



**Environmental  
Services**

**CITY OF TUCSON  
COMPREHENSIVE LANDFILL INVESTIGATION  
FINAL REPORT  
MARCH 2011**



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*Plot map 1/13  
2013*

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## EXECUTIVE SUMMARY

The City of Tucson, Environmental Services (COT-ES) began the Comprehensive Landfill Investigation (CLI) in 2000 to evaluate groundwater quality downgradient of landfills owned or operated by the City of Tucson which were not regulated by State or Federal Agencies. The landfills discussed in this report are: Kennedy Park Debris Pit, 29<sup>th</sup> Street, A-Mountain, Mission, Cactus, Columbus, Dragoon, Rio Nuevo North, St. Mary's, State Pit, and Walnut. The CLI project also encompassed a water level study at landfills along the Santa Cruz River, and an investigation of TCE detections in wells located in downtown Tucson, but not associated with any landfill. This report documents monitoring efforts from 2006 through 2009, and provides a summary of available historical data.

The Santa Cruz Water Level Study sought to determine if the regional groundwater was in contact with the waste in landfills along the Santa Cruz River. Extensive data from this study indicates groundwater is unlikely to rise to the elevations of the base of these landfills. Therefore, the Santa Cruz water level study will be discontinued.

This report also contains recommendations to discontinue groundwater monitoring and water level data collection at sites where no contamination and no elevated environmental risk has been identified. COT-ES can resume groundwater monitoring should additional information and/or data be provided which indicates further investigation is warranted. Shallow landfill gas will continue to be monitored quarterly at sites where the City is responsible for the monitoring.

### No Further Action Recommended

Site
29 <sup>th</sup> Street Landfill
Cactus Landfill
Dragoon Landfill
Kennedy Park Debris Pit
Mission Landfill
Rio Nuevo North
Rillito River Corridor East (Columbus Landfill and Walnut Landfills)
St. Mary's Landfill
State Pit Landfill



COT-ES will conduct annual groundwater monitoring and investigation for the following two sites due to detections of contamination and/or data trends as discussed in this report. Monitoring parameters and frequency will be evaluated and adjusted as needed.

Further Monitoring Recommended

Site
A-Mountain Landfill
Downtown Area

For sites where an elevated environmental risk is identified, this report establishes site specific monitoring schedules or provides recommendations for further actions.

COT-ES will initiate a program to inspect and maintain City-owned landfills to identify and correct problems such as wildcat dumping, erosion of soil cover, and vandalism of the wells. All COT-ES owned groundwater and deep vapor monitoring wells will be inspected and repaired as needed to insure they are secure and in proper working order. The inspection results and actions taken will be documented. This maintenance program is detailed in the *City of Tucson Closed Landfills Inspection and Maintenance Reporting and Procedures* dated March 2011.

Appendix 10 of this report contains a table listing information on ownership, landfill gas and groundwater monitoring frequency, associated permits and applicable regulatory agencies for 23 landfills owned and/or operated by the City of Tucson. Under the new maintenance program, COT-ES will inspect, monitor and correct issues that arise on landfills owned and maintained by the City as shown.

This will be the final report generated under the CLI project name. Future monitoring of these sites, if applicable, will be summarized in site specific annual reports.

## **1.0 INTRODUCTION**

The City of Tucson, Environmental Services (COT-ES) began the Comprehensive Landfill Investigation (CLI) in 2000 to evaluate groundwater quality downgradient of landfills owned or operated by the City of Tucson which were not regulated by State or Federal Agencies. Over the years, the project expanded to include other sites of environmental interest, such as trichloroethene (TCE) detections in monitor wells in the downtown area, and collection of water level data near the Santa Cruz River in the downtown area. COT-ES has prepared summary reports for the data collected in years prior to 2006. These summary reports are located in COT-ES central files. This report documents monitoring efforts from 2006 through 2009, and provides a summary of available historical data. This report also contains recommendations to discontinue groundwater monitoring and water level data collection at sites where no contamination and no elevated environmental risk is identified as a result of the CLI project. For sites where an elevated environmental risk is identified, this report establishes site specific monitoring schedules or provides recommendations for further actions. This will be the final report generated under the CLI project name. In the future, annual site specific reports will be generated for sites that require routine monitoring as recommended in Section 7.0 of this report.

## **2.0 BACKGROUND**

In 1983 and again in 1995, the Mayor and Council directed city staff to investigate, manage and control methane gas from City owned and/or operated landfills (Loya, 1983 and Garza, 1998). Figure 1 provides the locations of twenty-four landfills which were City owned and/or operated. Table 1 provides site specific information for each of these landfills. The City of Tucson Solid Waste Management Department (SWMD) (precursor to the City of Tucson – Environmental Services) was also directed by Mayor and Council to follow-up on further environmental concerns such as investigations of pollutants in groundwater and in deep soil vapor, construction of improved final closure caps, and determination of land reuse options at city-owned landfills (Garza, 1998).

As required under State and Federal regulations, groundwater and landfill gas (LFG) monitoring programs were established at the following six city-owned and/or operated landfill sites: Broadway North, Harrison, Irvington, Los Reales, Silverbell, and Vincent Mullins. These landfills (shown in blue in Figure 1 and under a blue heading in Table 1) are not discussed in this report.

The following landfills: Cottonwood, Prudence, Congress, Nearmont, Ryan Airfield, Ryland, and Tumamoc, were given site specific monitoring programs during the CLI project although they are not regulated by either State or Federal agencies. These landfills are shown in green on Figure 1 and are listed under a green heading in Table 1 and are also not discussed in this report. They meet the definition of a “closed solid waste facility”, and are not subject to regulation by the Arizona Department of Environmental Quality (ADEQ) Solid Waste Unit (Arizona Revised Statutes § 49-701 (3)(b) and (29)). These landfills are also not regulated under the federal Environmental Protection Agency’s Title 40 Part 258 of the Code of Federal Regulations, as they did not operate beyond October 9, 1991 (40 CFR 258.1(c)). Data from these sites was collected and evaluated individually by COT-ES. Groundwater at Cottonwood, Ryland and Ryan Airfield

was monitored for approximately 8 years but was discontinued in 2009 since no groundwater contamination had been detected. An aerobic bioreactor was constructed at the Congress and Nearmont Landfills under the ADEQ Voluntary Remediation Program (VRP) in 2002 as the Rio Nuevo Landfill Stabilization Project. Groundwater monitoring was conducted for the Rio Nuevo project in accordance with a Work Plan submitted to the VRP in 2003 (HGC, November 2003). The bioreactor project was shut down due to a lack of funding in 2008 and COT-ES withdrew the site from the VRP in 2010. In the future, groundwater monitoring and evaluation will be conducted annually for these two landfills. Groundwater contamination related to landfill activities has been detected at both the Prudence and Tumamoc landfills, and COT-ES has developed an annual groundwater monitoring and evaluation program for each of them. For further details regarding each of these sites, refer to COT-ES site specific files.

The landfills discussed in this report also meet the definition of a “closed solid waste facility” and were placed in the CLI project to be monitored and evaluated annually. The landfills discussed in this report are: Kennedy Park Debris Pit, 29<sup>th</sup> Street, A-Mountain, Mission, Cactus, Columbus, Dragoon, Rio Nuevo North, St. Mary’s, State Pit, and Walnut. These landfills are shown in orange in Figure 1 and listed under an orange heading in Table 1.

The CLI project also includes an evaluation of regional groundwater elevations, and a six year water level study specifically initiated to evaluate groundwater elevations beneath the base of several landfills along the Santa Cruz River (Santa Cruz Water Level Study). In addition, an area of TCE contamination in the downtown area has been included in the CLI project and is discussed in this report.

### **3.0 REGIONAL GROUNDWATER ELEVATIONS**

This section includes a regional groundwater flow map constructed using water level data collected in 2007 and 2008 and the results of a six year water level study along the Santa Cruz River initiated by COT-ES in 2004. The regional groundwater flow map in this report was used to determine the direction of groundwater flow for the city-owned landfills discussed in this report. The results of the Santa Cruz water level study were used to determine if the regional groundwater table intersects the base of waste in landfills situated along the Santa Cruz River.

#### ***3.1 Regional Groundwater Elevation Map***

Tucson Water staff collect non-pumping regional groundwater levels at City-owned wells between November and February of each year. COT-ES, Marana, and Metropolitan Domestic Water Improvement District (DWID) also provide water level data to Tucson Water during that same time period. Tucson Water staff prepare a regional groundwater map for each annual collection period, however it may take several years between data collection and publishing of the map. Therefore, COT-ES used the data collected in 2007 and 2008 from 730 non-pumping wells to contour a groundwater elevation map for use with this report. The groundwater elevation contour map is shown in Figure 2.

The Tucson basin is a valley bordered by the Tucson Mountains to the west, Santa Catalina Mountains to the north, and the Rincon Mountains to the east. Groundwater flow in the basin is generally to the northwest except near the Santa Catalina Mountains, where flow is to the southwest.

The contours provided in Figure 2 are incorporated into Figures 4 and 5 of this report so groundwater flow direction can be seen in selected individual project areas.

### **3.2 Local Perched Water Aquifer**

A perched aquifer is generally present beneath downtown Tucson at depths between 40 and 70 ft below ground surface (bgs). Additional information about this perched aquifer in the downtown area can be found in groundwater monitoring reports associated with City of Tucson Police/Fire Station HQUST Leaking Underground Storage Tank Site, the City of Tucson Rio Nuevo Full Scale Stabilization Project, and the City of Tucson Pioneer Paints Project. Several environmentally impacted sites in the downtown area have encountered a perched aquifer including the Union Pacific Railroad / Passenger Depot Site, ADEQ 7<sup>th</sup> Street & Arizona Avenue Water Quality Assurance Revolving Fund (WQARF) site, and the Park-Euclid WQARF site. All of these sites, except for the Park-Euclid WQARF site, have contamination solely in the perched aquifer because the clay aquitard which is the base of the perched aquifer generally creates a barrier and prevents migration to the regional aquifer. Although the perched aquifer is known to be present beneath several of the sites discussed in this report, the extent, connectivity and general perched groundwater flow direction was not investigated. However, flow in the perched aquifer is to the northwest at the HQUST and Pioneer Paints projects (see project specific reports located in COT-ES central file for more information). In the vicinity of the Congress and Nearmont Landfills, the perched groundwater is discontinuous and occurs only in isolated perched aquifer monitor wells.

### **4.0 THE SANTA CRUZ WATER LEVEL STUDY**

From 2003 until 2009, COT ES conducted a study of water levels along the Santa Cruz River to evaluate the regional groundwater elevation in relation to the base of waste in landfills located along the River. The data are also helpful in evaluating any future plans for proposed projects, such as riparian restoration or artificial recharge to the Santa Cruz River.

There are thirteen closed landfills within the approximately 7 mile segment of the Santa Cruz River bounded by Mission Road/Silverbell Road to the west, the Silverbell Golf Course to the north, Stone/6<sup>th</sup> Avenue to the east and West Ajo Way to the south. The landfills are, from north to south: Silverbell, UofA Open Dump, State Pit, Dragoon, St. Mary's, Rio Nuevo North, Nearmont, Congress, A-Mountain, Mission, 29<sup>th</sup> Street, Cottonwood, and Ryland (Figure 3). Dedicated transducers and automatic data loggers were installed in twelve groundwater wells in 2003 (Figure 3). Data were recorded every 12 hours. Three times a year, COT ES staff downloaded the transducer data in the field and then appended it to historical data in the office. Hydrographs are produced for each well and are included on Figure 3. The hydrographs also include rainfall data.

Variables that can influence the hydrograph trends seen on Figure 3 include distance from the Santa Cruz River, lithology, well construction, and precipitation. With the exception of B-079A, most monitoring wells show noticeable spikes in water levels in response to summertime monsoon rains. At B-079A, the water level in the well is approximately 20 feet higher than nearby regional groundwater wells, and the water levels in the well do not respond to

precipitation events. Although there are no boring or video logs available for B-079A, its location near the base of A-Mountain suggests it may be screened in fractured bedrock.

In general, water levels in wells north of A-Mountain have been decreasing an average of 1.2 feet per year (ft/yr). The wells north of A-Mountain with the greatest average decreases are WR-349A at -1.20 ft/yr, and WR-182A at -1.65 ft/yr. Water levels in wells south of A-Mountain have been increasing an average of 1.5 feet per year. The wells south of A-Mountain with the greatest average increases are WR-441A and SS-013A, which have each increased an average of +2.34 ft/yr.

Monitoring well WR-364A, located 80 ft from the Santa Cruz River to the east of A-Mountain Landfill, had the most immediate and significant response to precipitation with an approximate 14 foot rise in September 2006. The groundwater elevation at this well was 2254.65 feet above mean sea level (ft amsl) in September 2006. This maximum groundwater elevation is still approximately 105 ft below ground surface, and about 60 feet below the estimated maximum bottom depth of refuse in the A-Mountain Landfill.

Among the wells south of A-Mountain which are experiencing an overall increasing trend in water levels, monitoring well WR-441A, located next to Cottonwood Landfill, has had the most significant increase and has the highest groundwater elevation (2251.86 ft amsl) for this area. Using a linear trend line for the groundwater elevation data collected from WR-441A since 2005, the increasing slope is +0.0049 ft/day or +1.79 ft/yr. If the current trend seen in WR-441A continues, it will take approximately 52 years for the water table to reach bottom of estimated elevation of refuse at the Cottonwood Landfill at 2346 ft amsl. Tucson Water Staff have also noticed this increasing groundwater elevation trend south of A-Mountain, particularly near the Tucson International Airport and near Pima Mine Road. Wally Wilson with Tucson Water attribute this change to increased use of Central Arizona Project (CAP) water by the Tohono O'Odham Nation and the two operating mines in the same vicinity, and their corresponding decreased use of groundwater (personal communication, January 28, 2011).

Figure 3 contains a table listing the estimated base of waste elevation for each landfill. Water level elevations in wells measured for the study are not high enough to be in contact with the base of waste. Water levels along the Santa Cruz River appear to respond mainly to precipitation events. In evaluating sporadic groundwater increases and potential increasing long-term trends, it appears that regional groundwater is not likely to come in contact with waste in the landfills. Therefore, the Santa Cruz Water Level Study will be discontinued, and most of the transducers and dataloggers will be removed and used at other sites as needed.

## **5.0 SHALLOW LANDFILL GAS MONITORING**

Assessing landfill gas migration was specified by the Mayor and Council directives (Loya, 1983 and Garza, 1998). COT-ES has routinely monitored permanent shallow soil gas probes at the boundaries and interiors of the following landfills: A-Mountain, Dragoon, Mission, Rio Nuevo North, and St. Mary's. At a minimum, COTF-ES conducts this monitoring quarterly. COT-ES also maintains and operates a landfill gas control system at the Rio Nuevo North Landfill to control off-site migration of landfill gases as needed.

The 29<sup>th</sup> Street and State Pit Landfills are currently owned by other governmental agencies (County and State, respectively), they have been turned-over to those agencies for additional investigation as deemed necessary (Garza, 1998). The City of Tucson is not responsible for monitoring or maintaining these sites.

The Cactus, Columbus, and Walnut landfills are not routinely monitored by COT-ES, because the properties are privately owned, and where necessary, are routinely monitored by the private owner with results reported to the Tucson Fire Department as required under the City Landfill Ordinance # 10037 adopted under Mayor and Council on September 13, 2004.

A small debris area which was operated by City of Tucson Parks and Recreation located at the Kennedy Park Debris Pit is not monitored by COT-ES for methane as the buildings located within the vicinity are not occupied, and there are no permanent monitor probes established at the site.

The landfill gas monitoring data collected from probes at the Mission, A-Mountain, Rio Nuevo North, St. Mary's, and Dragoon Landfills are discussed in more detail in the next section under each specific landfill heading.

## **6.0 SITE HISTORIES AND ENVIRONMENTAL ASSESSMENTS**

This section will discuss site specific histories and the results of environmental investigations for sites in the CLI project. These landfills include 29<sup>th</sup> Street, A-Mountain, Cactus, Columbus, Dragoon, Kennedy Park Debris Pit, Mission, Rio Nuevo North, St. Mary's, State Pit, and Walnut Landfills. The Downtown TCE contamination area will also be discussed in this section.

The CLI project mainly utilizes existing groundwater wells located within a vicinity of or downgradient of a project area. In other cases, wells were installed for this study. Due to the limited availability of existing wells, some serve as monitoring points for multiple landfills and other project areas. As seen in Figures 4 and 5, project areas were developed so groundwater data for a particular well serving multiple sites is discussed only once. The project areas will be discussed from south to north and are: Kennedy Park Area; Southern Santa Cruz River Area; Downtown Area; Middle Santa Cruz River Area; Northern Santa Cruz River Area, and the Rillito River Corridor Landfills West and East.

### **6.1 Kennedy Park Debris Pit**

The site was originally a rock quarry located near Ajo and Mission Roads at the current Kennedy Park Area (see Figure 4 for the general location of the site, and Attachment 1 for a site specific map). The site is owned and maintained by the City of Tucson. The City of Tucson Parks and Recreation used the pit from the mid to late 1970's to early 1980's for the disposal of excess soil from various sources, and construction debris including concrete, wood and steel. To their knowledge, no municipal waste was disposed (Wittwer, 1994). The debris pit appears to be exempted from the definition of a municipal solid waste facility as it mainly consists of landscaping rubble that was used to reclaim the land (ARS § 49-701.01 (B) 15). Therefore, this site does not fall under the state definition of a landfill. The property is currently operated by the City of Tucson Parks and Recreation as the Kennedy Park Fiesta Plaza. Below is a brief

overview of data collected from the site. Additional information is available in the site file at COT-ES.

As part of site specific environmental assessments, seven boreholes were drilled in 1994 by a consultant (EEC, 1994). In March 2005 COT-ES installed three groundwater monitor wells (WR-460A, WR-461A and WR-462A) and one soil boring. From these assessments, the fill area ranges in depth from 1 ft bgs to 30 ft bgs, and was described as primarily silty, sandy gravelly soil with wood, twigs, leaves, organic content, brick, plastic, glass, cloth, and foam (EEC, 1994 and van Rijn, 1994). The waste footprint is approximately 0.5 acres (Zonge, July 2004). Bedrock was encountered at depths ranging from 21 ft bgs to 32 ft bgs. Subsurface water was found at depths ranging from 10.5 ft bgs to 18 ft bgs.

Information collected during assessments and a geophysical survey supports that no or very little municipal solid waste was disposed in this area (EEC, 1994 Zonge, July 2004 and Byrd, July 2008). However, due to the presence of non-degraded organic material (wood, branches, etc.) in the subsurface near the Fiesta Plaza, surface settlement and production of methane are of concern. A temporary soil vapor testing location was installed by SWMD but no methane was detected (Murray, 2002). COT-ES advised Parks & Recreation of methane migration and land surface stability concerns for nearby building structures (van Rijn, 1994). Parks & Recreation had experienced land subsidence, building settlement and foundation damage, to the point where several structures had to be demolished in 1999-2000 (Byrd, July 2008). Methane at the site is not monitored by COT-ES as the buildings located within the vicinity are not occupied, and there are no permanent monitor probes. As this site does not fall under the state definition of a landfill, it will not be monitored in the future for methane.

#### *6.1.1 Kennedy Park Debris Pit Water Quality*

Groundwater monitoring was conducted annually at the site from 2005 to 2009. Soil samples collected during well installation in 2005, and groundwater samples from the three monitor wells were analyzed for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). Samples were not analyzed for metals, anions, or general chemistry as these compounds are not typically of concern at City-owned landfills. No VOCs or SVOCs have been detected above laboratory method detection limits in the soil or water samples, except for minor anomalous detections of naphthalene in water samples in collected in 2007. Naphthalene was detected in monitor wells WR-461A and WR-462A at 0.0012 mg/L and 0.0011 mg/L, respectively. Subsequent monitoring events in 2008 and 2009 were non-detect for all VOCs. Table 1 contains a summary of selected VOC data for the wells (see Attachment 1 for charted detected values and Attachments 8 and 9 for fieldsheets and laboratory analytical reports).

The above data and information do not indicate that the debris pit at Kennedy Park Debris Pit has adversely affected groundwater quality in this vicinity. At this time, the site appears to have low environmental risk potential for groundwater. No further groundwater monitoring is necessary however; COT-ES can resume groundwater monitoring should additional information and/or data be provided which indicates further investigation is warranted.



## 6.2 *Southern Santa Cruz River Area*

These three landfills share upgradient and downgradient wells. The site specific history for each landfill is discussed followed by water quality results for the Southern Santa Cruz River Area. Groundwater has been monitored near the sites from 2000 through 2009. Methane gas has been routinely monitored at the A-Mountain Landfill since at least 1997.

### 6.2.1 *29<sup>th</sup> Street Landfill*

The 29<sup>th</sup> Street Landfill is located at the Pima County Main Jail Complex at 1270 W. Silverlake Road (Figure 4). The landfill property is currently owned and maintained by Pima County and the City is not responsible for it. Most of the refuse area is capped by soil. A portion of the refuse is capped by a paved parking lot. The Santa Cruz River is located along the landfill's eastern side.

Although there are no detailed records available, the 29<sup>th</sup> Street Landfill was operated by the City for a short period in the mid-1960's for disposal of Class II trash which included green waste and construction debris. The waste footprint is estimated to be 6.5 acres (Gutierrez, 1995). COT residential and commercial trucks did not use the landfill for disposal of municipal waste, but there were no site restrictions and the site could have potentially been used by the public as a wildcat dump (Gutierrez, 1995).

In 1995, a shallow soil gas survey completed by the City of Tucson Solid Waste Department within waste at the landfill indicated low concentrations of vapor phase VOCs. The highest reported concentrations of VOCs were PCE and TCE each at 0.015 µg/L. In comparison to other landfill sites, the VOC concentrations observed would not appear to be of environmental concern. During the same investigation, methane was detected at a maximum average concentration of 33% in the center of the landfill. The lowest methane and VOC concentrations were reported near the perimeter (Cawein, 1995). Permanent soil gas probes were not installed since Pima County is responsible for monitoring and maintenance of this property.

There are no deep vapor probes or groundwater wells at the site, thus no information is available on the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary. There is also no information confirming the presence or absence of a perched aquifer in the vicinity of this landfill.

### 6.2.2 *Mission Landfill*

Mission Landfill is located at 1056 S. Mission Road, near the Mission Road and Starr Pass Blvd intersection (Figure 4). It is owned and maintained by the City of Tucson. The landfill operated from approximately 1963 – 1970 for the disposal of Class II trash. The waste footprint is approximately 7.6 acres based on the historical outlines provided in the CDM, 1996 report Table 1 in the CDM report lists the landfill size as 30 acres but in Section 8 of the same report, a memorandum lists the landfill footprint size as 10 acres (COT Environmental Services, 1983). Using the outline provided in the 1996 CDM report, COT-ES calculated 7.6 acres for the buried waste footprint. During bank protection construction by Pima County in 1996, primarily construction debris (bricks, concrete, rebar, newspaper, and green-waste) was observed protruding from the bank side with minor household waste (CDM, 1996). The presence of construction debris was confirmed again in 1999 with borings (Garbage Project, 1999).

A geophysical survey confirmed that there is not a significant amount of waste buried at the Mission Landfill site (Zonge, December 2003). The survey, which consisted of 5 station lines, showed a fairly simple layered subsurface structure which is consistent with a clean fill or disturbed alluvium. The Zonge survey lines identified only two areas with a minimum size of 40 ft x 35 ft and 20 ft x 35 ft in the northern portion of the landfill boundary, which appeared to contain municipal solid waste based on signal characteristics.

COT-ES installed two permanent shallow soil vapor probes in 1998, (Attachment 2). MS-1 is equipped with one probe at a depth of 10 ft bgs, and MS-2 is nested with 10 ft bgs and 20 ft bgs probes. They were monitored between July 1998 and June 1999, initially on a weekly basis for the first couple of months and then on a monthly basis. Only minor amounts of methane (less than 0.2%) were found. These concentrations were considered within equipment error tolerances and very minor (COTSWMD, September 1999). COT-ES has continued methane monitoring at the probes quarterly since 2000. Methane has not been detected. Because no methane has been detected since 2000, this data was not charted in Attachment 2.

No information was found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary. There is also no information confirming the presence of a perched aquifer.

### *6.2.3 A Mountain Landfill*

The A-Mountain landfill is located between the Santa Cruz River and Mission Road at the eastern base of A-Mountain (Figure 4). This landfill operated from 1953 to 1962 for disposal of municipal solid waste including residential, commercial and construction/demolition debris. There were no site restrictions and it could have been potentially used by the public as a wildcat site. The waste foot print is estimated to be 31.4 acres. The landfill is owned and maintained by the City of Tucson.

Pima Association of Governments (PAG) gave this landfill a pollution potential rating of C which indicated that it had a good possibility for groundwater pollution (PAG, 1986). Since the date of that report, COT-ES has completed a geophysical/IP survey to delineate the waste footprint, and installed and monitored three site groundwater monitoring wells (WR-364A, WR-365A, and WR-366A).

The IP and resistivity geophysical survey conducted in late 2000 by Zonge indicated the refuse was prominent over most of the area with a depth ranging from 0 to 45 feet bgs. Refuse was most prevalent in the 15 to 30 foot depth range. The deepest, thickest refuse area is in the northeastern portion where it averages 30 to 45 feet deep (Attachment 2).

Today COT-ES monitors twelve permanent perimeter shallow landfill gas probes, and four groundwater monitoring wells surrounding the landfill (Attachment 2). Minor methane detects (0.1% by volume) have occurred in two probes (AMT-2 and AMT-4) four times since 2000. These detects are within error tolerances of the methane monitoring machines. Methane detections have been charted and are provided in Attachment 2.

#### *6.2.4 Southern Santa Cruz River Area Groundwater Quality*

COT-ES has monitored groundwater wells WR-364A, WR-365A, and WR-366A since 2000, SS-019A since 2002, and LM-007A since 2007 for 35 inorganic constituents and VOCs. Detected constituents are summarized in Tables 2 and 3 and charted in Attachment 2. All detected compounds including general chemistry, anions, metals, and VOCs show decreasing or stable trends. In well SS-019A, no VOCs were detected (Table 2), and most inorganics are below the Aquifer Water Quality Standard (AWQS) except for arsenic, which ranges from 0.06 to 0.08 mg/L at the well. However, arsenic is a naturally occurring metal in groundwater in the Tucson Basin and has been consistently detected above the 0.05 mg/L AWQS in SS-019A (Table 3 and Attachment 2).

Low concentrations of tetrachloroethene (PCE), 1,4-dichlorobenzene, cis-1,2-dichloroethene, trihalomethanes, methylene chloride, and toluene have been detected in wells within the vicinity of the A-Mountain Landfill (Table 2). All of these concentrations are below their respective AWQS, are relatively stable and/or have declining trends (see charted data in Attachment 2).

The above concentrations and trends do not indicate that the 29<sup>th</sup> Street and Mission Landfills have adversely affected groundwater quality. These landfills are considered a low future environmental risk. Therefore, well SS-019A will no longer be monitored.

The groundwater concentrations of VOCs in wells WR-346A, WR-365A, WR-366A and LLM-007A around the A-Mountain Landfill will continue to be monitored. Monitoring will be conducted annually for VOCs and seventeen inorganic and field parameters as listed in Table 4. In the future, an annual site specific report will be prepared to document the groundwater monitoring data for the A-Mountain Landfill.

#### *6.2.5 Southern Santa Cruz River Area Landfill Gas Monitoring*

Shallow landfill gas concentrations will continue to be monitored at both the Mission and A-Mountain Landfills. Documentation of the data will be provided in the annual site specific report. Shallow landfill gas concentrations are not monitored at the 29<sup>th</sup> Street Landfill as the property is the responsibility of Pima County.

### **6.3 Downtown Area**

PCE, trichloroethene (TCE) and elevated nitrate concentrations have been detected in the following regional aquifer monitoring wells in the downtown area: (SS-016A, WR-248A, WR-249A, WR-271A, and WR-271B). These wells are not located downgradient of any known landfill (Figure 4). Groundwater monitoring has been conducted in the area since at least 2001.

Former groundwater production well SS-016A has been sampled by COT-ES since 2002 as part of the CLI. SS-016A is owned by Tucson Water, and located on the east side of I-10 at 501 W. 18<sup>th</sup> Street within Tucson Water Plant 1. Nitrate concentrations appear to be increasing in the well and since 2006, nitrate has consistently exceeded the AWQS of 10 mg/L. Also since 2006, TCE, and PCE have been detected in the well at levels below the AWQS of 5 ug/L, (Table 2 and Attachment 3). SS-016A is screened across both the perched or regional aquifers, and it is unknown which aquifer the nitrate and TCE results represent. Drilled in March 1946, SS-016A was perforated by Mills knife from 50 to 190 ft bgs and is uncased from 196.5 to 275 ft bgs

(original well log in well file at COT-ES). The video log done in November 2001 confirmed perforations from 53 to 195 ft bgs, damp casing beginning approximately 90 ft bgs (with algae growth), and static water level at 127 ft bgs. The video log also indicated the extremely poor condition of the casing due to corrosion and age. SS-016A could potentially be a conduit of contamination from the perched aquifer to the regional aquifer. COT-ES recommends that the cased area in the perched aquifer at SS-016A be sealed or the well abandoned entirely. In February 2011, the COT-ES and Tucson Water met to discuss the well. COT-ES will collect a groundwater sample from the well in February 2011, and Tucson Water will have the well video logged and modify it if possible. If the well cannot be modified to seal off the perched layer, Tucson Water has agreed to abandon the well.

TCE has been detected at levels below the AWQS of 5 ug/L in all regional groundwater monitor wells (WR-271B, WR-248A and WR-249A) at the former Pioneer Paint & Varnish (PP&V) site since 2001. This site is located approximately half of a mile downgradient of SS-016A (Figure 4) and was the location of a leaking under ground storage tank (LUST) which impacted the perched aquifer with PCE. The site was remediated and the LUST case closed by ADEQ in 2008. The perched aquifer wells were abandoned by the property owner in April 2009. Groundwater monitoring data for the PP&V are documented in site specific reports. Concentrations of TCE have not been detected in the perched aquifer wells at the PP&V site (which are not shown on Figure 4). The absence of TCE in the perched layer indicates that PP&V was not the source of the TCE.

The source of TCE and nitrate in the regional aquifer on the eastside of I-10 is unknown, and at this time appears to be unrelated to the landfills located to the west of the Santa Cruz River. It is also unclear if TCE concentrations at the PP&V site regional wells and those found at the SS-016A well are related although the rate of increase in concentration of the contaminant is similar between the wells (Attachment 3). A-Mountain Landfill, the closest proximity landfill to SS-016A, primarily has detections of PCE at concentrations below 1 µg/L, no detectable concentrations of TCE and nitrate concentrations below 2.5 mg/L (Byrd, June 2008, and Table 3).

The downtown TCE issue will continue to be monitored by COT-ES. Wells SS-016A (unless well is abandoned), WR-248A, WR-249A, and WR-271B will be monitored annually for VOCs, anions (including nitrate), total dissolved solids, and field parameters as listed in Table 5. An annual site specific report will be prepared to document the groundwater data for the area.

#### **6.4 Middle Santa Cruz River**

These two landfills share groundwater monitoring wells (Figure 4). The site specific history for each landfill is discussed followed by water quality and methane monitoring results. The Rio Nuevo North Landfill has been routinely monitored for methane since 1997. The St. Mary's Landfill has been routinely monitored for methane since 1998. Groundwater monitoring has been conducted since 1999.

##### **6.4.1 Rio Nuevo North Landfill**

The Rio Nuevo North landfill (RNN), historically known as Linda Landfill, is located at 401 N. Bonita Avenue. The waste footprint is approximately 9 acres (Figure 4). Originally the area was

used for clay, sand, and gravel mining operations in the 1930's. Later the site was used for waste disposal from 1960 to 1971. Refuse disposed mainly by City of Tucson trucks has been documented as municipal solid waste, landscaping waste, and construction debris (CDM, 1996 and Agra, 1998). The City of Tucson owns and maintains the landfill.

In the 1980's, the city's Downtown Development Corporation, hired a firm to investigate the subsurface for the presence of unacceptable fill materials, remove these materials, and replace with appropriate fill. Waste from 100 test pits was excavated as part of this project, but there was concern that pockets of trash still existed. To investigate that concern, the city hired another consultant in the late 1990's to identify potential pockets of trash on parcels surrounding the main refuse body.

Of the eight parcels investigated, clean fill was commonly found, but a pocket of refuse was identified south of the main landfill body in Lots 17 and 18 (Agra, 1999, Phase II Site Assessments - 8 reports total for each parcel). Approximately 30,300 cubic yards of refuse is estimated to exist beneath these two lots. The boundary of the waste is shown on the map in Attachment 4. Borings identified refuse consisting of concrete, asphalt, brick, wood, soil, glass, vegetation, metal, wire, rags, and fabric. The borings also confirmed a perched aquifer (saturation at 37 ft bgs), which was in direct contact with the refuse in the smaller pocket of trash just south of the main landfill. Soil samples obtained directly below the refuse were analyzed for petroleum hydrocarbons, pesticides, and semi-volatiles organic compounds but had no detections of any compounds. In 1998, COT SWMD constructed a landfill gas extraction system to remove methane accumulating in the waste as needed.

From March 2000 to April 2010, COT-ES monitored twenty-five shallow, permanent landfill gas probes around and within the waste footprint boundary (Attachment 4). Due to close proximity of buildings, monitoring of probes within the waste boundary is necessary in some areas. There have been several methane detections with the highest detection in September 2008, at 3.3 % by volume in probe RNN-35 at 10 ft bgs. In response, COT-ES operated the site landfill gas extraction system to reduce the methane accumulation and in subsequent monitoring events, the concentrations have dropped to less than 0.5% (see Attachment 4 for methane chart at RNN). Concentrations have not exceeded the lower explosive limit (5% by volume) of methane in any probe since 2000.

No information was found in regards to the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the main (larger) landfill boundary. There is also no information confirming the presence of a perched aquifer in the vicinity of the main landfill, but it is highly likely present since it was identified at the smaller pocket of trash just to the south.

#### *6.4.2 St. Mary's Landfill*

St. Mary's Landfill is located at Menlo Park at 425 N. Grande Ave, along the west side of Grande Ave., 0.1 mile south of St. Mary's Road (Figure 4). The landfill operated from approximately 1963 to 1973 for the disposal of Class II trash and debris consisting primarily of green waste and construction debris. The waste footprint is approximately 10.5 acres (CDM, 1996). The City of Tucson owns and maintains the landfill.

St. Mary's Landfill waste consists of inert material such as fill dirt as confirmed in studies completed by City SWMD during a methane gas investigation and waste characterization (COTSWMD, September 1999 and Garbage Project, 1999). Waste samples were collected during the installation of permanent landfill gas monitoring probes and the drilling of exploratory borings within waste at the landfill.

COT-ES has monitored twenty-nine landfill gas probes located outside and within the landfill footprint on a quarterly basis since March 2000. Attachment 4 contains a map showing the probe locations. Significant quantities of methane have not been detected, except a detection of 0.8% in December 2007 at SMT-19. This concentration is also the maximum methane concentration detected in the past decade of monitoring. Methane readings are plotted in Attachment 4.

No information was found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary. There is also no information from the site which confirms the presence or absence of a perched aquifer.

#### *6.4.3 Middle Santa Cruz River Area Groundwater Quality*

COT-ES has monitored regional groundwater monitor wells WR-349A, and A-030A, which are downgradient of the Rio Nuevo North and the St. Mary's Landfills on an annual basis for VOCs and 35 inorganic compounds since 1999. Data was incorporated from wells ASDB, located within the Arizona Deaf and Blind facility, and WR-131A which Tucson Water monitors annually for VOCs, anions, and five metals. WR-131A is located 0.43 of a mile downgradient from St. Mary's Landfill. ASDB is located 0.75 mile downgradient of the RNN landfill and was sampled by COT-ES one time in 2004 at the beginning of the CLI project. No constituents of concern were found and the well was not sampled subsequently.

VOCs that are commonly associated with landfill releases (PCE and TCE) have not been detected in the wells, and of the 35 inorganic compounds analyzed, all have been non-detect or below the respective AWQS, except for nitrate (Tables 2 and 3, Attachment 4). The regional groundwater monitoring well WR-349A has a narrow concentration range for nitrate above and below the AWQS of 10 mg/L. In June 2009, nitrate concentrations met the AWQS (Table 3 and Attachment 4). Wells A-030A and WR-131A appear also to have an increasing trend in nitrate although the concentrations remain less than half of the AWQS of 10 mg/L.

Concentrations of the VOCs chloroform and total trihalomethanes have been observed just above detection limits in wells WR-349A, A-030A, and WR-131A since 2000. Chloroform is a total trihalomethane, and the standard for total trihalomethanes is 0.10 mg/L. All trends for these two VOCs appear to be stable, and the maximum concentration observed in this vicinity was in well WR-349A at 0.001 mg/L on 7/15/2004 (Attachment 4).

Concentrations of methyl tert butyl ether (MTBE) were detected ranging from 0.005 mg/L to 0.006 mg/L in well WR-349A before January 2005. There is no AWQS or EPA MCL for this compound, but ADEQ has a Tier I remedial level of 0.020 mg/L. This well has been non-detect

for this compound since January 2005 (see MTBE chart in Attachment 4). MTBE is generally not associated with landfills.

Zinc appears to have an increasing trend in monitoring well WR-349A, but a linear regression trend line interprets a rate of only +0.1 mg/L per year (Attachment 4). The appearance of a significant increasing trend is likely due to the low concentration scale which is appropriate for the data set. The increase in zinc is therefore negligible.

There is no information on the presence or absence of a perched aquifer in the area, although it is likely present in the southern portion of the area since perched zone was identified south of the RNN main landfill body cell.

The above concentrations and trends do not appear to indicate that the St. Mary's and RNN Landfills have adversely affected groundwater quality in this vicinity and additional monitoring of groundwater is not recommended. At this time, the site appears to have low environmental risk potential. COT-ES can resume groundwater monitoring should additional information and/or data be provided which indicates further investigation is warranted.

#### *6.4.4 Middle Santa Cruz River Area Landfill Gas Monitoring*

Shallow landfill gas concentrations will continue to be monitored at both the St. Mary's and RNN landfills quarterly. Documentation of the data will be provided in an annual landfill gas monitoring report.

### **6.5 Northern Santa Cruz River Area**

The site specific history for each landfill is discussed followed by a combined water quality results section for this area (Figure 4). The Dragoon Landfill was routinely monitored by COT-ES for methane from 2000 to 2010. The State Pit Landfill is not owned by COT-ES and is not monitored for methane. Groundwater monitoring in the area has been conducted by Tucson Water or COT-ES routinely since 1990.

#### *6.5.1 Dragoon Landfill*

This site is located southwest of the intersection of Grant Road and Dragoon Street, just west of I-10 (Figure 4). The landfill operated from 1964 – 1966, and accepted Class II trash (green waste and construction debris). The waste footprint is approximately 30 acres (CDM, 1996). Today, the land is privately owned by several businesses.

In November 1996, the City SWMD performed a methane gas investigation by testing the interior of buildings and bar-hole testing for landfill gas along the perimeter of the properties, and next to buildings. No methane was detected inside any structures. There was a single detection of 1% by volume of methane that was measured near the Tucson Tractor structure. This structure is built on 20-30 feet of clean fill and has a passive venting system (Leverenz, 1996).

During the 1996 methane investigation, City of Tucson staff learned that Tucson Tractor completed a Phase I Environmental Assessment and waste excavation prior to constructing a building addition. An area of waste measuring 100 feet by 300 feet was excavated to depths of



20 to 30 feet and transported to a local active landfill. Clean fill was used to replace the waste and a passive venting system was added for the new addition due to odor complaints. Tucson Tractor said that the excavated waste was predominately construction debris with small amounts of glass, plastic, newspapers, tires, and a refrigerator.

The COT-ES has been monitoring a nested permanent shallow landfill gas probe (DRG) at depths of 10 ft bgs and 25 ft bgs. The probe is located approximately 250 feet southeast of the landfill boundary (See the map in Attachment 5). Between December 2000 and January 2010, the probes were monitored on a minimum quarterly schedule for landfill gases. Methane has never been detected. Because no methane has been detected, this data was not charted in Attachment 5. COT-ES and Tucson Fire Department agreed to discontinue methane monitoring at the landfill in 2010.

No information was found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary.

#### *6.5.2 State Pit Landfill*

The State Pit landfill is located at 1444 W. Grant Rd, on the north side of Grant Rd, between the Santa Cruz River, and I-10 (Figure 4). The waste footprint is approximately 14.6 acres. The landfill was operated from 1968 to 1970. There is little information available concerning the type of trash deposited (CDM, 1996). The nature and extent of the City's participation of disposing there is also unknown. The State of Arizona owns this landfill and has constructed multiple Department of Transportation support facilities on the property. The State of Arizona is currently responsible for monitoring and maintaining the landfill.

In August of 1997, the City SWMD tested for methane inside 11 structures in the State yard. Methane was not detected. In addition the City tested for methane in 62 bar holes (to a depth of 3 feet) around the site perimeter and around structures. All detections were below the regulatory limit of 5% for methane (COTDSWM, January 1999).

No information has been found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary.

#### *6.5.3 Northern Santa Cruz River Area Groundwater Quality*

COT-ES reviewed data from the following wells for evaluation of these two landfills. A-024A, PK-004, WR-183A and University of Arizona wells VDL, and 2346. Former production well A-024A is located 0.25 mile downgradient from Dragoon Landfill, and VDL is located 0.27 mile downgradient from the State Pit Landfill. Wells WR-183A, and the University of Arizona well 2346 are located downgradient of the Dragoon and State Pit landfills respectively, and are monitored semiannually as part of the Silverbell Landfill Water Quality Revolving Fund (WQARF) Site. PK-004A is up and cross gradient of both landfills. It was monitored one time in 2006, and the data was used to provide upgradient well information for this report.

Only data from wells A-024A and PK-004 are tabulated in Tables 2 and 3. Data from wells VDL, WR-183A and 2346 were trended for this report (see Attachment 5); but were not

tabulated in Tables 2 and 3 as it is available within the Silverbell Landfill WQARF site project files.

All compounds analyzed have been non-detect or below the respective AWQS (Tables 2 and 3). For inorganics, increasing trends (based on linear regression slopes) were observed in well WR-183A for nitrate (+0.15 mg/L per year) and bromide (+0.015 mg/L per year), and in well VDL for chloride (+1.6 mg/L per year) and bromide (+0.03 mg/L per year) (see charts in Attachment 5). VDL had a recent increase in total phosphate from 0.02 mg/L in 2009 to 0.19 mg/L in 2010. The charted data visually appear to have significant increasing trends, but considering the shortened concentration scales which are appropriate for the data set, and the concentration rates per year, these increases are actually negligible. WR-183A sulfate concentration trend (+5.11 mg/L per year) is not negligible. However, monitoring well A-024A which is upgradient of WR-183A has a decreasing sulfate concentration trend (-0.29 mg/L per year) which indicates that the concentrations of sulfate at WR-183A may decrease in the near future.

Minor VOC concentrations have been observed in three wells. A-024A had an anomalous detection of toluene at 0.003 mg/L in 2005, but was non-detect prior to and following 2005. WR-183A had detections of PCE in 2000 at concentrations just above the detection limits (0.005 - 0.006 mg/L), but has been non-detect in all subsequent events. The up/cross-gradient well PK-004A, consistently has concentrations of chloroform and total trihalomethanes, but these compounds are not observed in other site wells and are not typically attributable to landfills.

The above concentrations and trends do not indicate that the Dragoon and State Pit Landfills have adversely affected groundwater quality in this vicinity. At this time, the sites appear to have low environmental risk potential. Additional monitoring of wells A-024A, PK-004 is not recommended. Wells WR-183A and the University of Arizona wells 2346 and VDL may continue to be monitored as part of the Silverbell Landfill WQARF site. COT-ES can resume groundwater monitoring for the Dragoon and State Pit Landfills should additional information and/or data be provided which indicates further investigation is warranted.

## **6.6 Rillito River Corridor Landfills**

The site specific history for each landfill is discussed followed by the combined water quality results for the area (see Figure 5 for landfill locations). The discussion is divided into the western Rillito River Corridor (Cactus Landfill) and eastern Rillito River Corridor (Columbus and Walnut Landfills). There are no downgradient monitoring wells for the Cactus Landfill. The Columbus and Walnut landfills share downgradient monitoring wells, which have been routinely monitored since 2002.

### *6.6.1 Western Rillito River Corridor: Cactus Landfill*

The Cactus Landfill is located on northern Cactus Blvd, 0.4 mile northeast of the Prince Road and Tucson Blvd intersection. The landfill waste footprint is approximately 5.3 acres (Figure 5). The landfill was given a zero potential for impacting groundwater as it operated for only a two year period (1959 – 1961) for the disposal of primarily construction debris (Dames & Moore, 1989). Today, this land is privately owned, and COT-ES is not responsible for maintaining or monitoring it.

Investigations completed at the site support that this landfill was not for the disposal of municipal solid waste, but primarily construction debris. Methane gas studies completed in 1989, 1996, and 2004 indicated little to no methane generation, except for the central portion of the landfill with a methane concentration range of 2 to 4% of the LEL (Aplomado, 2005). Construction debris consisting of bricks, metal piping, wood, charred wood and soot, wire, hoses, and some paper were encountered in sixteen excavation trenches (Aplomado, 2005).

There is conflicting information in regards to size (45 acres vs 5.3 acres) and contents of this landfill (municipal solid waste vs primarily construction material) presented in the CDM report (CDM, 1996). Based on the 2005 Aplomado Report, 5.3 acres comprised mainly of construction material appears to be accurate.

No information was found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary.

#### *6.6.2 Western Rillito River Corridor Water Quality*

COT-ES has monitored CF-001A (a former inactive production well) located 0.15 mile up and cross-gradient from the Cactus landfill since 2002 (Figure 5). During that period, there have been minor, anomalous detectable concentrations of VOCs (1,2,4 trimethylbenzene, 1,3,5 trimethylbenzene, and total xylenes were detected one time in 2008). Inorganic concentrations in the well are either non-detect or below the AWQS (see Attachment 6 for charted data and Tables 2 and 3 for tabulated data). The closest active downgradient well is located 0.77 mile from Cactus Landfill (A-008B). The well is used for public water supply, and is owned by Tucson Water. A review of data collected by Tucson Water for the years between 2004 – 2010 has shown no detectable concentrations of VOCs. Inorganics are either non-detect or stable below respective AWQSs (see Attachment 6). The Cactus Landfill does not appear to have affected water quality and additional groundwater monitoring is not recommended.

#### *6.6.3 Columbus Landfill*

The Columbus Landfill is located along the southern bank of the Rillito River, at the north end of Columbus Blvd (Figure 5). Sand and gravel was mined from the area prior to the onset of landfill activities, and can be seen in the 1953 aerial photograph (PAG, 2000). According to the PAG 2000 report, the City of Tucson was the landfill operator. The landfill's operation was from 1959 to 1965 according to Aplomado, 2002 and CDM, 1996. However, an operating period from the 1960's through the early 1980's was described in PAG, 2000. Filling and leveling activities can be seen in aerial photographs extending into the early 1980's (Aplomado, 2002), and interviews with local residents confirmed continued landfill practices during that extended period (PAG, 2000). The Columbus Landfill property is currently owned by Pima County, and the City is not responsible for maintaining or landfill gas monitoring of it. Where necessary, routine landfill gas monitoring has been completed by a private party on behalf of the adjoining subdivision as per the City Landfill Ordinance # 10037.

The pits from sand and gravel mining were filled with Class II trash and debris consisting primarily of construction material. The original waste footprint has been stated to be approximately 80 acres (Table 1, CDM, 1996), but the boundary provided in the CDM 1996 report, which is also used as the landfill boundary in Figure 5 equals 46 acres as measured by

COT-ES. Borrow pits were observed in historical photographs from 1953 to 1974 and indicated a combined excavated area of 21 acres. The 21 acre boundary provided in the Aplomado 2002 report can also be seen in Figure 5. However, the Aplomado 2002 report does not review the historic borrow pits in the creek bed and also on the northern side of the Rillito River as discussed in PAG, 2000. There is no clear evidence showing that landfill activity extended beyond the southern bank of Rillito Creek (PAG, 2000).

According to various reports, the composition of the Columbus Landfill is primarily construction material (PAG, 2000). Trenching and exposed bank material indicated bricks, concrete, asphalt, plastic trash bags, paving materials, metal, drywall, plaster, electric wire, piping, sheet metal, rebar, wood, fiber-glass, paper, ceramic tile, insulation, and other construction type material (PAG, 2000 and Aplomado, 2002). Testing confirmed the presence of asbestos containing material within the debris (PAG, 2000).

Several landfill gas studies have been conducted in the soil at and near the landfill boundary, by COT and private interests. None have indicated any methane generation at Columbus Landfill even within the landfill footprint (PAG, 2000) (Aplomado, 2002) (COTSWMD, January 1999).

No information was found regarding the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary.

#### *6.6.4 Walnut Landfill*

The Walnut Landfill is located at 3291 N. Walnut Avenue in northern Tucson, 0.4 mile northeast of Alvernon Way and Fort Lowell Roads (Figure 5). The waste footprint is approximately 5 acres. The site was operated as a private landfill from 1961 to 1965. Note that there is conflicting information in regards to size (16 acres vs 5 acres) of this landfill presented in the CDM report (CDM, 1996). Based on review of recent reports (Zonge, 2002 and Aplomado, 2002) and their supporting information, the above description of 5 acres appears to be accurate. The landfill property is currently owned by private interests and the City is not responsible for maintaining or landfill gas monitoring of it.

Landfill gas surveys in 1990 and 1996 of sample collection points along the property boundary and from the landfill interior demonstrated no methane activity. Methane monitoring points placed along the property boundary monitored from February 2001 – September 2002 have indicated methane gas concentrations ranging from 0.0 to 2.6% of the LEL (Aplomado, 2002).

A one-time shallow (5 foot) soil gas survey conducted by the City between November 1989 and April 1990 indicated trace levels of vapor phase VOCs (HGC, 1990). The highest concentrations observed over the eleven sampling points were: total hydrocarbons at 73.7 µg/L, benzene at 0.10 µg/L, toluene at 0.63 µg/L, M&P xylenes at 0.5 µg/L, o-xylene at 0.5 µg/L, TCE at 0.02 µg/L, PCE at 0.14 µg/L, and 1,1,1 TCA at 0.05 µg/L. As noted in the report, these concentrations are not of significant environmental concern (HGC, 1990).

Installation of the perimeter shallow soil gas probes along the northern and western property boundary encountered landfill material consisting mainly of concrete, asphaltic concrete rubble,

brick, pieces of plastic, steel strapping, iron bar, transite pipe, and minor amounts of glass (GRC, 2001 & 2000). The transite piping is suspected to contain asbestos.

A 2002 geophysical survey consisting of four lines across the entire site indicated a pit approximately 20 feet in depth that had been back-filled primarily with green or construction waste. Due to the relatively weak IP response of the fill material, there is not likely a substantial amount of municipal solid waste present at this landfill (Zonge, 2002).

No information has been found in regards to the deep vertical soil gas concentrations and/or groundwater concentrations directly at or within the landfill boundary.

#### *6.6.5 Eastern Rillito River Corridor Landfill Water Quality*

Near the Columbus and Walnut landfills, COT-ES has monitored wells A-046A; B-073A; and, GB-002A (Figure 5) for VOCs and 35 inorganic compounds since 2002. As seen in Tables 2 and 3 and Attachment 7, VOCs and inorganics have been non-detect or within respective AWQs, except for nitrates for A-046A. Monitoring well A-046A detected nitrates above the 10 mg/L AWQS with a concentration of 14 mg/L in June 2009. Nitrate concentrations had ranged between 1.8 mg/L – 2.8 mg/L from July 2002 to June 2008 (Attachment 7) in this well. Between the 2008 and 2009 sampling events, well A-046A showed increases in other parameters as well. Hardness increased from 176 mg/L to 341 mg/L; total dissolved solids increased from 308 mg/L to 517 mg/L; bromide increased from below the detection limit of 0.1 mg/L to 0.15 mg/L; chloride increased from 9.1 mg/L to 49 mg/L; sulfate increased from 24 mg/L to 54 mg/L; calcium increased from 64 mg/L to 120 mg/L; and, magnesium increased from 4.2 mg/L to 10 mg/L (see Attachment 7 for charts on each compound). The well has not been sampled since 2009.

At this time, it is unclear if these recent changes in water quality in well A-046A indicate a release from the Columbus Landfill as the well is located over 0.5 mile downgradient. COT-ES does not own or maintain the property on which these landfills lie, and will not continue to monitor downgradient groundwater quality. COT-ES will provide the historical water quality results to ADEQ Solid Waste Unit to notify them of the water quality issue at A-046A in March 2011.

The above information does not appear to indicate that the Walnut Landfill has adversely affected groundwater quality. At this time, the Walnut Landfill appears to have low environmental risk potential.

## **7.0 CONCLUSIONS AND RECOMMENDATIONS**

This report has reviewed the original directives, landfill gas monitoring activities, site histories and environmental assessments associated with the CLI project. Below is a summary of recommendations for the projects.

**7.1 Regional Groundwater Flow Maps**

Construction of regional groundwater flow maps by COT-ES based on data collected annually by Tucson Water and others will be discontinued. Future groundwater flow maps will be constructed on a site-by-site basis using local wells.

**7.2 Santa Cruz Water Level Study**

The Santa Cruz water level study will be discontinued. The study sought to determine if the regional groundwater was in contact with the waste in landfills along the Santa Cruz River. COT-ES has determined that groundwater is unlikely to rise to the elevations of the base of these landfills.

**7.3 No Further Groundwater Monitoring**

Groundwater monitoring for the sites listed in the table below will be discontinued. These sites appear to have low environmental risk potential based on available information, and no further groundwater monitoring is necessary. COT-ES can resume monitoring should additional information and/or data be provided which indicates further investigation is warranted.

Site	Wells
29 <sup>th</sup> Street Landfill	SS-019A
Cactus Landfill	A-008B, CF-001A
Dragoon Landfill	A-024A
Kennedy Park Debris Pit	WR-460A, WR-461A, WR-462A
Mission Landfill	SS-019A
Rio Nuevo North	WR-349A
Rillito River Corridor East (Columbus Landfill and Walnut Landfills)	GB-002A, A-046A, B-073A, B-070A, GB-001A
St. Mary's Landfill	A-030A, PK-004, WR-183A
State Pit Landfill	VDL, 2346

**7.4 Continued Investigation Warranted**

COT-ES will continue groundwater monitoring and investigation for the following sites due to detections of contamination and/or data trends as discussed in this report. Monitoring is recommended annually for each site. Monitoring parameters and frequency will be evaluated and adjusted as needed.

Site	Wells
A-Mountain Landfill	WR-364A, WR-365A, WR-366A, LM-007A
Downtown Area	SS-016A, WR-248A, WR-249A, WR-271B

Discussions of data collected and additional work performed will be evaluated in future individual site specific reports.

The common analyte list for future groundwater monitoring for the above sites is provided in Tables 4 for A-Mountain Landfill. This list includes VOCs by 8260, seventeen inorganic parameters, and field parameters. The list can be adjusted if specific site conditions warrant it.

The Downtown TCE Area project will be monitored for VOCs and field parameters as listed in Table 5.

#### **8.0 MAINTANENCE PROGRAM FOR ES LANDFILLS AND ASSETS**

COT-ES will initiate a program to inspect and maintain City-owned landfills to identify and correct problems such as wildcat dumping, erosion of soil cover, and vandalism of the wells. All COT-ES owned groundwater and deep vapor monitoring wells will be inspected and repaired as needed to insure they are secure and in proper working order. The inspection results and actions taken will be documented. This maintenance program is detailed in the *City of Tucson Closed Landfills Inspection and Maintenance Reporting and Procedures* dated March 2011.

Appendix 10 contains a Figure showing 23 landfills with some involvement by the City of Tucson, and a corresponding Table which contains information on ownership, landfill gas and groundwater monitoring frequency, associated permits and applicable regulatory agencies. Under the new maintenance program, COT-ES will inspect, monitor and correct issues that arise on landfills owned and maintained by the City. Kennedy Park Debris Pit does not meet the state definition for a landfill under ARS § 49-701.01 (B) 15, and is not included in this table.



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## **TABLES**

**Table 1  
Landfill Information  
Comprehensive Landfill Investigation**

Map ID	Landfill Name	Approx. Refuse Area (acreage)	Operation Dates	Age of Waste (years, as of 2011)	Regulations	Refuse Type	Property City Owned?	Methane Monitoring Completed By:	Site Specific Deep Soil Vapor Probes	Site Specific Groundwater Monitor Wells
<b>Non-Regulated Landfill, Part of Comprehensive Landfill Study</b>										
1	29th Street	6.5	1963-1967	48-44	Closed Solid Waste Facility <sup>1</sup>	Green waste and construction debris	N	Pima County	NA	NA
2	A Mountain	31.4	1953-1962	58-49	Closed Solid Waste Facility <sup>1</sup>	Municipal waste	Y	COT-ES	N	Y
3	Cactus	5.3	1959-1961	52-50	Closed Solid Waste Facility <sup>1</sup>	Primarily construction debris	N	Private Party	N	N
4	Columbus	46.0	1959-1985	52-26	Closed Solid Waste Facility <sup>1</sup>	Class II Trash including green waste and construction debris. May be primarily construction debris	N	Private Party	N	N
5	Dragoon	20.0	1964-1966	47-45	Closed Solid Waste Facility <sup>1</sup>	Trash	N	COT-ES	N	N
6	Kennedy Park Debris Pit	0.5	1970-1980's	41-31	Exempted (ARS § 49-701.01 (B) 15) <sup>2</sup>	Excess soil, concrete, wood, steel, and vegetation	Y	COT - Parks & Recreation	N	Y
7	Mission	7.6	1963-1970	47-41	Closed Solid Waste Facility <sup>1</sup>	Primarily inert material	Y	COT-ES	N	N
8	Rio Nuevo North	9.1	1960-1971	51-40	Closed Solid Waste Facility <sup>1</sup>	Trash	Y & N	COT-ES	N	Y
9	St. Mary's	10.5	1963-1973	47-38	Closed Solid Waste Facility <sup>1</sup>	Primarily inert material	Y & N	COT-ES	N	N
10	State Pit	14.6	1968-1970	43-41	Closed Solid Waste Facility <sup>1</sup>	Trash	N	State of Arizona	NA	NA
11	Walnut	4.2	1961-1965	50-46	Closed Solid Waste Facility <sup>1</sup>	Trash. May be primarily construction debris.	N	Private Party	N	N
<b>Non-Regulated Landfill, ES Site Specific Monitoring Program Implemented</b>										
12	Congress (Rio Nuevo South Landfill Stabilization Project)	5.7	1953-1960	58-51	VRP Program	Municipal waste	Y	COT-ES	N	Y
13	Cottonwood	10.0	1973-1985	38-26	Closed Solid Waste Facility <sup>1</sup>	Municipal waste	Y	COT-ES	Y	Y
14	Nearmont (Rio Nuevo South Landfill Stabilization Project)	3.9	1960-1967	51-44	VRP Program	Municipal waste	Y	COT-ES	N	Y
15	Prudence	8.5	1974-1978	37-33	Closed Solid Waste Facility <sup>1</sup>	Municipal waste	Y & N	COT-ES	Y	Y
16	Ryan Airfield	16.0	1973-1977	38-34	Closed Solid Waste Facility <sup>1</sup>	Trash from Avra Valley area	Y	COT-ES, No Probes	Y	Y
17	Ryland	27.0	1960-1965	51-46	Closed Solid Waste Facility <sup>1</sup>	Trash	Y	COT-ES, No Probes	Y	Y
18	Tumamoc	21.0	1962-1966	49-45	Closed Solid Waste Facility <sup>1</sup>	Municipal waste	Y	COT-ES	N	Y
<b>Regulated Landfill, Site Specific Monitoring Program Implemented</b>										
19	Broadway North	68.8	1967-1970	44-41	Closed Solid Waste Facility <sup>1</sup> and WQARF Program	Municipal waste	N	Private Party	Y	Y
20	Harrison	64.7	1972-1996	39-15	Closed Solid Waste Facility - Regulated but no APP	Municipal waste	Y	COT-ES	Y	Y
21	Irvington	12.8	1978-1988	33-23	Closed Solid Waste Facility with APP Permit	Municipal waste	Y	COT-ES	Y	Y
22	Los Reales	247.7	1967-present	44-0	WQARF Site and Active Solid Waste Facility	Municipal waste	Y	COT-ES	Y	Y
23	Silverbell	45.8	1966-1975	45-37	WQARF Site	Municipal waste	Y	COT-ES	Y	Y
24	Vincent Mullins	36.0	1976-1987	35-24	Closed Solid Waste Facility with APP Permit	Municipal waste	Y	COT-ES	Y	Y

Notes:

<sup>1</sup> Not subject to regulation by ADEQ Solid Waste Unit (ARS § 49-701 (3)(b)).

<sup>2</sup> Exempted from the definition of a municipal solid waste facility as it mainly consists of landscaping rubble that was used to reclaim the land (ARS § 49-701.01 (B) 15).

NA = Not applicable

N = No

Y = Yes

COT-ES = City of Tucson - Environmental Services

TABLE 2  
 COMPREHENSIVE LANDFILL INVESTIGATION  
 WATER QUALITY RESULTS  
 SELECTED VOCs (ug/L)

Well Name	Date	PCE	TCE	cis-1,2-DCE	Vinyl Chloride
ASDB	2/2/2004	<0.5	<0.5	<0.5	<0.5
A-024A	6/9/2009	<0.5	<0.5	<0.5	<0.5
	6/10/2008	<0.5	<0.5	<0.5	<0.5
	2/22/2007	<0.5	<0.5	<0.5	<0.5
	2/22/2007	<0.5	<0.5	<0.5	<0.5
	3/13/2006	<0.5	<0.5	<0.5	<0.5
	3/13/2006	<0.5	<0.5	<0.5	<0.5
	3/22/2005	<0.5	<0.5	<0.5	<0.5
	3/22/2005	<0.5	<0.5	<0.5	<0.5
	3/24/2004	<0.5	<0.5	<0.5	<0.5
	3/24/2004	<0.5	<0.5	<0.5	<0.5
	3/18/2003	<0.5	<0.5	<0.5	<0.5
A-030A	6/11/2009	<0.5	<0.5	<0.5	<0.5
	6/12/2008	<0.5	<0.5	<0.5	<0.5
	2/26/2007	<0.5	<0.5	<0.5	<0.5
	2/2/2006	<0.5	<0.5	<0.5	<0.5
	2/2/2006	<0.5	<0.5	<0.5	<0.5
	2/3/2005	<0.5	<0.5	<0.5	<0.5
	2/3/2005	<0.5	<0.5	<0.5	<0.5
	1/28/2004	<0.5	<0.5	<0.5	<0.5
	1/28/2004	<0.5	<0.5	<0.5	<0.5
	4/15/2003	<0.5	<0.5	<0.5	<0.5
	1/9/2002	<0.5	<0.5	<0.5	<0.5
	1/9/2002	<0.5	<0.5	<0.5	<0.5
A-046A	6/11/2009	<0.5	<0.5	<0.5	<0.5
	6/11/2008	<0.5	<0.5	<0.5	<0.5
	2/27/2007	<0.5	<0.5	<0.5	<0.5
	2/9/2006	<0.5	<0.5	<0.5	<0.5
	2/3/2005	<0.5	<0.5	<0.5	<0.5
	2/3/2005	<0.5	<0.5	<0.5	<0.5
	2/4/2004	<0.5	<0.5	<0.5	<0.5
	2/4/2004	<0.5	<0.5	<0.5	<0.5
	3/17/2003	<0.5	<0.5	<0.5	<0.5
	7/9/2002	<0.5	<0.5	<0.5	<0.5
B-070A	2/27/2002	<0.5	<0.5	<0.5	<0.5
	2/27/2002	<0.5	<0.5	<0.5	<0.5
B-073A	1/7/2002	<0.5	<0.5	<0.5	<0.5
	1/7/2002	<0.5	<0.5	<0.5	<0.5
CF-001A	6/10/2009	<0.5	<0.5	<0.5	<0.5
	6/11/2008	<0.5	<0.5	<0.5	<0.5
	2/27/2007	<0.5	<0.5	<0.5	<0.5
	3/14/2006	<0.5	<0.5	<0.5	<0.5
	3/14/2006	<0.5	<0.5	<0.5	<0.5
	3/21/2005	<0.5	<0.5	<0.5	<0.5
	3/21/2005	<0.5	<0.5	<0.5	<0.5
	3/18/2004	<0.5	<0.5	<0.5	<0.5
	3/18/2004	<0.5	<0.5	<0.5	<0.5
	3/18/2003	<0.5	<0.5	<0.5	<0.5
	11/19/2002	<0.5	<0.5	<0.5	<0.5
E-001A	5/9/2002	<0.5	<0.5	<0.5	<0.5

TABLE 2  
 COMPREHENSIVE LANDFILL INVESTIGATION  
 WATER QUALITY RESULTS  
 SELECTED VOCs (ug/L)

Well Name	Date	PCE	TCE	cis-1,2-DCE	Vinyl Chloride
E-013A	1/22/2002	<0.5	<0.5	<0.5	<0.5
	1/22/2002	<0.5	<0.5	<0.5	<0.5
GB-002A	1/10/2002	<0.5	<0.5	<0.5	<0.5
	1/10/2002	<0.5	<0.5	<0.5	<0.5
LM-007A	6/10/2009	<0.5	<0.5	<0.5	<0.5
	6/10/2008	<0.5	<0.5	<0.5	<0.5
	5/10/2007	<0.5	<0.5	<0.5	<0.5
PK-004	9/27/2006	<0.5	<0.5	<0.5	<0.5
	1/9/2002	<0.5	<0.5	<0.5	<0.5
	1/9/2002	<0.5	<0.5	<0.5	<0.5
SS-016A	6/11/2009	0.5	1.5	<0.5	<0.5
	6/12/2008	0.5	1.2	<0.5	<0.5
	2/28/2007	<0.5	0.9	<0.5	<0.5
	5/17/2006	<0.5	0.7	<0.5	<0.5
	2/9/2006	<0.5	0.8	<0.5	<0.5
	2/9/2006	<0.5	0.7	<0.5	<0.5
	2/2/2005	<0.5	<0.5	<0.5	<0.5
	2/2/2005	<0.5	<0.5	<0.5	<0.5
	2/3/2004	<0.5	<0.5	<0.5	<0.5
	2/3/2004	<0.5	<0.5	<0.5	<0.5
	3/20/2003	<0.5	<0.5	<0.5	<0.5
	2/14/2002	<0.5	<0.5	<0.5	<0.5
	2/14/2002	<0.5	<0.5	<0.5	<0.5
	SS-019A	6/9/2009	<0.5	<0.5	<0.5
2/22/2007		<0.5	<0.5	<0.5	<0.5
3/13/2006		<0.5	<0.5	<0.5	<0.5
3/22/2005		<0.5	<0.5	<0.5	<0.5
3/23/2004		<0.5	<0.5	<0.5	<0.5
3/23/2004		<0.5	<0.5	<0.5	<0.5
3/24/2003		<0.5	<0.5	<0.5	<0.5
2/26/2002		<0.5	<0.5	<0.5	<0.5
2/26/2002	<0.5	<0.5	<0.5	<0.5	



TABLE 2  
 COMPREHENSIVE LANDFILL INVESTIGATION  
 WATER QUALITY RESULTS  
 SELECTED VOCs (ug/L)

Well Name	Date	PCE	TCE	cis-1,2-DCE	Vinyl Chloride
WR-349A	6/18/2009	<0.5	<0.5	<0.5	<0.5
	6/18/2009	<0.5	<0.5	<0.5	<0.5
	6/9/2008	<0.5	<0.5	<0.5	<0.5
	6/9/2008	<0.5	<0.5	<0.5	<0.5
	2/20/2007	<0.5	<0.5	<0.5	<0.5
	2/20/2007	<0.5	<0.5	<0.5	<0.5
	1/24/2006	<0.5	<0.5	<0.5	<0.5
	7/20/2005	<0.5	<0.5	<0.5	<0.5
	1/20/2005	<0.5	<0.5	<0.5	<0.5
	7/15/2004	<0.5	<0.5	<0.5	<0.5
	1/21/2004	<0.5	<0.5	<0.5	<0.5
	6/16/2003	<0.5	<0.5	<0.5	<0.5
	12/9/2002	<0.5	<0.5	<0.5	<0.5
	6/4/2002	<0.5	<0.5	<0.5	<0.5
	6/4/2002	<0.5	<0.5	<0.5	<0.5
	9/6/2001	<0.5	<0.5	<0.5	<0.5
	6/12/2001	<0.5	<0.5	<0.5	<0.5
	3/21/2001	<0.5	<0.5	<0.5	<0.5
	12/12/2000	<0.5	<0.5	<0.5	<0.5
	12/12/2000	<0.5	<0.5	<0.5	<0.5
9/6/2000	<0.5	<0.5	<0.5	<0.5	
3/30/2000	<0.5	<0.5	<0.5	<0.5	
WR-364A	6/18/2009	0.6	<0.5	<0.5	<0.5
	6/9/2008	0.6	<0.5	<0.5	<0.5
	2/20/2007	0.6	<0.5	<0.5	<0.5
	1/26/2006	0.7	<0.5	<0.5	<0.5
	7/21/2005	0.7	<0.5	<0.5	<0.5
	7/21/2005	0.7	<0.5	<0.5	<0.5
	1/19/2005	0.8	<0.5	<0.5	<0.5
	7/15/2004	0.8	<0.5	<0.5	<0.5
	1/21/2004	0.7	<0.5	<0.5	<0.5
	6/16/2003	0.9	<0.5	<0.5	<0.5
	6/4/2002	0.7	<0.5	<0.5	<0.5
	9/10/2001	1	<0.5	<0.5	<0.5
	6/11/2001	0.8	<0.5	<0.5	<0.5
	3/22/2001	0.7	<0.5	<0.5	<0.5
12/13/2000	1.1	<0.5	<0.5	<0.5	
7/31/2000	0.7	<0.5	<0.5	<0.5	
WR-365A	8/7/2006	<0.5	<0.5	0.5	<0.5
WR-366A	6/18/2009	0.9	<0.5	<0.5	<0.5
	6/9/2008	1	<0.5	<0.5	<0.5
	2/20/2007	0.9	<0.5	<0.5	<0.5
	1/26/2006	0.6	<0.5	<0.5	<0.5
	1/26/2006	0.6	<0.5	<0.5	<0.5
	7/21/2005	0.6	<0.5	<0.5	<0.5
	1/18/2005	0.6	<0.5	<0.5	<0.5
	7/14/2004	0.6	<0.5	<0.5	<0.5
	1/22/2004	0.6	<0.5	<0.5	<0.5
	1/22/2004	0.6	<0.5	<0.5	<0.5
	6/17/2003	0.6	<0.5	<0.5	<0.5
	12/10/2002	0.6	<0.5	<0.5	<0.5
	6/3/2002	0.6	<0.5	<0.5	<0.5
	9/6/2001	0.5	<0.5	<0.5	<0.5
	6/12/2001	0.5	<0.5	<0.5	<0.5
	3/21/2001	0.6	<0.5	<0.5	<0.5
12/13/2000	0.6	<0.5	<0.5	<0.5	
7/31/2000	<0.5	<0.5	<0.5	<0.5	

TABLE 2  
 COMPREHENSIVE LANDFILL INVESTIGATION  
 WATER QUALITY RESULTS  
 SELECTED VOCs (ug/L)

Well Name	Date	PCE	TCE	cis-1,2-DCE	Vinyl Chloride
WR-460A	1/9/2006	<0.5	<0.5	<0.5	<0.5
	1/2/2007	<0.5	<0.5	<0.5	<0.5
	1/9/2008	<0.5	<0.5	<0.5	<0.5
	1/6/2009	<0.5	<0.5	<0.5	<0.5
WR-461A	1/9/2006	<0.5	<0.5	<0.5	<0.5
	1/2/2007	<0.5	<0.5	<0.5	<0.5
	1/9/2008	<0.5	<0.5	<0.5	<0.5
	1/6/2009	<0.5	<0.5	<0.5	<0.5
WR-462A	1/9/2006	<0.5	<0.5	<0.5	<0.5
	1/9/2006	<0.5	<0.5	<0.5	<0.5
	1/2/2007	<0.5	<0.5	<0.5	<0.5
	1/2/2007	<0.5	<0.5	<0.5	<0.5
	1/9/2008	<0.5	<0.5	<0.5	<0.5
	1/9/2008	<0.5	<0.5	<0.5	<0.5
	1/6/2009	<0.5	<0.5	<0.5	<0.5
	1/6/2009	<0.5	<0.5	<0.5	<0.5





TABLE 3  
 COMPREHENSIVE LANDFILL INVESTIGATION  
 WATER QUALITY RESULTS  
 SELECTED INORGANIC ANALYTE CONCENTRATIONS (mg/L)

Well Name	Date																		Metals									
		Ba	Na	Ca	K	NO <sub>3</sub>	NO <sub>2</sub>	Bicarbonate Alkalinity	Total Hardness	Total PO <sub>4</sub> as P	F	SO <sub>4</sub>	Cl	Br	NH <sub>3</sub>	TDS	TSS	TOC	Al	As	Cr	Cu	Fe	Mg	Mn	Ni	Pb	Zn
WR-364A	6/18/2009	0.023	89	21	2	2.5	<0.1	160	76	0.092	1.4	72	10	<0.1	<0.05	339	2.2	0.51	<0.1	<0.002	<0.02	<0.02	0.06	5.9	<0.02	<0.02	<0.002	0.1
	6/9/2008	0.021	84	20	1.9	2.6	<0.1	144	76	0.046	1.4	74	11	<0.1	<0.05	340	6	0.44	<0.1	<0.002	<0.02	<0.02	0.14	5.9	<0.02	<0.02	0.002	0.38
	2/20/2007	0.023	90	22	2	2.6	<0.1	150	81	0.068	1.4	75	11	<0.1	<0.05	345	3.4	0.41	0.23	<0.002	<0.02	<0.02	0.72	6.3	<0.02	<0.02	0.0026	0.28
	1/26/2006	0.027	92	25	2.2	2.8	<0.1	152	NA	NA	1.4	86	12	<.1	<.05	374	NA	0.33	NA	0.0032	<.02	<.02	0.5	6.9	<.02	NA	<.002	0.12
	7/21/2005	0.024	96	25	2.2	2.8	<0.1	163	90	0.042	1.3	85	12	<.1	<.05	360	11.5	0.66	NA	0.0035	<.02	0.026	0.21	6.8	<.02	NA	<.002	0.19
	7/21/2005	0.027	91	25	2.2	2.8	<0.1	160	91	0.041	1.3	85	12	<.1	<.05	367	12.8	0.39	NA	0.0035	<.02	0.029	0.63	6.8	<.02	NA	0.0043	0.4
	1/19/2005	0.025	94	25	2.3	2.8	<0.1	164	90	0.14	1.4	85	13	<.1	<.05	366	11.6	0.31	NA	0.0021	<.02	0.077	0.37	6.8	<.02	NA	0.0036	0.19
	7/15/2004	0.045	94	29	2.5	2.8	<0.1	171	106	0.088	1.3	82	12	<.1	<.05	377	42.9	0.33	NA	0.0024	<.02	0.021	2.1	8.3	0.055	NA	0.005	0.74
	1/21/2004	0.038	94	29	2.4	2.7	<0.1	171	102	0.1	1.4	90	13	<.1	<.05	356	34.2	0.54	NA	<.002	<.02	<.02	1.2	7.5	0.036	NA	0.0024	0.18
	6/16/2003	0.024	96	24	2.2	2.8	<0.1	166	88	0.02	1.2	88	13	<.1	<.05	371	3.5	0.67	NA	<.002	<.02	<.02	0.12	6.9	<.02	NA	<.002	0.14
	6/4/2002	0.03	101	28	2.6	2.8	<0.1	168	102	0.017	1.3	102	14	<.1	<.05	378	11.7	0.48	NA	0.002	<.02	<.02	0.38	8	0.022	NA	<.002	0.15
	9/10/2001	0.021	99	26	2.2	2.8	<0.1	169	96	0.058	1.3	97	15	<.1	0.06	386	<.1	0.49	NA	<.002	<.02	<.02	<.02	7.4	<.02	NA	0.014	0.12
	6/11/2001	0.02	93	26	2.1	2.8	<0.1	171	94	<.01	1.4	100	15	0.1	0.62	392	2	0.53	NA	0.0023	<.02	<.02	0.09	7.2	<.02	NA	0.0051	0.14
	3/22/2001	0.037	100	33	2.9	2.8	<0.1	162	115	0.078	1.4	113	17	0.11	0.06	411	57.2	0.54	NA	0.0022	<.01	0.043	1	8	0.055	NA	0.027	0.21
	12/13/2000	0.031	100	30	2.8	3	<0.1	164	110	0.041	1.4	111	17	0.11	<.05	391	44.8	0.45	NA	0.0024	<.02	<.02	1	8.4	0.028	NA	0.01	0.18
	7/31/2000	0.059	104	38	3.5	3.3	<0.1	160	137	0.3	1.4	128	19	0.12	<.1	421	144	0.37	NA	NA	<.02	<.02	3.5	10	0.086	NA	NA	0.32
WR-366A	6/18/2009	0.038	135	40	2.9	1.8	<0.1	263	145	0.065	1.9	125	17	0.13	<0.05	543	3.4	0.49	<0.1	0.0068	<0.02	<0.02	0.036	11	<0.02	<0.02	<0.002	0.26
	6/9/2008	0.035	124	38	2.7	1.8	<0.1	241	139	0.042	1.9	125	18	0.15	<0.05	544	2.1	0.49	<0.1	0.0069	<0.02	<0.02	<0.02	10	<0.02	<0.02	<0.002	0.39
	2/20/2007	0.041	138	44	3.2	1.8	<0.1	237	159	0.094	1.9	130	18	0.13	<0.05	539	5	0.64	0.26	0.0058	<0.02	<0.02	0.22	12	<0.02	<0.02	0.0024	0.23
	1/26/2006	0.034	130	44	3.1	2	<.1	236	NA	NA	1.9	145	20	0.13	<.05	552	NA	0.49	NA	0.0078	<.02	0.03	0.032	12	<.02	NA	0.0026	0.2
	1/26/2006	0.035	131	43	3.2	2	<0.1	234	NA	NA	1.9	144	20	0.13	<.05	553	NA	0.62	NA	0.0071	<.02	0.041	0.036	11	<.02	NA	0.0032	0.21
	7/21/2005	0.034	131	44	3	1.9	<.1	252	156	0.042	1.8	148	19	0.12	<.05	553	1.5	0.91	NA	0.0077	<.02	0.05	<.02	12	<.02	NA	0.0023	0.27
	1/18/2005	0.038	132	45	3.1	1.9	<.1	253	160	0.052	1.8	150	20	0.14	<.05	558	5.6	0.44	NA	0.0071	<.02	<.02	0.14	12	<.02	NA	<.002	0.25
	7/14/2004	0.037	132	42	3	1.9	<.1	258	150	0.08	1.8	144	19	0.13	<.05	540	2.4	0.32	NA	0.0061	<.02	<.02	0.024	11	<.02	NA	<.002	0.21
	1/22/2004	0.037	126	43	2.8	1.9	<.1	255	152	0.11	1.8	150	20	0.13	<.05	568	2.8	0.58	NA	0.007	<.02	<.02	<.02	11	<.02	NA	<.002	0.2
	1/22/2004	0.036	125	41	2.8	1.9	<.1	261	149	0.082	1.8	150	20	0.13	<.05	567	2.3	0.57	NA	0.0069	<.02	<.02	<.02	11	<.02	NA	<.002	0.2
	6/17/2003	0.034	126	40	2.9	1.9	<.1	255	142	0.039	1.7	134	19	<.1	<.05	530	2.8	0.6	NA	0.0062	<.02	<.02	0.029	10	<.02	NA	<.002	0.21
	12/10/2002	0.034	124	39	2.8	1.9	<.1	258	141	0.023	2	131	19	0.11	<.05	532	<.1	0.75	NA	0.0075	<.02	<.02	<.02	10	<.02	NA	<.002	0.18
	6/3/2002	0.036	127	41	3	1.9	<.1	248	148	0.017	1.9	142	19	0.1	<.05	518	3	0.52	NA	0.0066	<.02	<.02	0.052	11	<.02	NA	<.002	0.2
	9/6/2001	0.035	129	41	3	1.9	<.1	255	146	0.058	1.9	131	20	0.12	0.08	524	7.6	0.62	NA	0.0072	<.02	<.02	0.096	11	<.02	NA	0.007	0.17
	6/12/2001	0.042	127	41	3.2	1.9	<.1	253	146	0.026	2	137	20	0.13	0.09	518	15.2	0.59	NA	0.0078	<.02	<.02	0.36	11	<.02	NA	0.0035	0.18
	3/21/2001	0.042	130	45	3.1	1.9	<.1	254	158	0.062	2	136	21	0.14	<.05	515	49.2	0.69	NA	0.0069	<.02	<.01	2.1	11	0.022	NA	0.0048	0.2
	12/13/2000	0.039	133	47	3.8	2	<.1	244	167	0.019	1.9	155	21	0.15	<.05	541	24.1	0.61	NA	0.0072	<.02	<.02	0.34	12	<.02	NA	0.0087	0.17
	7/31/2000	0.04	130	43	3.6	1.9	<.1	246	153	0.011	1.8	147	20	0.14	<.1	532	<.1	0.41	NA	NA	<.02	<.02	0.023	11	0.024	NA	NA	0.15
	<b>AWQS</b>	<b>2</b>				<b>10</b>	<b>1</b>				<b>4</b>									<b>0.05</b>	<b>0.1</b>					<b>0.1</b>	<b>0.05</b>	

**Bold** = Concentration Exceeds Aquifer Water Quality Standard (AWQS)

Kennedy Park wells WR-460A, WR-461A, WR-462A were not monitored for any inorganic compounds and were therefore not included in this summary table.

**Table 4**  
**Proposed General Analyte List**

Proposed Groundwater Sample List

Sample Parameter	Method
Alkalinity	SM 2320 B
Ammonia	E200.7
Anions	E300.0
Calcium	EPA 6010
Iron	E200.7
Magnesium	E200.7
Manganese	E200.7
Potassium	E200.7
Sodium	E200.7
Total Dissolved Solids	SM 2540 C
Total Organic Carbon	SM 5310 D
VOCs	E8260 (HCL)
Specific Conductivity	Field Flow Through Cell
pH	Field Flow Through Cell
Temperature	Field Flow Through Cell

Anions include: Nitrate, Nitrite, Sulfate, Fluoride, and Chloride

Table 5  
Proposed Analyte List for the  
Downtown TCE Area

Proposed Groundwater Sample List

Sample Parameter	Method
Anions	E300.0
Total Dissolved Solids	SM 2540 C
VOCs	E8260 (HCL)
Specific Conductivity	Field Flow Through Cell
pH	Field Flow Through Cell
Temperature	Field Flow Through Cell

Anions include: Nitrate, Nitrite, Sulfate, Fluoride, and Chloride

## **FIGURES**

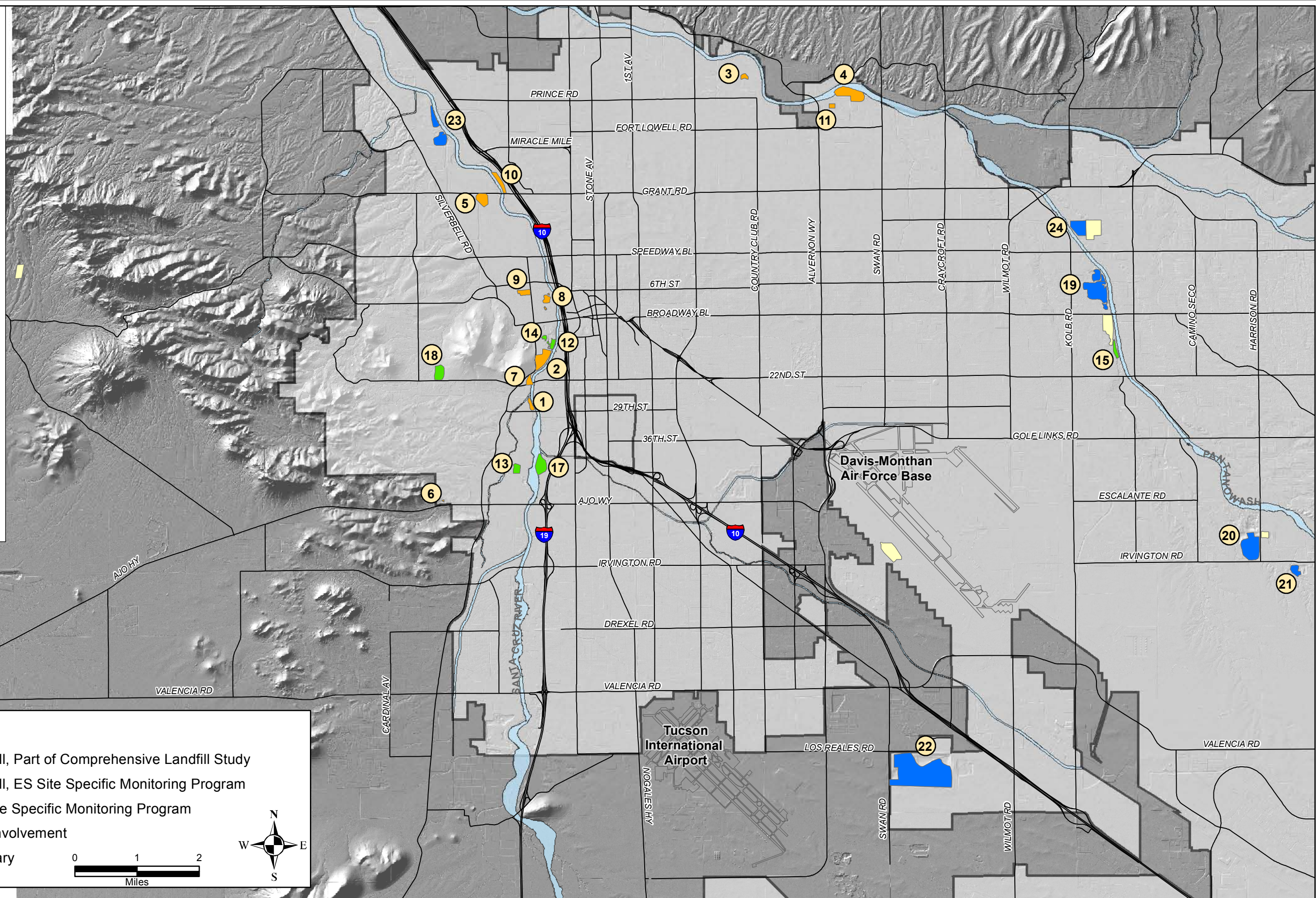
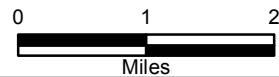


**LANDFILL NAMES**

- ① 29<sup>th</sup> Street
- ② A Mountain
- ③ Cactus
- ④ Columbus
- ⑤ Dagoon
- ⑥ Kennedy Park Debris Pit
- ⑦ Mission
- ⑧ Rio Nuevo North
- ⑨ St. Mary's
- ⑩ State Pit
- ⑪ Walnut
- ⑫ Congress
- ⑬ Cottonwood
- ⑭ Nearmont
- ⑮ Prudence
- ⑯ Ryan Airfield
- ⑰ Ryland
- ⑱ Tumamoc
- ⑲ Broadway North
- ⑳ Harrison
- ㉑ Irvington
- ㉒ Los Reales
- ㉓ Silverbell
- ㉔ Vincent Mullins

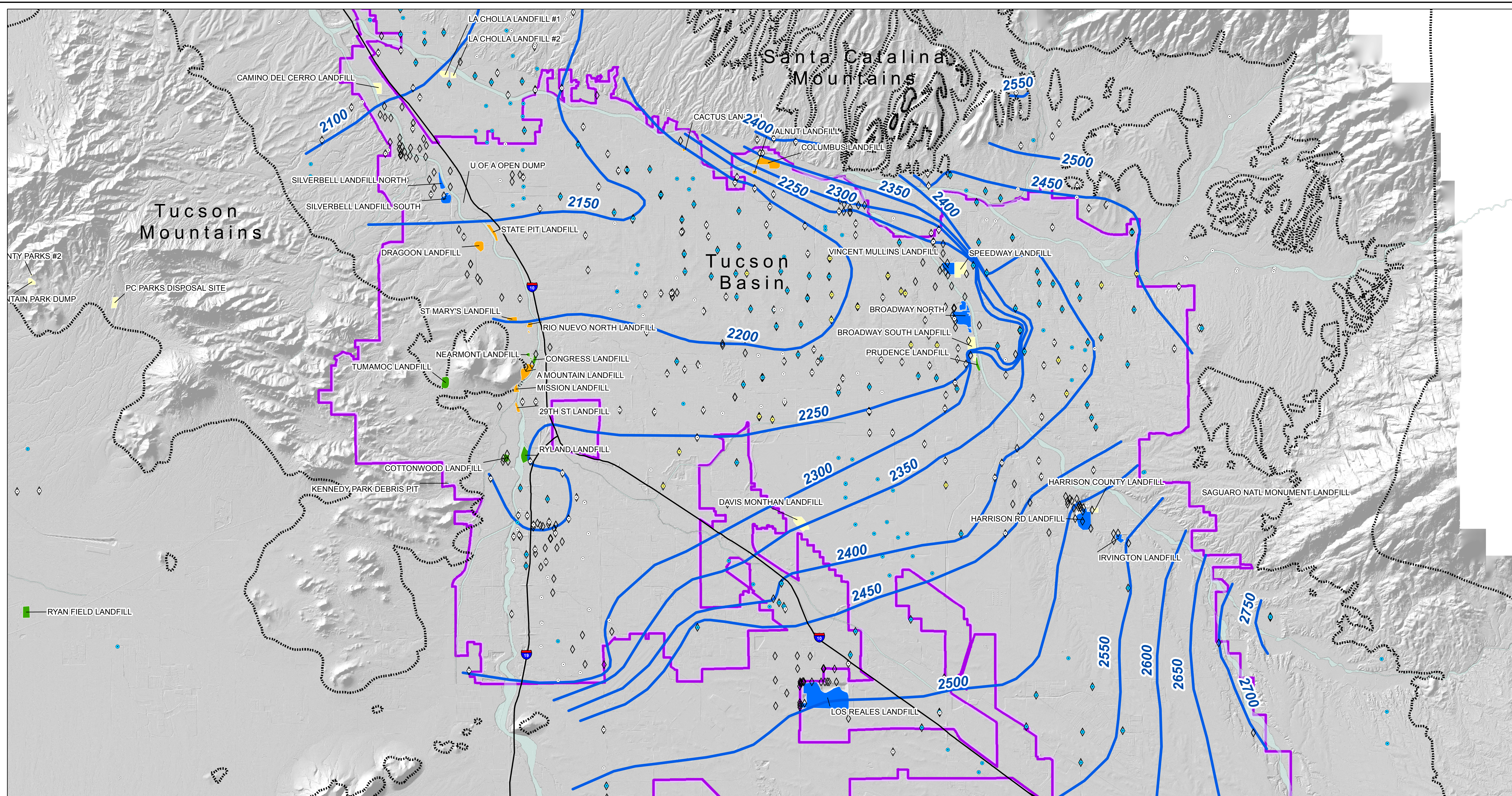
**Explanation**

- Non-Regulated Landfill, Part of Comprehensive Landfill Study
- Non-Regulated Landfill, ES Site Specific Monitoring Program
- Regulated Landfill, Site Specific Monitoring Program
- Landfill with No City Involvement
- City of Tucson Boundary



**Figure 1**  
**Landfill Location Map**  
**Comprehensive Landfill Investigation**





**Figure 2**  
**Landfill Locations and**  
**2007 - 2008 Regional**  
**Water Level Contour Map**

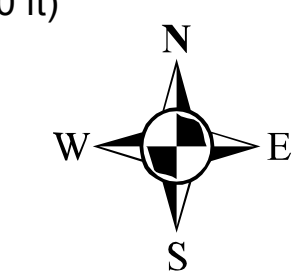
**Explanation**

**Landfill Types**

- ◆ Non-Regulated Landfill, Part of Comprehensive Landfill Study
- ◆ Non-Regulated Landfill, ES Site Specific Monitoring Program
- ◆ Regulated Landfill, Site Specific Monitoring Program
- ◆ Landfill with No City Involvement

- Active Potable
- Standby Potable
- Inactive Potable
- ◇ Groundwater Well Used for Water Levels

- Water Table Elevation Contours (Interval=50 ft)
- Bedrock Boundary
- Major Washes
- City of Tucson Limits
- Interstate

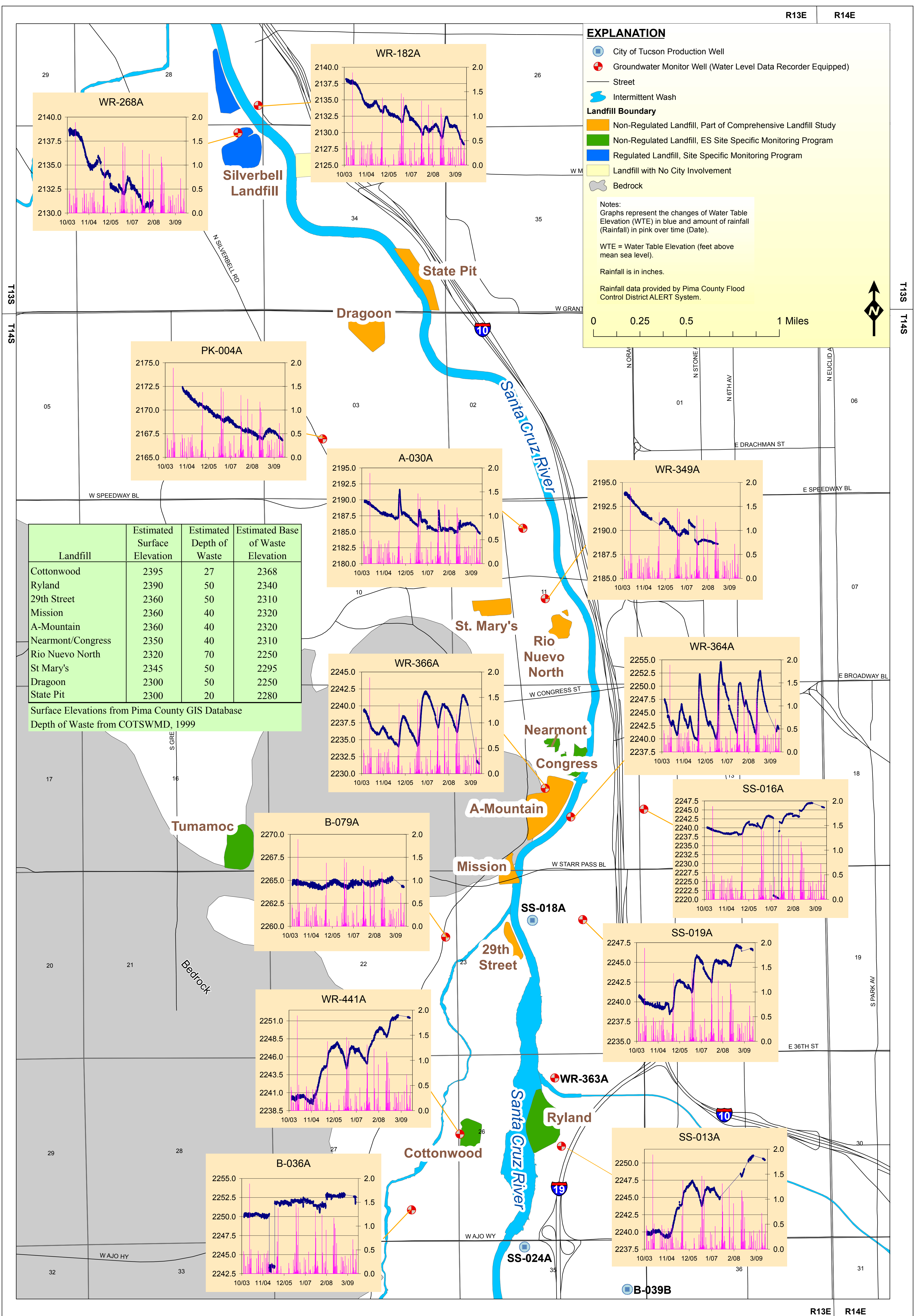


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Approved:	JD
Date:	3/24/2010
File:	See Below

0 0.5 1 2 Miles

Contour Elevations are given in feet above mean sea level (amsl)





**FIGURE 3**  
**SANTA CRUZ WATER LEVEL STUDY, TUCSON, AZ**  
**HYDROGRAPHS SHOWING WATER TABLE ELEVATION**  
**OCTOBER 2003 THRU NOVEMBER 2009**



Drawn By:	LE
Checked:	MC
Approved:	JD
Date:	9/28/10
File:	See Below

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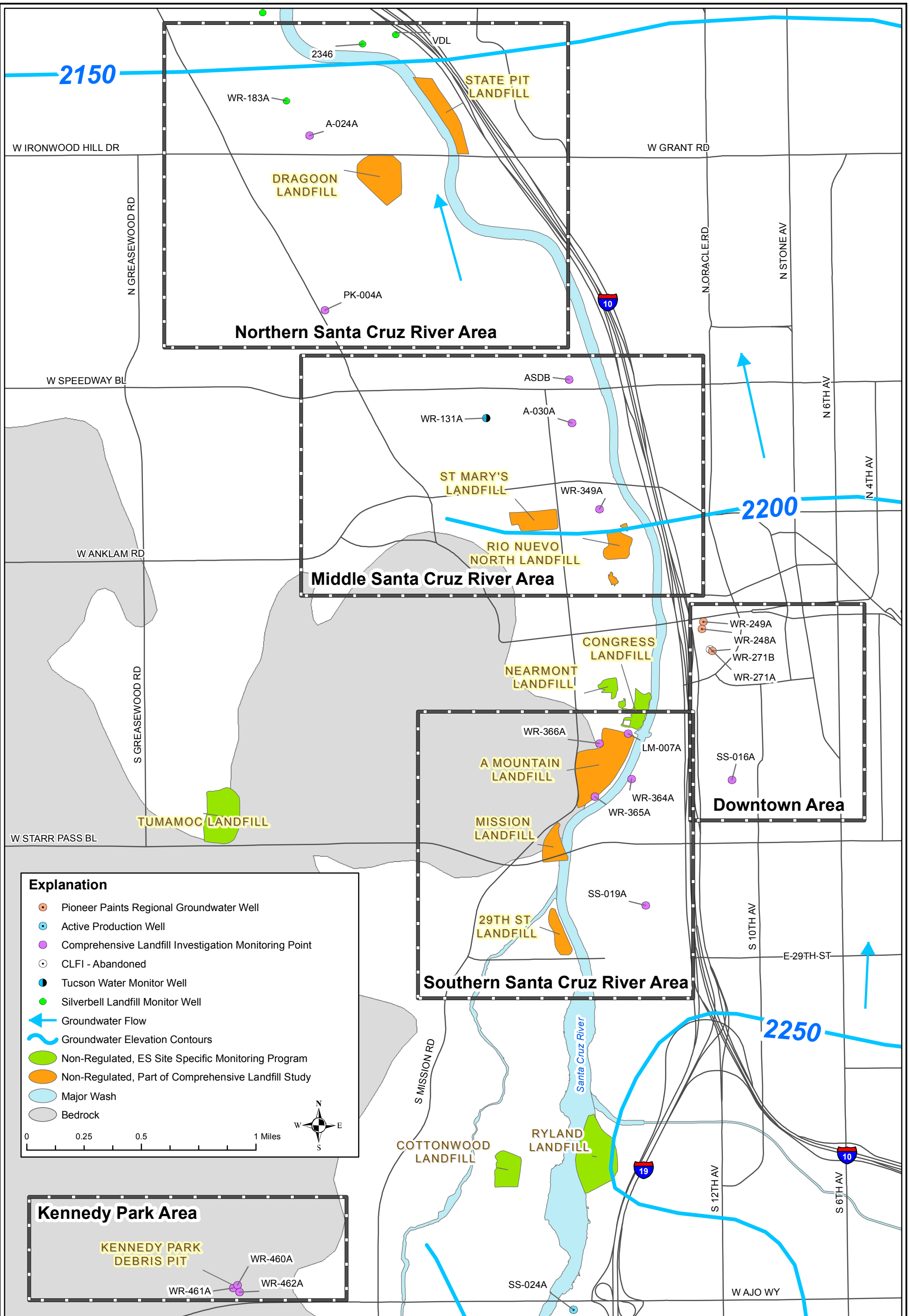
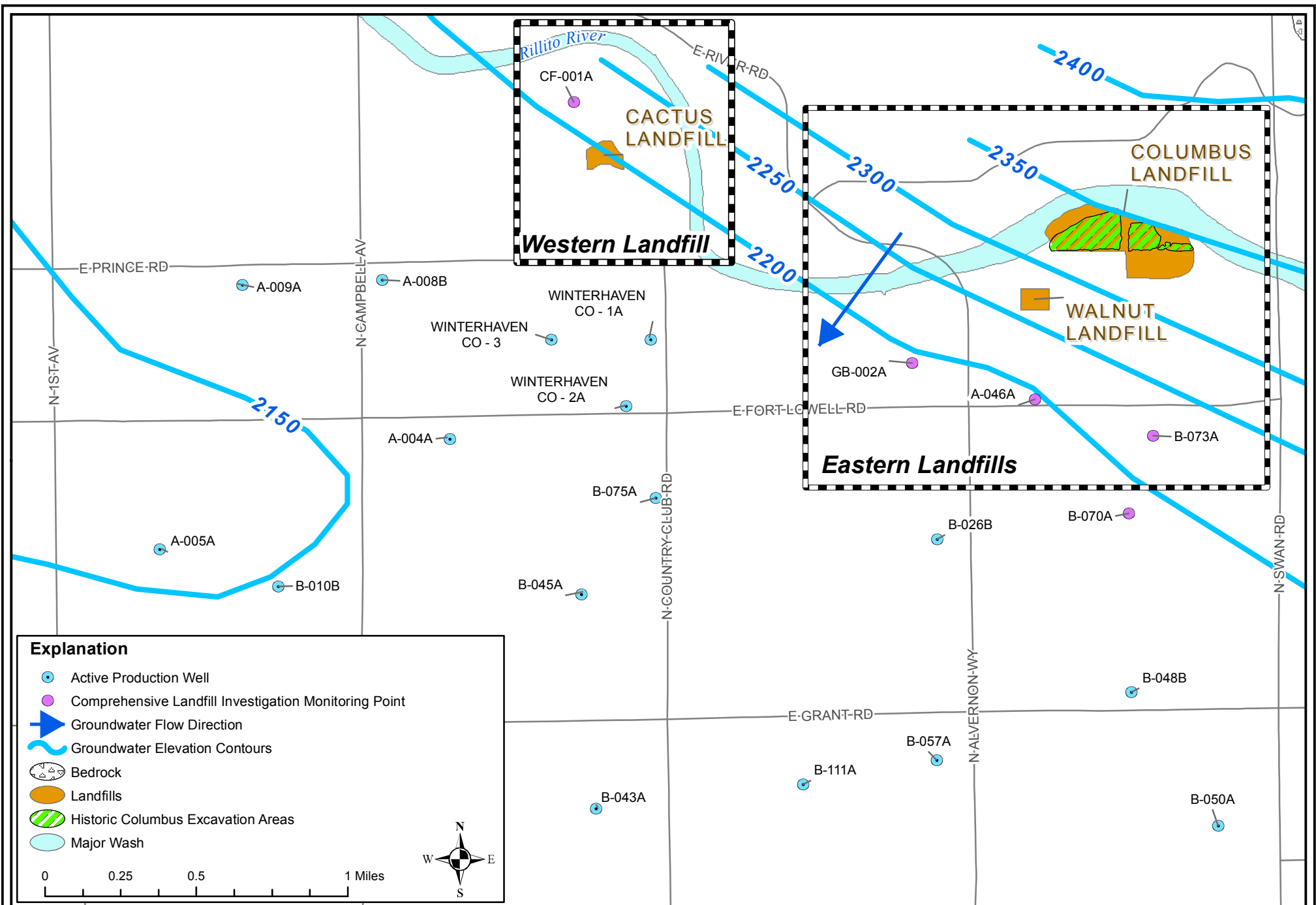


Figure 4  
 Santa Cruz River Corridor Vicinity Map  
 Comprehensive Landfill Investigation



**Explanation**

- Active Production Well
- Comprehensive Landfill Investigation Monitoring Point
- Groundwater Flow Direction
- Groundwater Elevation Contours
- Bedrock
- Landfills
- Historic Columbus Excavation Areas
- Major Wash

0 0.25 0.5 1 Miles

**Figure 5**  
**Rillito River Corridor Landfills**  
**Comprehensive Landfill Investigation**