CITY OF TUCSON
ENVIRONMENTAL SERVICES

MEMORANDUM

DATE: April 22, 2011

TO: Nancy Petersen
Deputy Director
Environmental Services

FROM: Molly Collins
Project Coordinator
Environmental Services

SUBJECT: **Harrison Road Landfill: Remedial System Status, 2011 Soil Vapor Testing Results and Landfill Gas Extraction System Operational Recommendations**

This memorandum provides background information on groundwater and soil vapor remediation and landfill gas extraction systems at the Harrison Road Landfill. This memo also summarizes the deep soil vapor monitoring results collected at the Landfill (Figure 1) in January 2011 and provides recommendations for further action to control the migration of soil vapor from the landfill waste. Figure 2 provides a site map, including details of the remediation systems.

Control and removal of contaminants from the waste buried at the Harrison Road Landfill is accomplished with three systems. The groundwater extraction, treatment and reinjection system is designed to remove levels of volatile organic compounds (VOCs) above the applicable aquifer water quality standard (AWQS), and prevent the migration of these contaminants off-site. The soil vapor extraction system (SVE/AI) was designed to remove vapor phase contaminants between the waste and the groundwater table to prevent groundwater contamination. The landfill gas extraction system was designed to control the off-site migration of methane, and has an added benefit of removing contaminated vapor from the waste before it can migrate downward to the water table.

Groundwater Extraction and Treatment System
Since June 2001, the City of Tucson (COT) Environmental Services (ES) has operated the groundwater extraction and treatment system to remove groundwater contaminated with tetrachloroethene (PCE) and trichloroethene (TCE) above the AWQS (Figure 3). The system was designed to capture contamination that had migrated off-site with the extraction well network (WR-285A, WR-371A and WR-444A). Initially, treated groundwater was reinjected to five injection wells (R-095A, R-097A, WR-119A, WR-120A, and WR-245A) at the property boundary to flush contaminated groundwater toward the extraction wells and provide a barrier to the migration of contaminated groundwater off-site. A sixth injection well was

equipped in 2005 (WR-276A) to flush contaminated groundwater toward WR-285 for extraction. As of November 2010, the groundwater treatment system has removed 80.5 pounds (lbs) of total VOCs, including 11.6 lbs of PCE and 4.0 lbs of TCE. Groundwater concentrations of PCE and TCE have been decreasing since the system began operation and are now below the AWQS in all extraction wells and all but one downgradient monitoring well (Figure 3). The system goal is reduction of PCE and TCE concentrations in all extraction wells to ½ of the AWQS (2.5 ug/L).

Injection wells R-097A and WR-119A were shut down for an extended rebound test in January 2006 to measure the concentrations of VOCs left within the source area (beneath the waste footprint). Injection well R-095A, which is located within the waste footprint, was also shut down in January 2006 to insure the concentrations observed at R-097A were not influenced by the injection of clean water upgradient at the source area. PCE and TCE concentrations appear to be stable and have remained below the AWQS in boundary injection well R-097A (Figure 3). Concentrations of PCE increased to just below the AWQS in November 2010 at well WR-119A (Figure 3). The well was returned to operation in December 2010 to prevent off-site migration of PCE above the AWQS.

In response to the increasing concentrations of PCE at WR-119A, ES scheduled a soil vapor sample event for January 2011 to determine if soil vapor was still present in sufficient concentrations to cause the rebound in PCE observed at WR-119A. The purpose of the soil vapor sampling was to determine if the SVE/AI system should be restarted to remove a buildup of soil vapor VOCs.

SVE/AI

The SVE/AI system was installed in 1999 to remove and treat vapor phase VOCs, primarily PCE and TCE, from soil between the landfill waste footprint and the groundwater table (approximately 90 feet below ground surface (bgs) to 250 feet bgs respectively) to prevent contaminated soil vapor movement to the water table which could cause groundwater contamination. As shown in Figure 4, the Harrison SVE/AI system wells consist of three extraction wells (SVE-1, SVE-2 and SVE-3), one air injection well (SVI-1), and various vapor probes for monitoring. The Harrison Landfill SVE/AI system began operation in July 1999 and was run continuously until September 2002 when it was shut down for an extended rebound test due to low VOC recovery rates. The SVE/AI system was restarted in December 2005 to lower the levels of VOC's detected in soil vapor samples collected in August 2005. VOC recovery rates fell quickly after the system was restarted and it was again shut off in February 2006. The system removed approximately 18,034 lbs of total VOCs from below the landfill during its operational history, including 1,590 lbs of PCE.

In order to return the SVE/AI system to operation, a new air injection well must located and connected to the system because the air injection well, SVI-1 was abandoned in 2009 after it was discovered that the casing had broken at the base of waste (approximately 91 feet bgs). Groundwater injection well R-095A is suitable to be used as an air injection well because it was designed for either water or air injection. However, the well would not be optimal since it is not centered within the SVE well network and would not flush clean air equally toward the three SVE wells.

Landfill Gas Extraction

The City of Tucson Solid Waste Management Department (SWMD) constructed a permanent landfill gas (LFG) extraction and flare system for the Harrison Road Landfill in 1998 (Figure 5). The system is designed to control off-site migration of methane, and the well network is primarily located near the boundaries of waste. The system has run continuously since 1998, and has successfully prevented the off-site migration of methane. An added benefit to the LFG system is that it removes VOC mass directly from the waste and prevents the vapor from migrating to the vadose zone and potentially contaminating the groundwater.

The Harrison system uses a flare to burn off the LFG. The system runs most effectively at methane concentrations around 30% of the influent gas volume. Because the extraction wells are situated near the edge of waste, clean air is drawn into the system which causes relatively low methane concentrations at the flare influent. Average methane concentrations of the LFG system at Harrison now range from 25% to 30% and have been decreasing for the past 4 years.

COT-ES does not routinely sample the influent from the LFG system to track VOC mass removed, but it is likely that the VOC mass removed is far larger than that removed by the SVE/AI system since all of the LFG wells are located within the waste and the system operates continuously.

MONITORING RESULTS

ES performs semiannual sampling for landfill gases (LFG) (methane, carbon dioxide and oxygen) on the SVE/AI wells and monitoring probes SVE-1, 2, 3, VMW-1, VMW-2, R-095A, and R-096A. Readings are typically taken at a minimum of 3 depths in each well. The depths generally are; 240 feet below ground surface (bgs), which is just above the groundwater table, at 140 feet bgs, and near the base of the waste (approximately 90 feet bgs). Attachment 1 provides the LFG monitoring results through February 2011. There does not appear to be an increase in methane or carbon dioxide concentrations in any of the points measured.

ES compares levels of contaminants detected in soil vapor samples to site specific remedial action objectives (RAO) developed by Hydro Geo Chem, Inc. and provided in the *Draft Development of Remedial Closure Criteria for City of Tucson Landfills Undergoing Vadose Zone Remediation, December 28, 2001*. The RAOs are summarized in the table below. Soil vapor concentrations above the RAOs indicate that the soil vapor could contaminate groundwater with these compounds at levels above the respective AWQS and that operation of the SVE/AI system is important to remove the soil vapor and prevent groundwater contamination. RAOs are listed with the sampling results in the table below.

The VOC sampling results are tabulated and presented in Table 1 and graphically presented in Figure 2. The laboratory analytical report is provided in Attachment 2. Tables including the results of past sampling events at the SVE/AI wells and probes are provided in Attachment 3. Sample points were selected to provide information about concentrations just above the water table at 240 feet bgs and just below the waste at 100 feet bgs. Sample results from February 2011 indicate that soil vapor VOCs, including PCE and TCE have not rebounded to levels above the site specific RAOs. A comparison between the RAOs and the highest observed concentration for each contaminant is provided below. All sample results were below the respective RAO.

SUMMARY OF REMEDIAL ACTION OBJECTIVES (RAO)
AND HIGHEST OBSERVED CONCENTRATION
FEBRUARY 2011
HARRISON ROAD LANDFILL

Contaminant	Highest Vapor Concentration and Location February 2011	Remedial Action Objective (RAO)	Percentage of RAO
Methylene Chloride (DCM)	0.382 @ SVE-3-100	1	38%
cis 1-2, Dichloroethene (cis 1,2-DCE)	3.05 @ SVE-3-270	51	6%
Trichloroethene (TCE)	0.859 @ SVE-3-270	4	21%
Tetrachloroethene (PCE)	3.6 @SVE-3-270	11	33%
Vinyl Chloride (VC)	1.97 @SVE-3-270	135	1%

All vapor concentrations are given in ug/L

As shown above, the highest concentration in soil vapor is consistently located at well SVE-3, which is upgradient of well WR-119A (Figure 3). This suggests that the remaining source area for the groundwater contamination is located within the waste on the northeast side of the landfill footprint. However, the rebounding vapor concentrations do not appear to be high enough to cause groundwater concentrations of each contaminant in excess of the AWQS. Therefore, the rebounding concentrations of PCE observed at well WR-119A are likely due to residual groundwater contamination, and do not represent new groundwater contamination by contaminated vapor migrating to the water table.

RECOMMENDATIONS

Because the concentrations of VOCs within the deep vapor probes do not appear to be high enough to cause contamination to the groundwater above the AWQS, it is not recommended to restart the SVE/AI system at this time. Prior to restart of the SVE/AI system, a new air injection well will need to be installed and connected to the system because well R-095A is not situated to flush clean air toward the three extraction wells equally. Based on recent prices for well installation, it would cost about $70,000 to install a well suitable for air injection to a depth of 300 feet bgs. There would also be approximately $20,000 in costs associated with connecting the well to the existing piping, pressure testing the existing extraction and injection piping to insure there are no leaks, returning the extraction/injection blowers to operation and installing fresh carbon to treat the off-gas. Electrical and maintenance costs for the system operation were approximately $4,000 per month when it was last operated in 2006.

VOCs could be captured more effectively by expansion of the existing LFG system by adding additional wells in the northeast area, but deeper within the waste footprint (Figure 5). At the Vincent Mullins Landfill, an expansion of the LFG extraction system in 2005 has been effective in decreasing deep soil vapor VOC concentrations and preventing further groundwater contamination[1]. Expansion of the LFG system at the Harrison Road Landfill would also help increase methane concentrations in the flare influent and allow the system to operate more effectively.

Prior to expansion of the LFG system, vapor samples will be collected and tested for VOCs from existing LFG extraction wells HEW-2, HEW-6 and HEW-33, and at the LFG combined influent point prior to the flare. Methane and other LFG concentrations will also be measured at these sample points using a Landtec. A Velocicalc instrument will be used to measure the air flow rate within the pipe at the influent point. The purpose of the sampling is to measure VOC concentrations remaining in the waste at wells that have operated for approximately 13 years in a likely VOC source area to groundwater contamination (HEW-2 and HEW-6) and a at well within the waste that has operated for only 6 years (HEW-33). Although it is likely that VOC concentrations and methane in areas with HEW wells that have operated a number of years will be lower than those areas of waste without extraction wells, the testing will provide an idea of the amount of VOCs and methane remaining in the waste. The VOC test results will be used along with the LFG system flow rate to estimate the VOC mass removal rate. The sampling will occur in May 2011.

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[1] *COT-ES: Vincent Mullins Landfill Second Half 2010 APP No. P-100917 Annual Report, March 10, 2010*

To effectively expand the LFG system to control VOCs and prevent them from migrating to the groundwater, an additional 3-5 wells could be installed within the area shown on Figure 5. Based on recent prices for LFG extraction well installation, installation would cost $12,000 per well. Costs to pipe in new wells from the existing 10" line near HEW-7 are approximately $50 per foot of piping. There would be no additional operating costs for the LFG system.

Pima County may request that COT re-grade the slope from the west side of Harrison Rd in order to place a bike path within the right-of-way (ROW) for Harrison Road. The ROW for the road ends at the yellow property boundary as shown on Figure 2. Should COT be required to re-grade this slope which forms the eastern boundary of the Landfill, it may also be necessary to remove waste and to relocate LFG piping along that side of the landfill. Expansion of the LFG system as discussed in this memo would only occur after a decision is made on the necessary extent of the re-grading, which is expected to take place by the end of May 2011.

SUMMARY

- The SVE/AI system will not be restarted at this time as VOCs have not rebounded in SVE wells and sampling probes to levels that pose a threat to groundwater.
- Vapor samples will be collected for analysis of VOCs and methane from three HEW wells and the LFG influent port to determine the existing level of VOCs and methane within the LFG extraction system and provide an estimate on the VOC mass removal rate for the LFG extraction system.
- The LFG system may be expanded with the addition of 3-5 new LFG wells within the northeastern area of waste.
- A decision on the expansion of the LFG system will not be made until it is determined if COT will re-grade the slope between the roadway to the waste to accommodate a bike path within the ROW of Harrison Rd.

If you have any questions, please let me know.

MC/NP

Enclosures

Tables:
Table 1: Soil Vapor Sample Results January 2011

Figures

Figure 1	Landfill Location
Figure 2	Site Map and Remediation System Layout
Figure 3	Groundwater PCE Concentrations: November 2010
Figure 4	Soil Gas PCE Concentrations
Figure 5	Landfill Gas Extraction System

Attachments

Attachment 1	Graphs showing LFG Monitoring Results
Attachment 2	Laboratory Analytical Data
Attachment 3	Field Sampling Data Sheets
Attachment 4	Historical Soil Vapor Data Tables

cc: w/enclosures
Andrew Quigley, City of Tucson, Environmental Services (scanned document)
Jeff Drumm, City of Tucson, Environmental Services (scanned document)
Harrison Project File (Hard Copy)

TABLE 1
Soil Vapor Sample Results
January 2011
Harrison Road Landfill

Constituent (all concentrations in µg/L) — Sample ID / DATE	SVE-1-240 1/13/2011	SVE-1-80 1/13/2011	SVE-2-280 1/13/2011	SVE-2-100 1/13/2011	SVE-3-100 1/13/2011	SVE-3-270 1/13/2011	R-095A-WH 1/13/2011	VMW-1-140 1/13/2011
1,1,1-Trichloroethane (1,1,1-TCA)	ND(0.0273)	ND(0.0546)	ND(0.00546)	ND(0.0546)	ND(0.0546)	ND(0.0546)	ND(0.00546)	ND(0.0273)
1,1-Dichlorethene (1,1-DCE)	ND(0.0199)	ND(0.0397)	ND(0.00397)	ND(0.0397)	0.0635	ND(0.0397)	ND(0.00397)	ND(0.0199)
1,1-Dichloroethane (1,1-DCA)	ND(0.0203)	ND(0.0405)	ND(0.00405)	ND(0.0405)	ND(0.0405)	ND(0.0405)	ND(0.00405)	0.0891
1,2,4-Trimethylbenzene (Pseudocumene)	0.162	ND(0.0492)	ND(0.00492)	ND(0.0492)	0.453	2.26	ND(0.00492)	0.202
1,2-Dichlorobenzene (o)	ND(0.0301)	ND(0.0601)	ND(0.00601)	ND(0.0601)	ND(0.0601)	ND(0.0601)	ND(0.00601)	ND(0.0301)
1,3,5-Trimethylbenzene (Mesitylene)	ND(0.0246)	0.133	ND(0.00492)	ND(0.0492)	0.369	1.43	ND(0.00492)	ND(0.0246)
1,3-Dichlorobenzene (m)	ND(0.0301)	ND(0.0601)	ND(0.00601)	ND(0.0601)	ND(0.0601)	ND(0.0601)	ND(0.00601)	ND(0.0301)
1,4-Dichlorobenzene (p)	0.156	ND(0.0601)	ND(0.00601)	ND(0.0601)	0.962	1.26	ND(0.00601)	0.313
Benzene	ND(0.0160)	ND(0.0319)	ND(0.00319)	ND(0.0319)	0.0447	2.74	ND(0.00319)	ND(0.0160)
Chlorobenzene	ND(0.0230)	ND(0.0460)	ND(0.00460)	ND(0.0460)	ND(0.0460)	ND(0.0460)	ND(0.00460)	ND(0.0230)
Chloroethane (Ethyl Chloride)	ND(0.0132)	ND(0.0264)	ND(0.00264)	ND(0.0264)	ND(0.0264)	0.37	ND(0.00264)	ND(0.0132)
Chloroform	ND(0.0244)	ND (0.0488)	ND(0.00488)	ND(0.0488)	ND(0.0488)	ND(0.0488)	ND(0.00488)	ND(0.0244)
cis-1,2-Dichloroethene (*cis*-1,2-DCE)	0.0372	ND(0.0396)	ND(0.00396)	ND(0.0396)	1.7	3.05	ND(0.00396)	0.396
Dichloromethane (Methylene Chloride)	0.0625	ND(0.0347)	ND(0.00347)	ND(0.0347)	0.382	ND(0.0347)	ND(0.00347)	0.101
Ethylbenzene	0.152	ND(0.0434)	ND(0.00434)	ND(0.0434)	0.23	3.69	ND(0.00434)	0.781
Freon 11 (Trichlorofluoromethane)	ND(0.0281)	ND(0.0562)	ND(0.00562)	1.24	2.08	0.899	ND(0.00562)	ND(0.0281)
Freon 113 (1,1,2-Trichlorotrifluoroethane)	ND(0.0383)	ND (0.0766)	ND(0.00766)	0.107	0.176	ND(0.0766)	ND(0.00766)	ND(0.0383)
Freon 114(1,2-Dichlorotetrafluoroethane)	0.671	ND(0.0699)	ND(0.00699)	1.05	3.91	5.17	ND(0.00699)	1.4
Freon 12 (Dichlorodifluoromethane)	1.39	0.257	0.0297	12.4	18.3	17.8	ND(0.00990)	2.87
m,p-Xylenes	0.608	ND(0.0868)	ND(0.00868)	ND(0.0868)	0.608	7.38	ND(0.00868)	0.36
o-Xylene	0.191	ND(0.0434)	ND(0.00434)	ND(0.0434)	ND(0.0434)	ND(0.0434)	ND(0.00434)	ND(0.0217)
Styrene	ND(0.0213)	ND (0.0426)	ND(0.00426)	ND(0.0426)	ND(0.0426)	ND(0.0426)	ND(0.00426)	ND(0.0213)
Tetrachloroethene (PCE)	0.746	0.0678	0.203	0.4	3.46	3.6	ND(0.00678)	1.02
Toluene	0.528	0.098	ND(0.00377)	ND(0.0377)	0.249	18.9	ND(0.00377)	0.528
Trichloroethene (TCE)	0.258	ND(0.0537)	ND(0.00537)	ND(0.0537)	0.591	0.859	ND(0.00537)	0.591
Vinyl chloride (VC)	ND(0.0128)	ND(0.0256)	ND(0.00256)	ND(0.0256)	0.136	1.97	ND(0.00256)	0.0512
Total VOCs	**4.96**	**0.56**	**0.2**	**15**	**33.7**	**71.4**	**0.0**	**8.7**
Total NON-FREON VOCs	**2.90**	**0.30**	**0.20**	**0.40**	**9.2**	**47.5**	**0.00**	**4.4**

µg/L = micrograms per liter
NC = Not Calculated
ND = Not Detected at (Detection Limit)
#ND Detected but not quantified

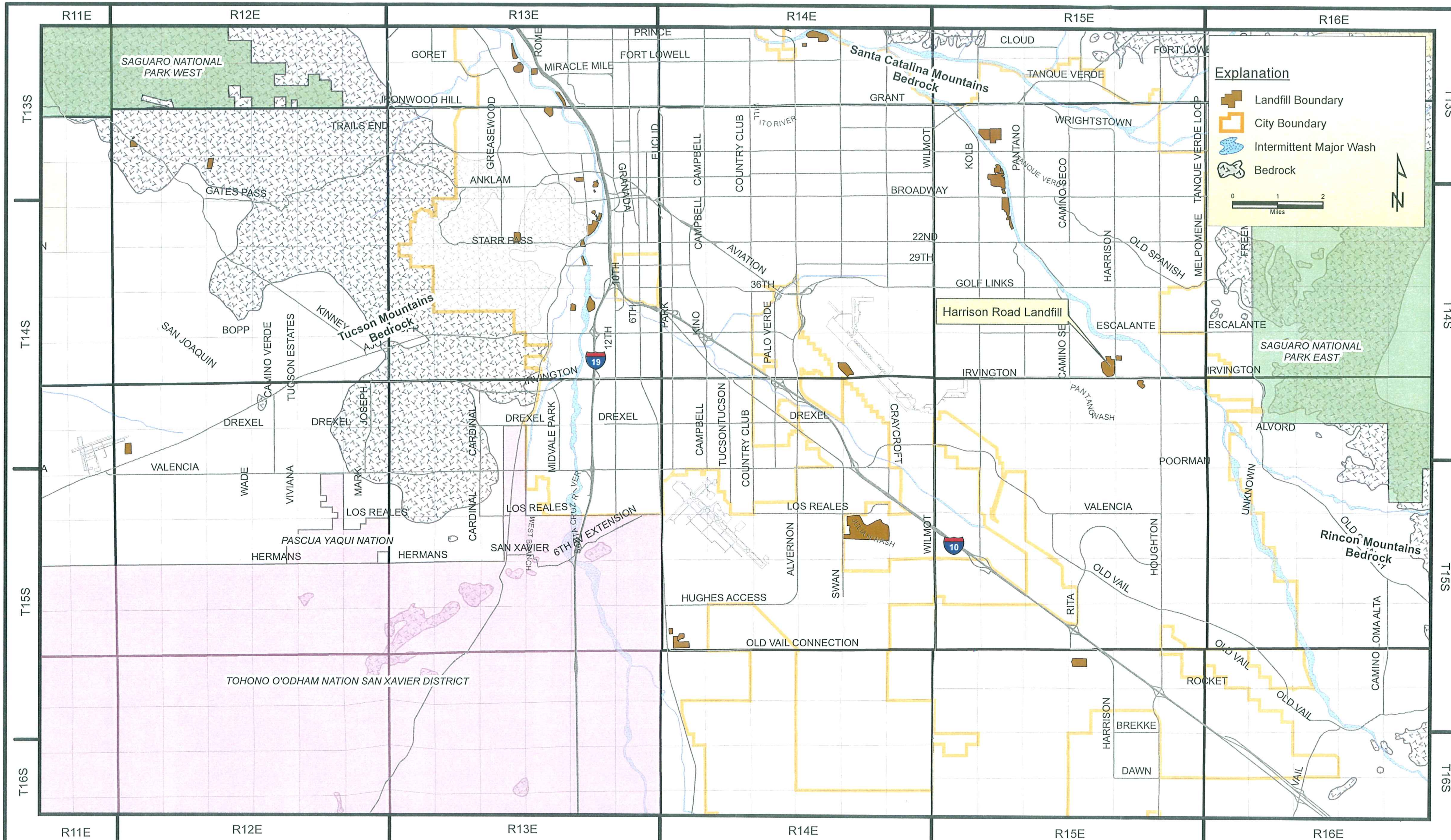

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Figure1
Landfill Location Map

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Approved:	JD
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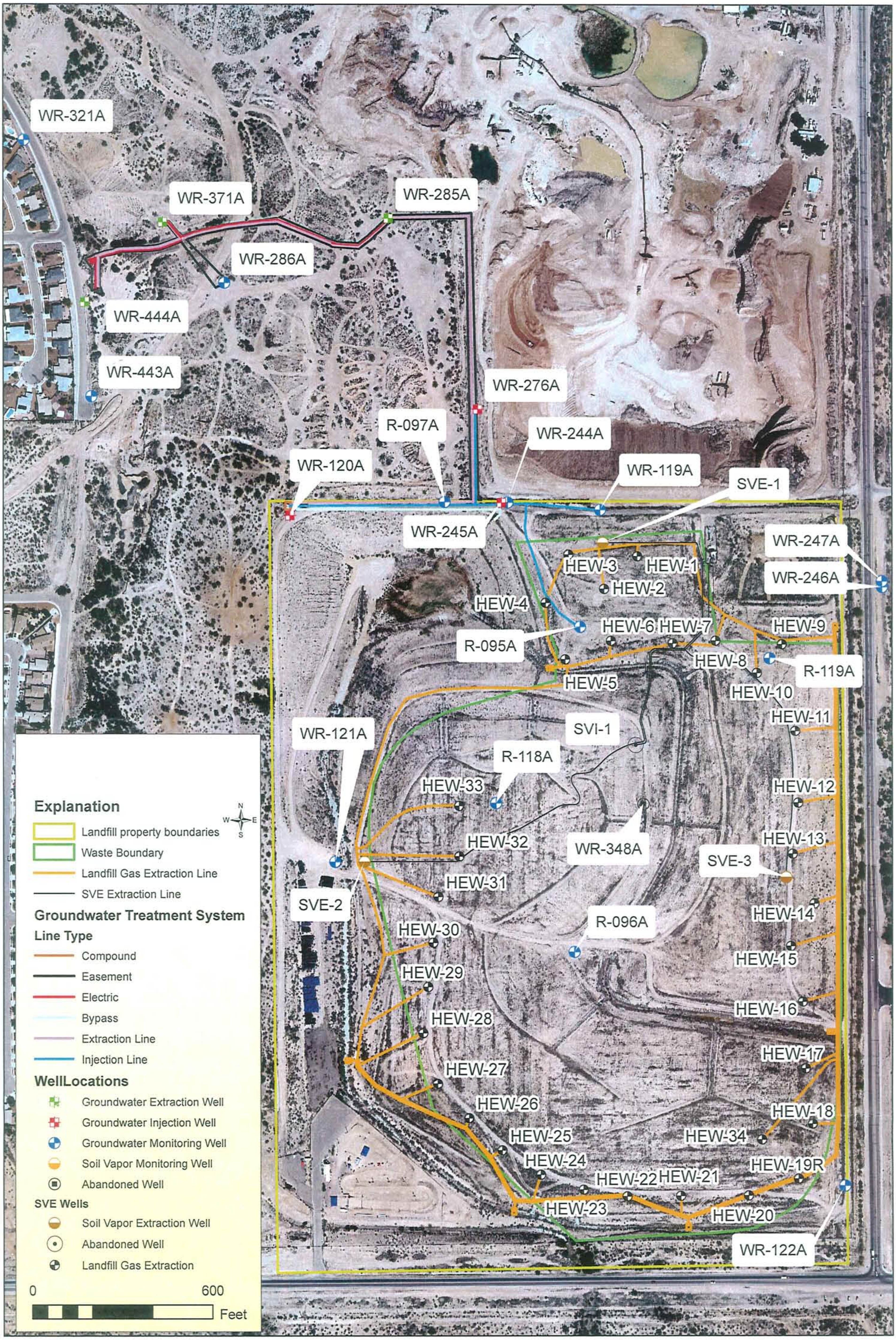

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Figure 2
Site Map and Remediation System Layout
Harrison Road Landfill

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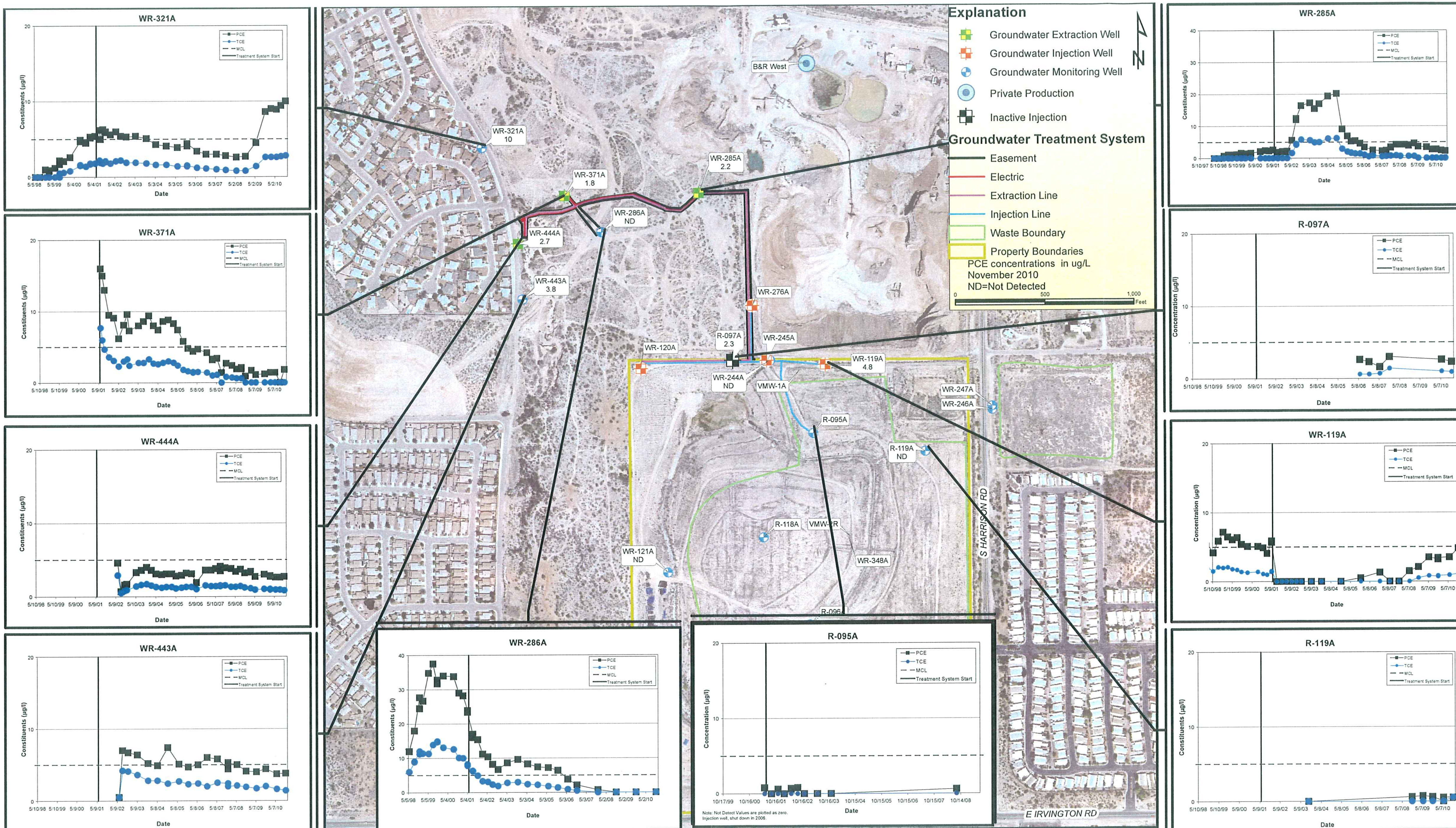

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Figure 3
Groundwater and PCE Concentrations
November 2010
Harrison Road Landfill

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Figure 4
Harrison Landfill
Soil Gas PCE Concentrations

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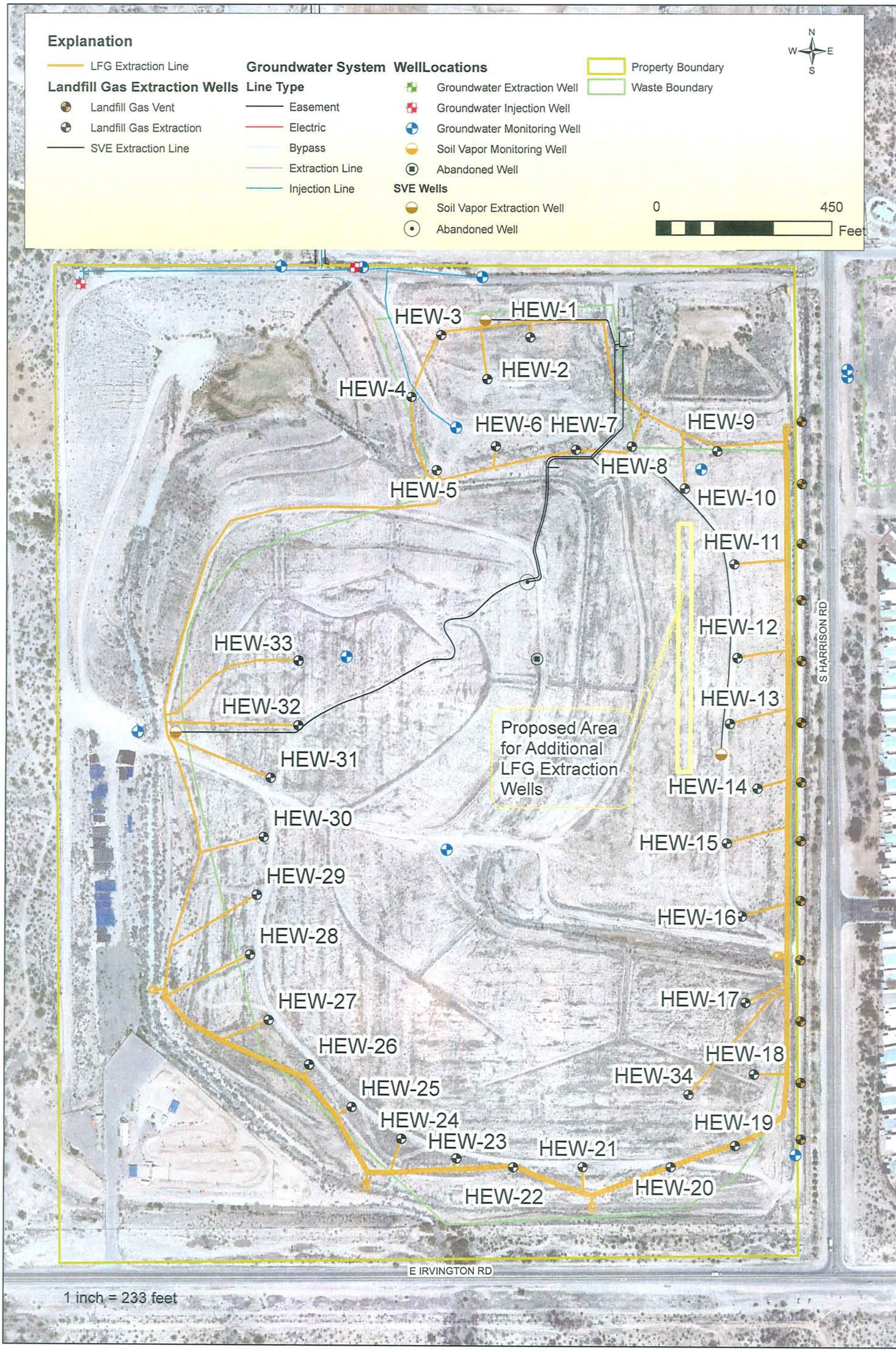

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Figure 5
Landfill Gas Extraction System
Harrison Road Landfill

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