County Landfill. The < indicates that values are below the given detection limits and a value of one half of the detection limit is used to calculate average and standard deviation.

Douglas County Landfill Groundwater Quality Monitoring	Monitoring Well LANDFILL SUPPLY WELL										
PARAMETER (units)	16-Mar-84	22-Jul-86	23-Sep-87	22-Mar-88	27-Apr-88	25-May-88	30-Jun-88	03-Aug-88	02-Nov-88	AVERAGE	STANDARD DEVIATION
pH (standard units; field)	7.2	8.1	8.0	8.2	7.6	7.8	7.4			7.6	
Specific Conductance (umhos/cm @25C)		395	268	393	402	375	373			367.7	45.8
Total Dissolved Solids (mg/L)	250	250	163	265	260	242	244			239.3	32.1
Chloride (mg/L as Cl)	21	15	15	12	13	17	16			15.6	2.7
Nitrate (mg/L)	4.2	19.2	8.5			9.4		33.0	18.0	15.4	9.5
Sulfate (mg/L as SO4)		36	19	31	37	33	35			31.8	6.1
Carbonate (mg/L)		0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0
Bicarbonate (mg/L)		149	98	172	151	146	157			145.5	22.9
Sodium (mg/L)		47	23	49	39	40	50			41.3	9.2
Potassium (mg/L)		2.0	4.0	2.7	1.3	2.9	2.4			2.6	0.8
Calcium (mg/L)		28	20	24	23	20	36			25.2	5.6
Magnesium (mg/L)		4.0	6.0	3.9	4.9	4.5	5.3			4.8	0.7
Silica (mg/L as SiO2)		31	23			37		36		31.8	5.5
Total Organic Carbon (mg/L)	5.7									5.7	
DISSOLVED METALS (ug/l):											
Cadmium		< 1	< 1	< 10	< 10	< 10	< 10			< 10	
Chromium	< 50	< 5	< 5	< 25	< 25	< 25	< 25			< 25	
Copper		0	0	< 25	< 25	< 25	< 25			< 25	
Iron	< 200	10	300	< 50	< 50	< 50	< 50			72.9	96.7
Lead		< 5	< 5	< 50	< 50	90	< 50			< 50	
Manganese		0	50	< 15	< 15	< 15	< 15			< 15	
Zinc		40	10	60	< 50	100	100			55.8	34.7
Arsenic		13								13.0	
Barium		90								90.0	
Mercury		< 0.5								< 0.5	
Selenium		2								2.0	
Silver		< 5								< 5	

Table 3.5. Chemical composition in Monitoring Well E-1 at the Douglas County Landfill. The < indicates that values are below the given detection limits and a value of one half of the detection limit is used to calculate average and standard deviation.

Douglas County Landfill Groundwater Quality Monitoring	Monitoring Well E-1								
PARAMETER (units)	27-Mar-84	22-Jul-85	22-Mar-88	27-Apr-88	25-May-88	29-Jun-88	02-Aug-88	AVERAGE	STANDARD DEVIATION
pH (standard units; field)	7.8	8.7	7.5	8.0	8.0	7.8		7.8	
Specific Conductance (umhos/cm @ 25C)		247	312	352	335	321		313.4	35.8
Total Dissolved Solids (mg/L)	200	138	214	226	220	224		203.7	30.6
Chloride (mg/L as Cl)	17	16	13	14	17	17		15.7	1.6
Nitrate (mg/L)	5.4	0.0			23.0		32.0	15.1	12.9
Sulfate (mg/L as SO4)		35	51	53	43	49		46.2	6.5
Carbonate (mg/L)		2.0	0.0	0.0	0.0	0.0		0.4	0.8
Bicarbonate (mg/L)		66	88	88	88	91		84.2	9.2
Sodium (mg/L)		45.0	52.0	48.0	46.0	50.0		48.2	2.6
Potassium (mg/L)		2.0	2.0	1.1	2.5	1.7		1.9	0.5
Calcium (mg/L)		5.0	11.0	11.0	11.0	15.0		10.6	3.2
Magnesium (mg/L)		0.0	0.8	1.0	1.3	1.0		0.8	0.4
Silica (mg/L as SiO2)		4.0			32.0		33.0	23.0	13.4
Total Organic Carbon (mg/L)	11.0							11.0	0.0
DISSOLVED METALS (ug/l):									
Cadmium		< 1	< 10	< 10	< 10	< 10		< 10	
Chromium	< 50	< 5	< 25	< 25	< 25	< 25		< 25	
Copper		0	< 25	< 25	< 25	< 25		< 25	
Iron	6400 *	50	270	170	100	220		178.0	73.0
Lead		< 5	< 50	< 50	90	< 50		18.0	
Manganese		0	25	< 15	< 15	< 15		5.0	
Zinc		10	300	310	230	500		270.0	157.9
Arsenic		6.0						6.0	
Barium		0.0						0.0	
Mercury		< 0.5						< 0.5	
Selinium		< 1						< 1	
Silver		< 5						< 5	

M-1: Monitoring Well M-1 contained significantly more iron, nitrate and sodium than did background wells (Table 3.6) and was also found to contain tetrachloroethylene and trichloroethane (Table 3.3). This well is located immediately adjacent to the Landfill Supply Well and corroborated the finding of likely contamination by industrial waste.

M-2: Monitoring well M-2 also contained significantly more iron than background wells (Table 3.7), again possible indication of municipal refuse leachate contamination. Organic compounds have occurred at very low levels and were not indicative of contamination. The most obvious chemical anomaly in M-2 is the high pH which ranges from 11.5 to 12.0, and associated increase in specific conductance. total dissolved solids, carbonate, calcium and sodium and decreased bicarbonate. Cement used to construct the well can cause such a profound increase in pH and may be a persistent problem. The elevated pH greatly reduces the value of the well as a monitoring station because metals such as iron and zinc, important leachate tracers, may be precipitated from solution.

In summary, data indicates convincingly that the organic solvents tetrachloroethylene and trichloroethane are present in groundwater beneath monitoring well M-1 and the Landfill Supply Well, but constituents typically associated with landfill leachate have not contaminated this immediate area. The plume of these organic solvents is believed to be small because wells E-1 and M-2, located downgradient and 1,100 to 1,400 feet away, were not similarly contaminated. The Fairground Supply Well also contained some organic compounds, but these are not thought to have originated at the landfill site. As a result, the Fairground Supply Well may be valuable as a background monitoring well for inorganic constituents.

Evidence of groundwater contamination by landfill leachate is far less convincing. The sole evidence of leachate contamination is that wells M-1, M-2 and E-1 contained significantly greater levels of iron, M-1 significantly more nitrate, and E-1 more zinc than did off-site wells. Additionally, sodium concentrations in wells E-1, M-1 and the Landfill Supply Well were

Table 3.6. Chemical composition in Monitoring Well M-1 at the Douglas County Landfill. The < indicates that values are below the given detection limits and a value of one half of the detection limit is used to calculate average and standard deviation.

Douglas County Landfill Groundwater Quality Monitoring	Monitoring Well M-1								
PARAMETER (units)	18-Jul-88	03-Aug-88	01-Sep-88	02-Nov-88	28-Nov-88	12-Jan-89	14-Jan-89	AVERAGE	STANDARD DEVIATION
pH (standard units; field)	8.0	8.2	8.0	8.2	8.5	7.5	8.1	8.0	
Specific Conductance (umhos/cm @ 25C)		328	335	415	395	500	460	405.5	62.0
Total Dissolved Solids (mg/L)	218	258	256	280	256	328	310	272.3	34.4
Chloride (mg/L as Cl)	18	14	12	14	<0.3	<0.5	1	8.5	7.3
Nitrate (mg/L)	15	27	15	17	18	29	22	20.4	5.3
Sulfate (mg/L as SO4)	36	31	24	38	31	43	26	32.7	6.2
Carbonate (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonate (mg/L)	131	128	161	172	149	240	268	178.4	50.5
Sodium (mg/L)	53	50	52	61	8	80	74	54.0	21.7
Potassium (mg/L)	2.7	3.4	2.9	3.0	2.6	3.6	3.5	3.1	0.4
Calcium (mg/L)	25	22	27	36	29	34	28	28.7	4.5
Magnesium (mg/L)	4.4	4.5	5.5	5.7	4.9	5.3	6.2	5.2	0.6
Silica (mg/L as SiO2)		37	34	95	37	40	34	46.2	21.9
Total Organic Carbon (mg/L)									
DISSOLVED METALS (ug/l):									
Cadmium		< 10	< 10	< 10	< 10	< 10	< 10	< 10	
Chromium		< 50	< 50	< 25	< 25	< 25	< 25	< 25	
Copper		< 25	< 25	< 25	< 25	< 25	< 25	< 25	
Iron	100	81	41	110	540	75	180	161.0	159.7
Lead		< 50	< 50	< 50	< 50	< 50	< 50	< 50	
Manganese	< 15	< 15	< 15	< 15	< 15	< 15	< 15	< 15	
Zinc		50	< 50	< 50	< 50	< 50	< 50	< 50	

Table 3.7. Chemical composition in Monitoring Well M-2 at the Douglas County Landfill. The < indicates that values are below the given detection limits and a value of one half of the detection limit is used to calculate average and standard deviation.

Douglas County Landfill Groundwater Quality Monitoring	Monitoring Well M-2							
PARAMETER (units)	03-Aug-88	26-Sep-88	02-Nov-88	28-Nov-88	12-Jan-89	14-Jan-89	AVERAGE	STANDARD DEVIATION
pH (standard units; field)	11.5	11.7	11.7	12.0	11.8	12.0	11.8	
Specific Conductance (umhos/cm @25C)	902	1200	1365	1110	1020	930	1087.8	160.2
Total Dissolved Solids (mg/L)	394	424	394	382	322	324	373.3	37.8
Chloride (mg/L as Cl)	12.0	13.0	<0.3	5.0	0.5	6.6	6.2	5.0
Nitrate (mg/L)	4.6	5.0	2.2	2.9	4.3	5.3	4.1	1.1
Sulfate (mg/L as SO4)	56	43	46	40	76	50	51.8	12.0
Carbonate (mg/L)	36	41	41	35	30	20	34.0	7.3
Bicarbonate (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sodium (mg/L)	67	72	81	73	72	80	74.2	4.9
Potassium (mg/L)	3.7	3.0	6.6	5.6	4.5	4.4	4.6	1.2
Calcium (mg/L)	48	116	81	52	50	40	64.5	26.3
Magnesium (mg/L)	0.1	0.1	<0.05	<0.05	<0.05	<0.05	0.07	0.0
Silica (mg/L as SiO2)	24	25	57	28	24	32	31.7	11.7
Total Organic Carbon (mg/L)								
DISSOLVED METALS (ug/l):								
Cadmium	< 10	< 10	< 10	< 10	< 10	< 10	< 10	
Chromium	< 50	< 50	< 50	< 50	< 50	< 50	< 50	
Copper	< 25	< 25	< 25	< 25	< 25	< 25	< 25	
Iron	72	< 25	71	400	83	110	124.8	126.5
Lead	< 50	< 50	< 50	< 50	< 50	< 50	< 50	
Manganese	< 50	< 50	< 15	< 15	< 15	< 15	< 15	
Zinc	< 50	75	< 50	< 50	< 50	< 50	< 50	

significantly greater than in background locations. However, other leachate tracers which typically occur simultaneously with elevated iron levels, chloride, specific conductance, and zinc, were not generally evident. Further doubt that leachate contamination has occurred exists because of the geologic and hydrologic setting of the landfill: (1) the extraordinary travel distance through unsaturated soils which would tend to attenuate contaminants, (2) the existence of an aquiclude between groundwater and the landfill which would impede migration to the aquifer and, (3) the small volume of leachate generated annually (see Section 5.3). Additionally and perhaps most importantly, the characterization of background conditions has been performed with a very small data set which may not be truly representative. In conclusion, there is no good evidence that leachate has contaminated groundwater in the landfill vicinity, yet there is enough evidence to justify concern and to warrant more extensive monitoring.

To increase the utility of the monitoring data, the following modifications are recommended:

(1) Install an upgradient monitoring well at the northeastern corner of the landfill property (see Figures 3.4 and 3.5). This well is to be sampled together with the other on-site monitoring wells.

(2) Install an additional well which will be downgradient of the proposed landfill area (see Figures 3.4 and 3.5).

(3) New wells should be constructed with a bentonite seal placed around the well casing at the depth of the aquiclude as well as in surficial soils.

(4) Continue to monitor offsite wells, including the Fairground Supply Well and the domestic wells of Johnson, Robertson and Geary. The current data analysis is weakened by the lack of background data.

(5) Add COD to the list of parameters monitored in each well due to its role as a leachate tracer.

(6) Monitor once annually federally regulated primary drinking water contaminants, which are not currently assessed. These include arsenic, barium, mercury, selenium and silver.

(7) Elevated pH in M-2 is likely caused by cement contamination and abandonment of the well as a monitoring location is possibly justified. It is especially important to purge the well several times, perhaps as many as 10, prior to sample collection. Purged water should be monitored for pH and specific conductance in alequoits collected from every five gallons removed. Only after pH and specific conductance have stabilized should a sample be collected. If stabilization does not occur, well data may be invalid due to the strong control pH exerts on chemical speciation.

(8) Reduce sampling frequency of on-site wells to six times annually.

These recommendations are summarized in Tables 3.8 and 3.9.

Table 3.8. Recommended sample frequency for existing and new monitoring wells.

Monitoring Well	Sample Dates J	F	M	A	M	J	J	A	S	O	N	D
E-1	•		•		•		•		•		•	
M-1	•		•		•		•		•		•	
M-2	•		•		•		•		•		•	
NEW UPGRADIENT WELL	•		•		•		•		•		•	
NEW DOWNGRADIENT WELL	•		•		•		•		•		•	
LSW	•				•				•			
FSW	•				•				•			
JOHNSON	•				•				•			
ROBERTSON	•				•				•			
GEARY	•				•				•			

Table 3.9. Recommended analytes for groundwater monitoring. Except as indicated, these compounds should be assessed on each sample occasion.

Field Data

pH
Specific Conductance
Temperature
Depth to Water

Conventionals

Chloride
Nitrate
Sulfate
Carbonate
Bicarbonate
Sodium
Potassium
Calcium
Magnesium
Total Dissolved Solids
Chemical Oxygen Demand

Metals

Cadmium
Chromium
Copper
Iron
Lead
Manganese
Zinc
Arsenic*
Barium*
Mercury*
Selenium*
Silver*

*Analyzed Once Annually

Volatile Organic Compounds

(Complete Scan)

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DATE: September 28, 1990

A. Reed Clerk of the 9th Judicial District Court of the State of Nevada, in and for the County of Douglas.

By Linda L. Lynch Deputy

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