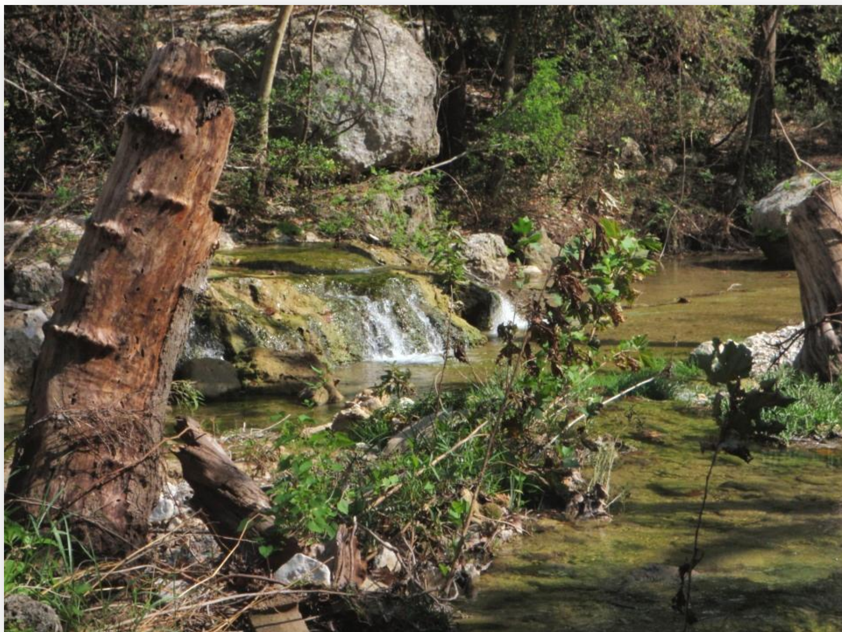
Water Treatment Plant #4

Environmental Monitoring Program



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June 2011

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1.0 Introduction

The purpose of this environmental monitoring program for the City of Austin is to establish water quality and water level conditions in the Edwards Formation, the Glen Rose Formation, and Bull Creek, and their tributary springs in the vicinity of the City of Austin's Water Treatment Plant 4 (WTP4) facilities constructed within or below the Bull Creek watershed. These facilities are the Jollyville Transmission Main and three associated construction shafts. The proposed monitoring program will supplement more than two decades of stream, spring, and well monitoring by the City of Austin, the U.S. Geological Survey, the Texas Commission on Environmental Quality and its predecessor agencies, and the Lower Colorado River Authority. Because of the comparatively short time frames before and during construction, evaluation of potential construction impacts will rely on historical data, as well as data collected under the program described in this report.

The monitoring program is designed to meet these objectives from the relevant Environmental Commissioning documents for WTP4: [1]

- Documentation of baseline hydrology, and stream and spring water quality prior to construction;
- Monitoring to detect possible changes from baseline conditions during and following construction; and
- Identification of changes from baseline conditions attributable to WTP4 from other changes that are observed in the watershed.

The geologic and hydrologic setting for the area of interest is discussed next in Section 2. Section 3, "Monitoring Program Elements," describes the environmental media to be monitored,

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[1] *Water Treatment Plant 4 Environmental Goals & Recommendations for Mitigation, Best Management Practices, Monitoring, and Environmental Commissioning*, October 2005; "Memorandum of Understanding between Austin Water Utility and Watershed Protection and Development Review Department for Implementing Environmental Mitigation Plans for Water Treatment Plant 4, Water Treatment Plant No. 4;" "Technical Memorandum, Environmental Commissioning, Final," January 2009; and *Jollyville and Forest Ridge Transmission Mains Environmental Commissioning Plan*, September 2010.

monitoring parameters, monitoring frequency, and related overall components of the plan. Specific monitoring plans for each Jollyville Transmission Main (JTM) system element are presented in Section 4, “JTM System Element Plans.” An estimated budget for implementing the overall Monitoring Program is addressed in Section 5.

This monitoring plan has been developed based on the best currently available information. Through the process of its implementation, additional information will be acquired. Adjustments to monitoring locations, parameters, equipment and frequency based on better information and deeper understanding of the system are expected.

2.0 Study Area

2.1 Watersheds

The proposed WTP4 treatment and transmission facilities will be constructed and operated within or beneath parts of four watersheds: Bullick Hollow (tributary to Lake Travis), Panther Hollow, Bull Creek, and Rattan Creek, as shown on Figure 2-1. These watersheds are located in northwest Austin and Travis County. The highest topography in the vicinity of these facilities is near the western edge at the Bull Creek/Bullick Hollow watersheds, at about 1,066 feet mean sea level. The eastern edge of the area of interest, near the Jollyville Reservoir, reaches an elevation of 946 feet mean sea level. The lowest areas of Bull Creek between the WTP4 facilities and the Jollyville reservoir have elevations of about 710 feet mean sea level.

Facilities in Bullick Hollow watershed include raw water transmission mains, pump station, the water treatment process units, the plant-finished water shaft, and approximately one-half mile of the Jollyville Transmission Main. The City of Austin moved the location for the water treatment plant from the Bull Creek watershed into the Bullick Hollow watershed to minimize potential environmental impacts to the Balcones Canyonlands Preserve and the Jollyville salamander habitat in the Bull Creek watershed.

WTP4 facilities within the Panther Hollow watershed consist only of 0.3 miles of underground tunnel for the Jollyville Transmission Main. There are no surface facilities within the Panther Hollow watershed. The segment of transmission main in this watershed is located beneath contributing areas to the headwaters, no more than about 1,300 feet from the topographic divides delineating this watershed from those of Bullick Hollow and Bull Creek.

Facilities within the Bull Creek watershed include the Four Points Shaft, the Spicewood Shaft, and about 5.32 miles of the Jollyville Transmission Main. The Jollyville Transmission Main is designed to be constructed below the upper reaches of the Bull Creek watershed from close to the Panther Hollow to the Rattan Creek watershed divides. It is subparallel to Bull Creek or its tributaries for a distance of about 21,500 feet.

WTP4 facilities proposed for the Rattan Creek watershed consist of about one-half mile of the Jollyville Transmission Main and a shaft at the Jollyville reservoir. These facilities are located in or beneath areas contributing to the headwaters of Rattan Creek.

2.2 Geology

The area of interest for monitoring is west of the Balcones Fault Zone. Surface and shallow geologic formations consist of the Edwards, Comanche Peak, Walnut, and Glen Rose, as illustrated in the stratigraphic column of Figure 2-2. A map of surface expressions of these formations, based on regional geologic maps supplemented by local City of Austin fieldwork, is shown on Figure 2-3. Generally the Edwards formation crops out at the highest elevations. Other formations are exposed in bands around drainage features at lower elevations as Bull Creek and its tributaries have cut through the Edwards and underlying, softer rock layers. Glen Rose Limestone crops out on lower slopes and creek channel bottoms. Alluvial sediment occupies bottomlands adjacent to creek channels.

The Edwards formation is thickest at the highest elevations in the watershed, near the divides with the Bullock Hollow watershed and with the Rattan watershed. Near the Rattan/Bull Creek watershed divide the Edwards formation is 120 to 150 feet thick, as indicated by the logs for wells JT-124, JT-125, JT-126, and JT-127. On the opposite side of the Bull Creek watershed, near the divide with Lake Travis, the thickness of the Edwards formation is about 90 feet, as indicated by logs for wells JT-112, JT-113, JT-114, JT-115, and JT-128.[2]

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[2] Black and Veatch. *Preconstruction Groundwater Assessment*, December 2010.

2.3 Hydrology

Recharge to the Jollyville Plateau portion of the Edwards occurs diffusely through inter-stream areas of the outcropping limestone.[3] No large contributing watersheds funnel water onto recharge areas. Streams are discharge, rather than recharge zones with respect to groundwater in this segment of the Edwards formation.

Water in the Edwards limestone is under water table conditions. Rainfall infiltrates vertically through the soil and karst system. Upon reaching less permeable layers of the Walnut and/or Glen Rose formations, predominately vertical groundwater movement shifts to predominately horizontal flow although some vertical flow is still indicated from the downward gradients. Groundwater moves laterally until it daylights at the down cut topography of Bull Creek or its tributaries, where it discharges as a spring or seep. Figure 2-4 illustrates the numerous and widely distributed springs and seeps that are an expression of this hydrogeologic process.

A dense dendritic channel pattern regularly interrupts groundwater flow paths. Distances from rainfall infiltration to spring or seep discharge are relatively short. Groundwater flow paths to these springs in the vicinity of the water treatment plant likely range from a few hundred feet to less than one half mile. Short flow paths, erosion of Edwards limestone to a thin section and the thin Edward's saturated thickness (e.g., < 10 feet in the vicinity of Four Points Shaft) limit the groundwater system's capacity to store and convey significant quantities of water to wells or springs.

Because of the limited storage capacity of the hydrogeologic system, the flow of springs and seeps vary significantly based on the recent weather and rainfall conditions. City of Austin staff estimated flow at Pit Springs to be less than 1 gallon per minute on November 9, 1999, and 50 gallons per minute on February 14, 2008. Flows at Lanier Spring were estimated at 12.5 to 15 gallons per minute in February to May, 2008. Flows from Moss Gully Spring were estimated at 1 to 3 gallons per minute (August 29, 2007 and February 14, 2008, respectively). Tanglewood

[3] City of Austin Watershed Protection Department, *The Jollyville Plateau Water Quality and Salamander Assessment*, Water Quality Report Series, COA-ERM 1999-01, June 22, 2001.

Spring flows were estimated to range from 0.1 to more than 300 gallons per minute.[4] Spring flows can reduce to zero during extended periods of drought.

Additional data on stream and spring flows in the vicinity of the Jollyville Transmission Main project has been collected for this project.[5] This additional monitoring data captured flows during both dry and wet rainfall conditions. Relationships between flows at different sites were developed as a basis for analyzing potential future changes in site flow that might indicate construction impacts.

Previous publications suggest that water in the underlying Glen Rose formation might contribute to spring flow through upward leakage[6]. Sustained spring flows during dry conditions and higher measured specific conductance in certain springs is cited as a basis for this hypothesis. Potentiometric measurements of groundwater in wells constructed for this project, however, indicate significant downward potentiometric pressure between the Edwards limestone and underlying Walnut and Glen Rose formations. Potentiometric levels measured in project wells on November 30, 2010, for example show water levels in the Edwards formation ranging from 854.5 to 978.5 feet mean sea level, compared to water levels in the Glen Rose from 720 to 827.8 feet mean sea level on the same date.[7] Given this strong downward head gradient, there is no water migrating vertically upward from the Glen Rose into the Edwards formation.

Baseflow in Bull Creek and Bullick Hollow is sustained by seeps and springs that emerge from geologic contacts between the Edwards/Walnut formations, the Walnut/Glen Rose formations, and, where Bull Creek cuts through the Glen Rose, from the Glen Rose. Locally springs may also be fed from water stored in Quaternary alluvium. Springs and upper reaches of Bull Creek and its tributaries can be dry during periods of extended drought.

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[4] City of Austin Microsoft Excel file: “Export.zip” provided by Chris Herrington to Rick Scadden via email on May 21, 2010 at 3:34 pm.

[5] Slade, Raymond, *Documentation and recommendations for water-resource data collected in the Bull Creek basin for the Jollyville Transmission Project, April 2009 through March 2010,* July 29, 2010.

[6] Snyder, Fred, Springs in the Northern Segment of the Edwards Aquifer, in *Edwards Aquifer – Northern Segment, Guidebook 8*, Austin Geological Society, 1985.

[7] *Preconstruction Groundwater Assessment,* December 2010, Table 2-1, page 21.

Average water quality measurements for several parameters are summarized in Table 2-1. An analysis of these historical water quality measurements suggest a reason other than groundwater contributions from the Glen Rose for specific conductance differences among springs in the Bull Creek watershed. Specific conductance measurements from spring samples cluster around two mean values. Ten locations have a mean specific conductance of 605 microSeimens per centimeter. Five sites have an average of 940 microSeimens per centimeter. The five sites with higher specific conductance also exhibit higher nitrate concentrations and/or detection of total petroleum hydrocarbons.

Table 2-1. Averages of Historical Measurements for Selected Parameters in Bull Creek Watershed

Spring Sites	Diel Conductance (uSeimens/ cm)	Instantaneous Conductance (uSeimens/ cm)	NO3 (mg/L)	TPH (# of detects)
Powerline Spring	no data	657	0.30	0
Bronc Spring	no data	1020	3.09	0
Tanglewood Spring	no data	877	1.42	4
Cistern (Pipe) Spring	no data	623	0.90	0
Pit Spring	no data	564	0.10	3*
Schlumberger Spring 1	no data	645	1.18	0
Canyon Creek Spring 1 (Tubb Spring)	no data	817	1.80	0
Spring Hollow Spring	no data	996	3.27	0
Fern Gully Spring	no data	609	1.33	no data
Moss Gully Spring	no data	648	0.61	no data
Lanier Spring	no data	591	0.01	no data
Ribelin Spring 2 (Lower Ribelin)	no data	582	0.34	no data
Surface Water Sites				
Tributary 6 at Bull Creek (EG)	989	no data	0.65	3
Bull Creek above Tributary 7 (Franklin)	555	no data	0.06	2*
Bull Creek at St. Edwards Park above dam	625	no data	0.32	no data
Tributary 5 below Hanks Tract Property Line	680	no data	0.42	2*
Bull Creek above WTP4	614	no data	0.83	no data
Bull Creek below WTP4	553	no data	0.05	no data
Bull Creek Tributary 8 upstream of Bull Creek	524	no data	0.20	no data

**These anomalous values indicate the presence of total petroleum hydrocarbons at locations with no other indications of contamination.*

Elevated nitrate concentrations or total petroleum hydrocarbon detections are evidence of urban impacts. In addition to these differences in specific conductance, nitrates, and total petroleum hydrocarbons, the City of Austin also determined statistically significant differences in alkalinity, calcium, magnesium, sodium, chloride, sulfate, and total organic carbon concentrations between rural and urban monitoring sites within the Bull Creek watershed.[8]

An analysis of historical groundwater quality data for wells completed in the Glen Rose Formation in north-central Travis County indicates that total dissolved solids concentrations in this aquifer are not as high as those measured in urban springs. Measured total dissolved solids concentrations in four Glen Rose wells in the general vicinity of the project range from 252 to 509 milligrams per liter.[9] These data, along with the potentiometric level measurements in projects wells, indicate that elevated specific conductance observations in spring samples from the Bull Creek watershed are not associated with water from the Glen Rose moving into overlying formations or Bull Creek. The high specific conductance in some springs is likely associated with urban impacts.

3.0 Monitoring Program Elements

This section presents an overview of general monitoring program elements in terms of the environmental media, monitoring parameters, frequency, duration, and a decision process to determine whether observations during or post construction indicate an impact when compared to baseline (i.e., preconstruction) data.

3.1 Environmental Media

Environmental monitoring will consist of field and laboratory measurements associated with monitor wells, springs, and streams or creeks. Each of these environmental media has a unique relationship with the proposed WTP4 Jollyville Transmission Main construction and therefore reflects different potential environmental impacts.

[8] City of Austin Watershed Protection Department, *The Jollyville Plateau Water Quality and Salamander Assessment*, Water Quality Report Series, COA-ERM 1999-01, June 22, 2001, pages 54-56.

[9] Brune, Gunnar and Gail L. Duffin, *Occurrence, Availability, and Quality of Ground Water in Travis County, Texas*. Texas Department of Water Resources Report 276, June 1983, Figure 12. Total dissolved solids concentrations in the four wells are 252, 450, 509, and 570 milligrams per liter.

3.1.1 Monitor Wells

Monitor wells provide useful information about groundwater potentiometric levels or pressure. Potentiometric levels in monitor wells are relatively easy to monitor. Automatic logging devices can be used to collect water pressure measurements at regular, frequent intervals, providing a virtually continuous record. Spring flow rates, by contrast, can be difficult to measure accurately.

Potentiometric pressure changes provide an indication of stored water volume changes in a geologic formation. Potentiometric differences give an indication of the directions of groundwater flow, though direction of flow within karst aquifers can only be verified through dye trace studies. Nevertheless, potentiometric maps along with hydraulic conductivity and porosity, provide a basis for calculating flux and apparent velocity. Wells provide the most useful information for identification of groundwater pressure responses to potential dewatering during shaft and tunnel construction.

Monitor well water samples are not as reliable as springs to indicate groundwater quality changes in the Jollyville Plateau Edwards karst environment. A well that is physically proximate to a potential contaminant source, but not on a well-connected flow path, might provide misleading indications of a lack of contamination. Springs generally provide an integration of discharge from a broad range of flow paths and therefore may be better for detecting contamination. This monitoring program will monitor both wells and springs for water quality changes.

3.1.2 Springs

Where wells within a karst formation may not reflect changes in groundwater chemistry due to the lack of flow paths between the source and the well, springs are natural sites of groundwater discharge. If a significant contaminant source is within the area contributing flow to a spring, the contaminant will eventually be reflected by changes in spring chemistry. Furthermore, springs are important as ecological habitat in the Bull Creek area which makes monitoring springs a significant element of the environmental monitoring program.

Spring water quality data will provide a basis for detecting changes from materials that are either released at the surface and infiltrate through soils or karst features; or materials that are released in the subsurface environment during or after construction.

3.1.3 Surface Water

Surface water conditions are responsive to the quality of surface runoff, the quantity and quality of spring flow, and the gain or loss of water through the streambed. Surface flow in Bull Creek and its tributaries will be monitored to detect flow changes that might be attributable to interception of or impacts to springs or groundwater by the shafts or tunnel construction and operations. The project design requires tunnel construction discharges to be conveyed to sanitary sewer lines wherever possible. Surface water will be monitored, however, to detect chemical changes in water quality associated with potential project surface or subsurface discharge.

Surface water chemistry varies naturally. One source of this variability is differences during storm runoff compared to baseflow conditions. The monitoring program will minimize this variability by sampling surface water preferentially during baseflow conditions. Baseflow conditions[10] are determined from average rainfall totals during the 24-hour, 48-hour, and 72-hour period preceding the time of sample collection, as described in Table 3-1.

Table 3-1. Antecedent Rainfall and Delay Defining Baseflow Conditions

Average Rainfall in 24-Hour Period Ending at 8:00 am on Sampling Day (inches)	Time to Baseflow Conditions Return (hours)
0.1 to 0.25	24
0.25 to 1.00	48
>1.00	72

3.2 Monitoring Parameters

A list of proposed monitoring parameters is presented in Table 3-2. This list includes parameters to detect potential environmental impacts from each element of the WTP4 system, during both construction and operation. Not every site will be monitored for all of these parameters because

[10] City of Austin Watershed Protection Department, *Water Resource Evaluation Standard Operating Procedures Manual*, first compiled August 2004, last updated April 2010.

each element of the monitoring system will not represent potential impacts from construction of the entire system. Specific monitoring parameters for each facility element and sampling site are presented in Section 4.

Table 3-2. Proposed Monitoring Parameters

Parameter	Purpose
Potentiometric level	Detects groundwater interception by shafts or tunnel
Surface water level	Detects groundwater interception by shafts or tunnel as reflected by a decrease in spring or base channel flow
Temperature	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
pH	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Specific conductance	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Total Suspended Solids (TSS)	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Total Dissolved Solids (TDS)	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Standard anions and cations: Ca, Mg, Na, SO4, HCO3, Cl	Indicator of impacts from discharge of shaft and tunnel water to surface waterways
Nitrate	Associated with blasting by-products, fertilizers
Ammonia	Associated with blasting by-products, fertilizers
Phosphate	Associated with fertilizers
Copper	Associated with drilling and mining operations, vehicular and equipment use
Chromium	Associated with drilling and mining operations, vehicular and equipment use
Zinc	Associated with drilling and mining operations, vehicular and equipment use
Total Petroleum Hydrocarbons (TPH)	Associated with drilling and mining operations, vehicular and equipment use
Rainfall	Correlating factor measured by others
Tunnel inflow	Correlating factor measured by contractor
Tunnel surface discharge	Correlating factor measured by contractor

3.3 Frequency

Water quality changes possibly attributable to construction impacts may appear at springs or streams quickly. The duration of impacts might range from short-term pulses to prolonged effects. Furthermore, a typical two-week (or even a one-week rush) laboratory turn-around for monitoring results precludes timely adaptive management response in the shaft or tunnel construction process. Therefore, some parameters (water level/flow and specific conductance) will be monitored continuously to indicate short-term changes, while the full list of water quality parameters will be measured monthly.

3.4 Decision Process for Impact Evaluation

Data from both historical and pre-construction monitoring will be used to establish baseline ranges and population characteristics for monitored parameters. If construction-phase data indicates a change from the baseline characteristics, mitigation responses would be swiftly implemented to minimize damage to natural systems.

Even without construction impacts, however, groundwater levels, spring and creek flows, and water quality at each proposed monitoring location vary naturally. This natural variability means that any decision regarding an impact must balance two opposing risks: the risk of attributing a natural change to construction impacts versus the risk of attributing construction impacts to natural hydrologic variability. The cost of the first risk is potential environmental damage. The cost of the second is unnecessary construction mitigation expense.

The science of statistics quantifies the probability associated with the two risks. Steps to develop an appropriate decision process include:

1. Evaluate each measurement set to determine whether they are adequately characterized by a normal (Gaussian) or transformed-Gaussian probability distribution function.
2. Evaluate each set of measurements for correlating factors (rain, creek flow, season, similar conditions at comparable unaffected locations) to determine which factors unassociated with construction can be used to account for observed monitoring parameter variability.
3. Using information developed in Steps 1 and 2, select a null hypothesis (for example: no change from the baseline conditions), and a suitable hypothesis test. For this particular application, the goal is to immediately identify conditions of concern. Suitable hypothesis tests would be in the families of control charts or statistical interval tests.
4. Based on the assumed probability distribution function, evaluate the probability of Type I and Type II statistical errors for any particular test. Adjust the hypothesis test parameters to achieve an appropriate balance between the two types of error.

Available and relevant historical data and monitoring data collected from the monitoring proposed in this report will be used for the above steps.

4.0 Monitoring Plans for JTM System Elements

This environmental monitoring program is designed for the Jollyville Transmission Main (JTM) and three of the shafts proposed for the transmission main tunnel construction: Four Points, Spicewood, and Jollyville Reservoir. The locations of these facilities are shown in Figure 2-1. The WTP4 finished water shaft is not included in this monitoring program, consistent with environmental risk management decisions for other facilities within the Bullick Hollow watershed.

Tunnel boring machines will create the subsurface opening for the water transmission main pipe installation. Tunnel boring machines travel only in one direction; therefore, each machine requires two shafts – a “working” shaft where the machine is inserted, and a “retrieval” shaft where the tunnel boring machine will re-surface after excavation is complete. The working shaft generally must be much larger in diameter (typically 30-40 feet for this tunnel) than the retrieval shaft (typically 20 feet). Additional area around the surface opening of the working shaft site is also required to accommodate removal of the excavated material, worker operations and safety, and dewatering storage, treatment, and/or disposal. The working shaft is also the location for staging and installing pipe.

Shafts will be created using either mechanical excavation or “drill and blast” methods. Drill and blast involves drilling holes into the rock base, loading the holes with explosive, initiating the blast, ventilating fumes and dust from the shaft, supporting shaft walls, loading blasted rock into a muck conveyance system, and starting the cycle again.

Table 4-1 summarizes potential environmental consequences of construction of the Jollyville Transmission Main and associated shafts.

Figure 4-1 illustrates the wells, springs, and stream locations proposed for environmental monitoring. The monitoring plan for the tunnel and each of the three shafts are presented in the following sections. Table 4-2 presents the monitoring program for each of the Jollyville Transmission Main elements. This table describes the rationale for choosing each location. Figure 4-3 is a map of the proposed monitoring locations for the Jollyville Transmission Main.

Table 4-1. Potential Environmental Impacts from Construction

Source	Potential Environmental Hazards	Environmental Monitoring Parameters	Facility
Construction machinery	Lubricants, fuels, solvents, equipment wear	Copper, chromium, zinc, TPH	Tunnel and shafts
Revegetation	Fertilizers, pesticides	Nitrate, ammonia, phosphate	Tunnel and shafts
Site clearing, excavation	Sediment	Turbidity, TSS	Tunnel and shafts
Blasting	Explosive residuals, sediment, undetonated explosives	Nitrate, ammonia, TPH	Shafts
Subsurface flow interception	Reduced spring flow	Potentiometric elevations, spring flow	Tunnel and shafts
Human activity	*E. coli*, litter	none	Tunnel and working shafts

Table 4-2. Proposed Monitoring for Jollyville Transmission Main Tunnel and Shafts

Facility monitored	Site	Rationale	Parameter	Baseline Sampling Events	Construction - Phase Sampling Events	Post - Construction Sampling Events	Formation
Jollyville Transmission Main	JT-107D-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-107IPZ-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-107S-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-108-A	Near where tunnel alignment is beneath Bull Creek	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-110-A	Western end of tunnel	Water level	Continuous	Continuous	Continuous	Glen Rose
	JT-126	Eastern end of tunnel	Water level	Continuous	Continuous	Continuous	Glen Rose
	Lanier Spring	Proximate to the tunnel alignment; presence of a metal flume; is suitability for continuous flow monitoring	Water level	Continuous	Continuous	Continuous	Glen Rose
			Specific Conductance	Continuous	Continuous	Continuous	
	Pit Spring	Proximate to the tunnel alignment below Bull Creek. Distributed discharge along the bank near the channel bottom eliminate the opportunity for direct flow measurement	Flow by visual estimate	6	36	None	Glen Rose
	Bull Creek above WTP4	Located above the ***old*** WTP4 site; available historical continuous flow monitoring data	Water level	Continuous	Continuous	Continuous	N/A
	Bull Creek at Tributary 7	Available historical surface water monitoring data; captures flow discharging from Pit Springs, combined with any stream flow	Water level	Continuous	Continuous	Continuous	N/A
			Specific conductance	Continuous	Continuous	Continuous	
	Bull Creek at Spicewood Springs 7th Crossing	Located on Bull Creek just downstream of the last point where the Jollyville Transmission Main parallels Bull Creek	Water level	Continuous	Continuous	Continuous	N/A

Table 4-2. Proposed Monitoring for Jollyville Transmission Main Tunnel and Shafts (continued)

Facility Monitored	Site	Rationale	Parameter	Baseline Sampling Events	Construction - Phase Sampling Events	Post - Construction Sampling Events	Formation
Four Points Shaft	JT-112	Shaft location dye traces to this well within 3 weeks. Contaminants, if any, will be more mobile in the Edwards and potential impacts of water interception more significant.	Water level	Continuous	Continuous	Continuous	Edwards/ Walnut contact
			Water quality	6	5 during liner construction and 4 after discharge event (9 total)	None None	
	JT-128	Proximity to shaft site	Water level	6	36	None	Edwards
	Bull Creek above WTP4	Downstream from shaft location	Water level	Continuous	Continuous	Continuous	N/A
			Water quality	12	Only if tunnel or shaft water is discharged to surface (4)	None	
Spicewood Shaft	Construction-phase well to be added; completed across water table to 20 feet below water table in upper Glen Rose	Adjacent to proposed shaft; monitoring upper Glen Rose	Water level	Continuous	Continuous	Continuous	Glen Rose
			Water quality	6	4 during liner construction and 4 after discharge event (8 total)	None	
	Tributary 4 downstream from Spicewood Shaft	Downstream from shaft location	Water level	12	Only if tunnel or shaft water is discharged to surface (4)	None	N/A
			Water quality	12		None	

Table 4-2. Proposed Monitoring for Jollyville Transmission Main Tunnel and Shafts (continued)

Facility Monitored	Site	Rationale	Parameter	Baseline Sampling Events	Construction-Phase Sampling Events	Post - Construction Sampling Events	Formation
Jollyville Reservoir Shaft	JT-127	Near shaft location to monitor Edwards formation; contaminants, if any, will be more mobile in the Edwards and potential impacts of water interception could be more significant.	Water level	Continuous	Continuous	Continuous	Edwards
			Water quality	6	6 during construction and 4 after discharge event (10 total)	None	
Reference Sites	Tributary 4 upstream of Spicewood Shaft	Characterizes background surface water condition.	Water level	6	36	None	N/A
			Water quality	6	36	None	
	Tanglewood Spring	Significant spring with (potential) habitat	Water level	6	36	None	N/A
			Water quality	6	36	None	
	Ribelin Spring	Significant spring characterizing background conditions	Water level	6	36	None	N/A
			Water quality	6	36	None	
	JT-101-A		Water level	6	36	None	Edwards
	JT-113		Water level	6	36	None	Edwards
	JT-114		Water level	6	36	None	Edwards
	JT-115		Water level	6	36	None	Edwards
	B-9		Water level	6	36	None	Glen Rose
	B-10		Water level	6	36	None	Glen Rose

Table 4-2. Proposed Monitoring for Jollyville Transmission Main Tunnel and Shafts (continued)

Facility Monitored	Site	Rationale	Parameter	Baseline Sampling Events	Construction-Phase Sampling Events	Post - Construction Sampling Events	Formation
Reference Sites	JT-118-A		Water level	6	36	None	Glen Rose
	JT-104-A		Water level	6	36	None	Walnut
	JT-124-A		Water level	6	36	None	Edwards
	JT-125-A		Water level	6	36	None	Glen Rose

4.1 Tunnel and Transmission Main

The Jollyville tunnel and transmission main will run 34,600 feet (6.5 miles) from the water treatment plant to the existing Jollyville Reservoir. Construction is scheduled to begin in September 2011, with a completion date of spring 2014 to match completion of the water treatment plant. The proposed tunnel excavation diameter is approximately 10 feet.

The proposed vertical alignment of the tunnel is shown in Figure 4-2. Tunnel depths below the ground surface will range from around 100 feet at the Spicewood Shaft to 320 feet at the Jollyville Reservoir. The tunnel alignment will be bored through the Glen Rose limestone at a minimum depth of 40 feet below the overlying Walnut formation. Two tunnel boring machines will work simultaneously from the Jollyville Reservoir and Four Points working shafts.

Anticipated environmental impacts from the tunnel during construction are none to minimal. Pressure gradients will force any groundwater in the adjacent rock into the open tunnel during construction, preventing tunnel water or contaminates from entering the surrounding geologic formation. Water flowing into the tunnel during construction will be discharged through the working shafts. Environmental monitoring for potential impacts from those discharges is addressed in the relevant shaft sections.

Water entering the tunnel during construction might affect the groundwater pressure and possibly the water flowing to seeps, springs, or streams. There are several factors, however, that make significant flow loss associated with tunnel construction unlikely. Most of the seeps and springs are fed by water from the Edwards formation, either directly or after water from this formation has migrated through the Walnut. The tunnel will be separated from Edwards formation water by approximately 90 feet of the Walnut formation and at least 40 feet of Glen Rose formation.

The volume of water flowing into the tunnel will depend upon formation characteristics and differences in potentiometric pressure along the tunnel alignment. Hydraulic conductivity measurements for the Walnut and Glen Rose formations, as well as previous experience tunneling through these formations, indicates a low probability of significant inflow. In addition, mitigation measures are planned if inflows to tunnels exceed specified target levels. Nevertheless, this environmental monitoring program is conservatively designed to detect changes in groundwater potentiometric levels and/or changes in Bull Creek or spring flow that might be associated with tunnel inflows. Changes in well water levels would provide an early warning signal of potential changes to seep, spring, or creek flow.

4.2 Access Shafts

There will be four access shafts required to facilitate tunnel construction and installation of the transmission main. Three of these four shafts are included in this monitoring program. The potential environmental impacts from shaft construction are:

- Surface or subsurface discharge of lubricants, fuels and solvents associated with mechanical excavation and drilling and blasting equipment;
- Surface or subsurface discharge of nitrogen compounds associated with blasting;
- Surface or subsurface discharge of sediment associated with mucking and general construction; and
- Interception and depletion of Edwards formation groundwater.

The Four Points and Jollyville Reservoir access shafts will be used as working shafts for the removal of tunnel boring debris and general construction materials/waste. As a result, these working shafts have additional potential environmental impacts from surface discharge of treated water from the tunneling operation, including lubricants, fuels, solvents, sediment, and nitrogen from blasting.

Water quality impacts will be monitored for each shaft site as described in the following sections.

4.2.1 Four Points Shaft

The Four Points Shaft is proposed as a working shaft. The tunnel boring machine will be inserted into this shaft and boring will proceed toward the Spicewood Shaft. A second tunnel boring machine will be inserted through this shaft and tunneling will proceed toward the WTP4 Shaft. The Four Points Shaft will be 40 feet in diameter and about 270 feet deep. Tunnel dewatering would occur from this working shaft. This dewatering discharge will occur into the City of Austin wastewater sewer system.

Based on the log for JT-112, this shaft will be constructed through 78 feet of the Edwards, 86 feet of the Walnut, and 96 feet of the Glen Rose formations. The preponderance of springs in the

Bull Creek watershed that emerge at the Edwards/Walnut Formation contact suggest that groundwater flows vertically through the Edwards to just above the Edwards/Walnut contact, though dye traces indicate that some water from the Edwards is migrating down into the Walnut[11]. The likely direction of groundwater flow at the contact in the vicinity of this shaft is a route similar to surface runoff: north or northeast, toward springs, seeps, and the headwaters of Bull Creek. A dye trace study is currently underway by the City of Austin to investigate directions of flow in the Edwards from this location. Preliminary results from this effort indicate a flow direction locally eastward from the proposed shaft. Additional monitoring and additional travel time for the injected dye may indicate additional directions of flow. Surface runoff from the Four Points Shaft site flows north into the headwater canyons of Bull Creek.

The shaft will have a watertight lining constructed from the ground surface through the Edwards and Walnut formations into the top of the Glen Rose. Water removed from the tunnel and shaft will be discharged to the sanitary sewer system. Although design elements are planned to mitigate or eliminate potential impacts, the monitoring program is conservatively designed to detect environmental impacts should any of these protection systems fail.

The environmental monitoring program for the Four Points Shaft will consist of the monitoring sites, parameters, and frequencies described in Table 4-2. This table describes the rationale for choosing each of these monitoring locations and the proposed monitoring parameters. Figure 4-4 is a map of the proposed monitoring locations.

4.2.2 Spicewood Shaft

The Spicewood Shaft will be located south and east of Spicewood Springs Road where it turns from an east-west to a north-south orientation. The property is an undeveloped parcel owned by the City of Austin Parks and Recreation Department. This shaft will be constructed as a retrieval shaft. The shaft location is proximate to Bull Creek Tributary 4 and upstream from several seeps and springs.[12] The Spicewood retrieval shaft will be 20 feet in diameter and approximately 125 feet deep.

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[11] Personal communication with David Johns, City of Austin, April 28, 2011

[12] Johns, David. “Memorandum to Chuck Lesniak regarding Investigation of Bull Creek Tributary 4 near Spicewood Springs Road,” September 2, 2010.

Based on the boring log for JT-120 at the proposed shaft location, this shaft would intercept 21 feet of fill and 99 feet of Glen Rose. The Edwards and Walnut formations at this location have been eroded by downcutting of Bull Creek and its tributaries.

Erosion of Edwards formation materials at this shaft location eliminates any potential for interrupting Edwards groundwater flows. The potential for affecting groundwater flows in the Glen Rose is limited by the formation's relatively low hydraulic conductivity. Interception of groundwater in the surface fill will be limited by an impermeable liner system through the fill and a grout injected into the top 50 -70 feet of Glen Rose material.

Surface water from the site flows east into Bull Creek Tributary 4. Some surface runoff may also flow west and into a roadside channel along the east side of Spicewood Springs Road and discharge into Bull Creek. There will be no tunnel dewatering discharge from this retrieval shaft. Inflows during shaft construction will be routed to and discharged through the City of Austin sanitary sewer system.

Although design elements are planned to mitigate or eliminate potential impacts, the monitoring program is conservatively designed to detect potential environmental impacts should the mitigation systems fail.

The environmental monitoring program for the Spicewood Shaft will consist of the monitoring sites, parameters, and frequencies described in Table 4-2. This table describes the rational for choosing each location and the proposed monitoring parameters. Figure 4-5 is a map of the proposed monitoring locations.

4.2.3 Jollyville Reservoir Shaft

The Jollyville Reservoir finished water shaft will be constructed as a working shaft. The tunnel boring machine will be inserted into this shaft and boring will proceed toward the Spicewood shaft. The Jollyville Reservoir shaft will be 40 feet in diameter and 350 feet deep.

Based on the log for JT-126, this shaft will be constructed through 135 feet of the Edwards, 105 feet of the Walnut, and 80 feet of the Glen Rose formations. There is insufficient groundwater level data and no dye tracing data to determine the direction of groundwater movement locally at the Jollyville Reservoir site, but is assumed that groundwater will move eastward based on both surface topography and the regional dip of the Edwards/Walnut contact.

Surface runoff from the Jollyville Reservoir Shaft site flows north to a roadside swale along the south side of McNeil Drive and then east. The receiving water for surface runoff is Rattan Creek. Tunnel water will be discharged through the Jollyville Reservoir Shaft to the City of Austin sanitary sewer system as long as there is available sanitary system flow capacity. Tunnel water discharges may exceed the sanitary system capacity, however, during short-term flush flows into the tunnel or during wet weather periods when the sanitary lines experience infiltration and inflow, surface discharge may be allowed during these time periods.

The shaft will have gasketed liner plates extending through the Edwards/Walnut contact. Water removed from the tunnel and shaft will be treated and/or discharged to the sanitary sewer. Although design elements are planned to mitigate or eliminate potential impacts, the monitoring program is conservatively designed to detect these potential environmental impacts should mitigation systems fail.

The environmental monitoring program for the Jollyville Reservoir Shaft will consist of the monitoring sites, parameters, and frequencies described in Table 4-2. This table describes the rationale for choosing each of these monitoring locations and the proposed monitoring parameters. Figure 4-6 is a map of the proposed monitoring locations.

4.3 Reference Sites

Due to the natural variability in water characteristics at the monitoring locations attributable to weather conditions, fifteen sites that are not expected to be affected by WTP4 construction will monitored on a monthly basis through the baseline and construction phases of the project. The surface water and spring sites will be monitored for flow and water quality, while the well sites will be measured only for water level. Figure 4-7 shows a map of the reference sites.

5.0 Cost Estimate

Estimated cost to implement the environmental monitoring program outlined above is $387,704. Included in this estimate are:

- Equipment and materials;
- Labor (for installation and maintenance of field equipment and scheduled grab sampling);

- Laboratory analysis;
- Telemetry data contracts;
- 20% contingency; and
- 5% percent cost recovery fee on other direct costs (ODCs) such as equipment purchases and subcontracted laboratory analysis.

This estimate does not include costs associated with data evaluation or summary reports, nor does it include any response to monitoring results that demonstrate potential negative impacts from construction of WTP4 and the Jollyville Transmission Main.

This cost estimate was developed by establishing unit costs for the elements of the sampling plan. Using these unit costs, we were able to explore the effects of changing various elements of the monitoring program (i.e. reducing sampling parameters, changing frequency of monitoring, removing monitoring locations, etc.) to achieve a more cost-conscious program that still met the monitoring goals of the Environmental Commissioning Team.

Table 5-1 shows the project costs presented in three different ways to give a comprehensive picture of how the costs are distributed among project elements. The sections below describe these elements in further detail.

Table 5-1. Monitoring Program Costs by Site Type, Construction Phase, and Element

Site Type	Number of Sites	Total	Percent
Surface water	4	$77,666	24%
Spring	4	$74,468	23%
Well	18	$145,857	45%
Project wide	--	$25,096	8%
Total	26	$323,087	
Total w/20% Contingency		$387,704	

Phase	Length (month)	Total	Percent
Start up	**0**	$84,227	26%
Baseline	4	$54,637	17%
Construction	36	$178,093	55%
Post Construction	6	$6,131	2%
Total		$323,087	
Total w/20% Contingency		$387,704	

Expense	Total	Percent
Start up	$84,227	26%
Laboratory	$70,340	22%
Labor	$162,000	50%
Data Transfer	$6,521	2%
Total	$323,087	
Total w/20% Contingency	$387,704	

5.1 Cost Elements

Three categories of unit costs were developed to create the cost estimate for the project: startup, labor and laboratory analysis, and data transfer. Startup costs are onetime costs associated with purchasing and installing monitoring equipment at each site or for the monitoring program as a whole. Labor and laboratory analysis costs were developed for each activity, site and trip. Data transfer costs associated with the sites with telemetry systems are also included.

5.1.1 Startup

Unit costs for startup include general project-wide costs, and costs specific to particular monitoring activities at individual sites.

Miscellaneous

Miscellaneous startup costs include sampling equipment and continuous monitoring equipment that can be used at multiple continuous monitoring sites, a flow cell, two project dedicated e-lines, and a compressed gas cylinder for operating bladder pumps.

Continuous Monitoring of Surface Water

Unit costs for continuous monitoring at surface water sites were made assuming monitoring will be done with an AquaTROLL 200 (for sites where specific conductance will be monitored) or a LevelTROLL 500 at sites where only flow will be monitored continuously. Cost includes necessary cables and mounting hardware and the effort to establish a flow rating curve. A City of Austin velocity meter is assumed to be available for monitoring calibration at no charge; and therefore the purchase cost of this instrument is not included in the unit cost.

Continuous Monitoring of Wells

Unit costs for continuous water level monitoring were made assuming monitoring will be done with a LevelTROLL 500. Continuous monitoring unit costs were different at each well because the difference in well depths affects the amount of cable required to install the equipment. The required hardware and cables as well as installation cost are included in the unit cost.

Dedicated Pumps

For wells with continuous water level monitoring and water quality sampling, a dedicated pump is proposed to facilitate water quality sampling. The pump will remain in place so that the LevelTROLL will not be disturbed during water quality sampling. This will keep the water level monitoring consistent by not moving the LevelTROLL and should make the water quality sampling faster and more efficient. Each well requiring a pump has a slightly different configuration, which results in different pump set-ups and costs.

Telemetry

Telemetry allows continuous monitoring data to be accessed without visiting the site where the continuous monitoring equipment is installed. This feature will allow for quick response to a predetermined trigger water level (preset alarm levels). The Four Points and Spicewood Shaft sites, and the JT107 well cluster were selected as locations for this technology. Costs include a TROLL Link 101 Telemetry system, vandal/wildlife resistant enclosure, associated cables and hardware, a data transfer activation fee and installation. At JT-107 a telemetry hub will be added to allow each of the three LevelTROLLs in the JT-107 well cluster to be attached to one telemetry system. A barometric sensor is also included at this location to allow for calibration of well elevation measurements during data evaluation.

5.1.2 Labor

Labor costs are based on two field technicians working together to accomplish the necessary field work at each site, at a rate of $80/hour for each worker (total of $160 per hour of labor). The INTERA Corporate Safety Program advocates the buddy system and does not support sending staff to perform fieldwork alone.

Continuous sampling sites

An average time of one half hour ($80) per site per visit was assumed for each continuous monitoring site based on the following foreseeable tasks:

- Preparation;
- Field notes, record keeping;
- Downloading data from continuous monitoring apparatus;
- Visual inspection of continuous monitoring apparatuses and telemetry equipment; completion of necessary minor repairs/adjustments; and
- Travel time to and between sites.

Site visits will be conducted monthly for sites with continuous monitoring.

Water quality samples/field work

An average time of 2.5 hours ($400) per site visit was assumed for each site where water quality samples will be taken. This estimate is based on the following assumed field tasks:

- Preparation;
- Field notes, record keeping;
- Collecting, documenting and packaging samples to be sent to laboratory;
- Field measurements (temperature, pH, dissolved oxygen, specific conductance);
- E-line reading (wells without LevelTROLLs) or gage reading (surface water, springs);
- Decontaminating equipment; and
- Travel time to and between sites.

The time estimate assumes increased efficiency resulting from multiple site visits in a single work day; and the availability of dedicated field and sampling equipment.

Visual flow estimate

For sites that do not have continuous measurement or sites where water quality samples will be taken, an e-line or gauge reading will be taken at normally scheduled visits. The labor cost associated with this is included in the site visits described above. For sites that are only being monitored for water level/flow, or will be monitored for these characteristics more frequently than the normal site visits, it was assumed that taking an e-line or gauge reading would take, on average, one half hour ($80) per site.

5.1.3 Laboratory

The laboratory costs are based on INTERA's contract with DHL Environmental Lab for this project. An additional 10% was added to the laboratory fees to account for the cost of quality assurance/quality control samples. The resulting cost was $347 per sample.

5.1.4 Data Transfer

Data charges of $45 per month for the services of wirelessly transferring data from each telemetry station to a password-protected online site for up to one gigabyte of data storage were assumed. This cost was multiplied by the number of telemetry stations and then by the length of the monitoring period to produce the total data transfer cost for the project.

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[13] Includes Lanier, Moss Gully Springs, and Bull Creek Tributary data.

[14] Includes flow data, water quality data for Lanier Springs

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[15] Includes Bull Creek @ 360 water quality data.

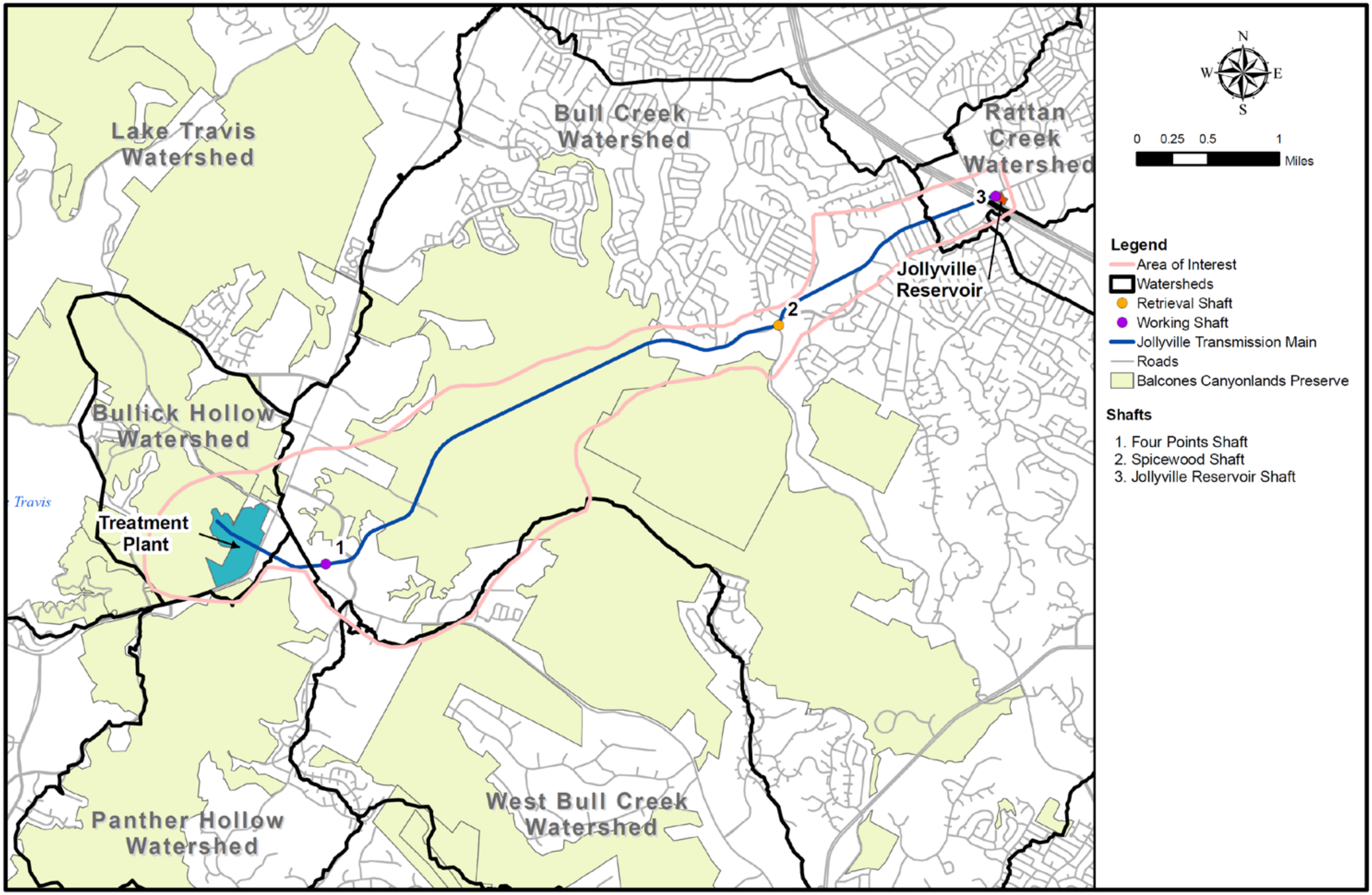

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FIGURE 2-1

WTP4 Proposed Project Facility Locations

June 2011

<table>
<tr><th>System</th><th>Series</th><th>Group</th><th colspan="2">Stratigraphic Unit</th><th>Hydrologic Unit</th></tr>
<tr><td>Quaternary</td><td>Recent</td><td></td><td colspan="2">Alluvial Sediment: unconsolidated gravel, sand silt, and clay</td><td>limited</td></tr>
<tr><td rowspan="8">Cretaceous</td><td rowspan="8">Comanche</td><td rowspan="5">Fredericksburg</td><td colspan="2">Edwards Limestone: thick-bedded to massive limestone, commonly dolomitic, may have several solution-collapse zones</td><td rowspan="2">Edwards</td></tr>
<tr><td colspan="2">Comanche Peak Limestone: marly, grayish-white limestone containing nodules and fossils, flaking and jointing give it a fractured appearance.</td></tr>
<tr><td rowspan="3">Walnut Formation</td><td>Cedar Park limestone</td><td rowspan="3">Not generally water bearing</td></tr>
<tr><td>Bee Cave marl</td></tr>
<tr><td>Bull Creek limestone</td></tr>
<tr><td rowspan="3">Trinity</td><td rowspan="2">Glen Rose Formation</td><td>Upper Member: shale and limestone alternating w/ think beds of impure limestone and dolomite. Bottom marked by iron-stained ledge of Corbula martinae. [1]</td><td>Upper Trinity</td></tr>
<tr><td>Lower Member: massive, fossiliferous limestone and dolomite grading upward into thin beds of limestone, shale, marl, anhydrite and gypsum.[2]</td><td rowspan="2">Middle Trinity</td></tr>
<tr><td>Travis Peak Formation</td><td>Hensel Sand: poorly sorted, cross-bedded conglomerate cemented with silica, sand sandstone, silts, clays and shale.[3]</td></tr>
</table>

FIGURE 2-2

Stratigraphic Column

[1] Brune, Gunnar and Gail L. Duffin, *Occurrence, Availability, and Quality of Ground Water in Travis County, Texas*, Texas Department of Water Resources Report 276, June 1983.
[2] Ibid.
[3] Ibid.

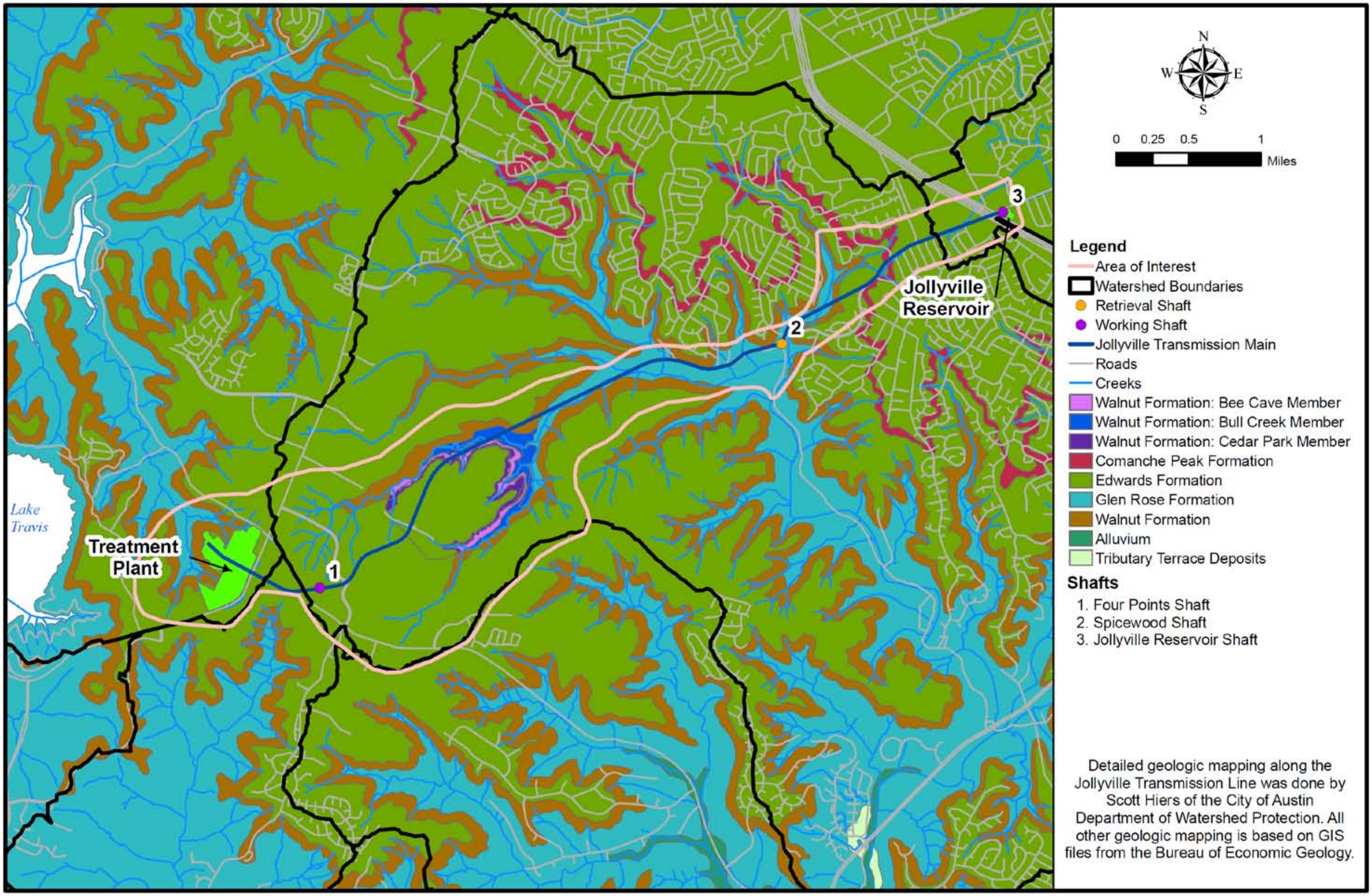

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FIGURE 2-3

Surface Geology

June 2011

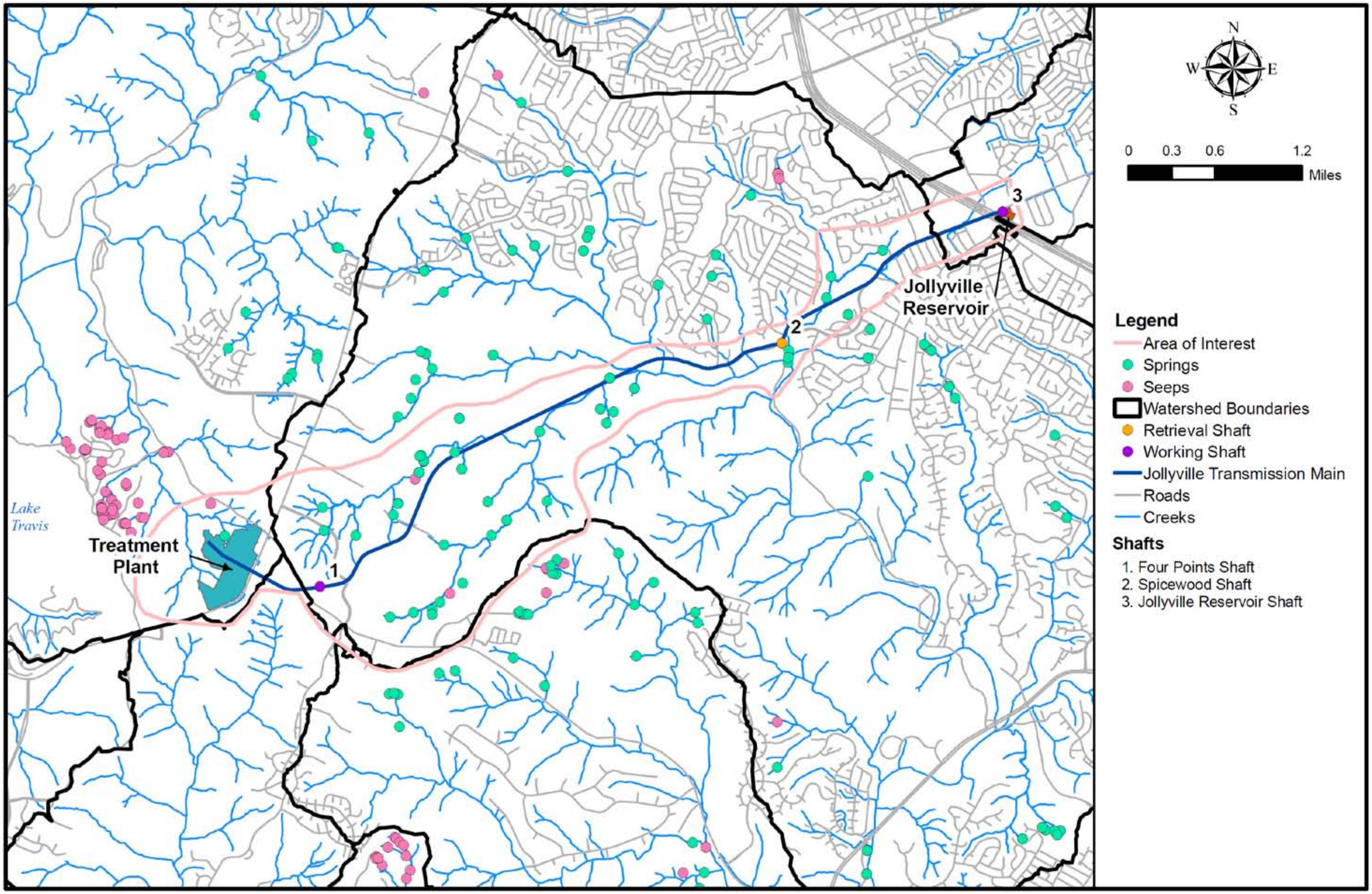

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FIGURE 2-4

Seeps and Springs

June 2011

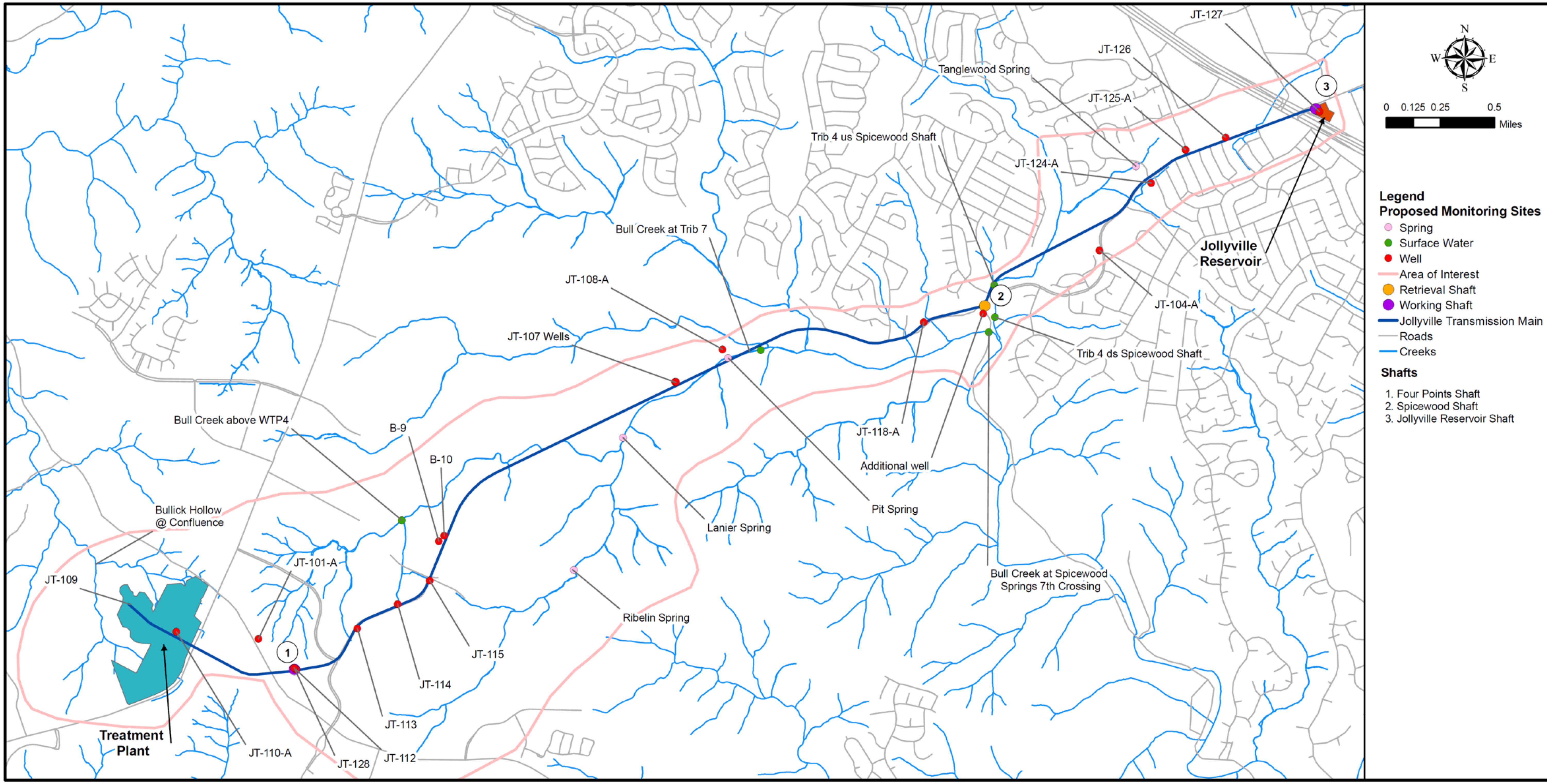

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FIGURE 4-1

Proposed Monitoring Sites

June 2011

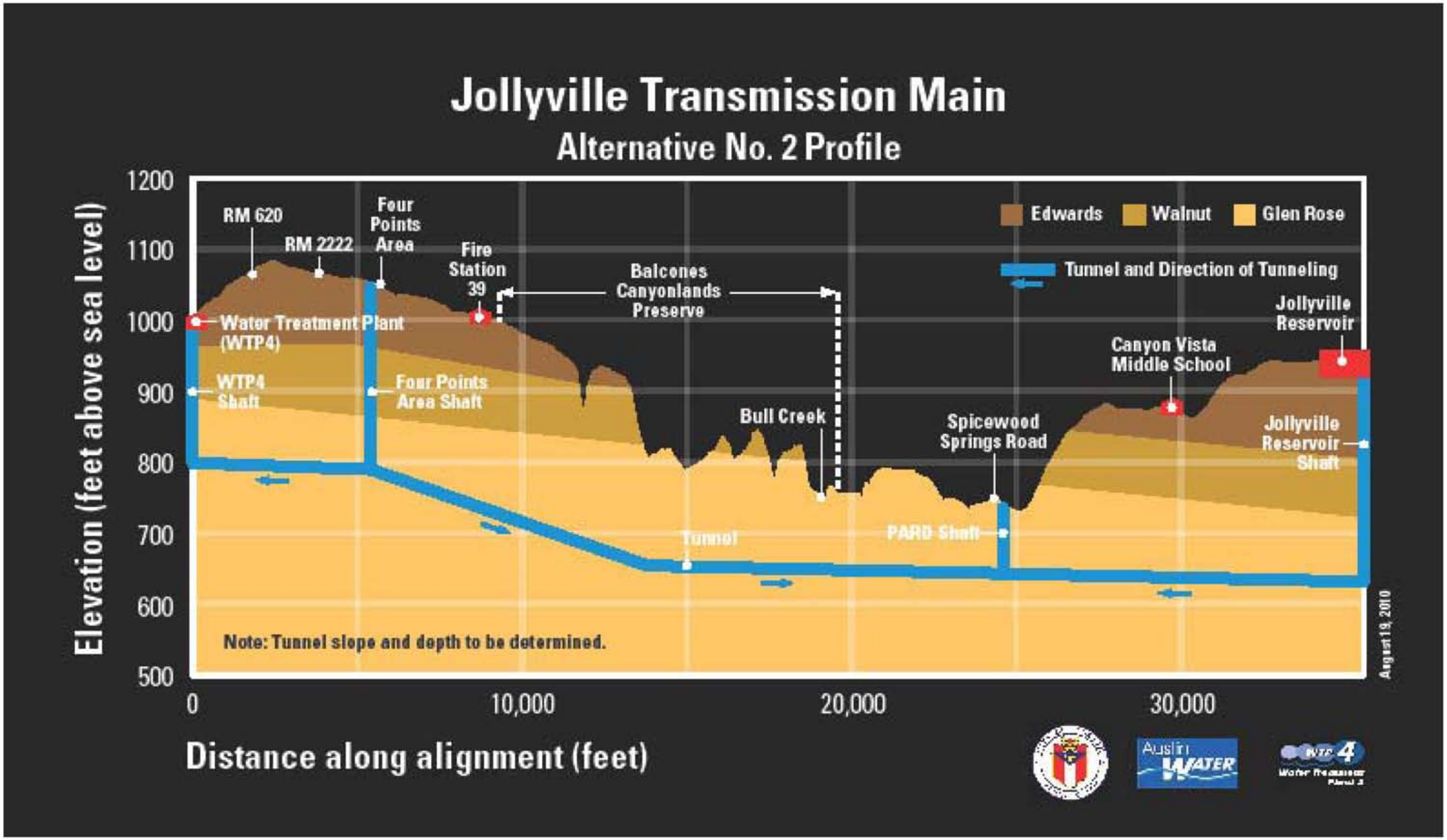

FIGURE 4-2

Jollyville Transmission Main Profile

February, 2011

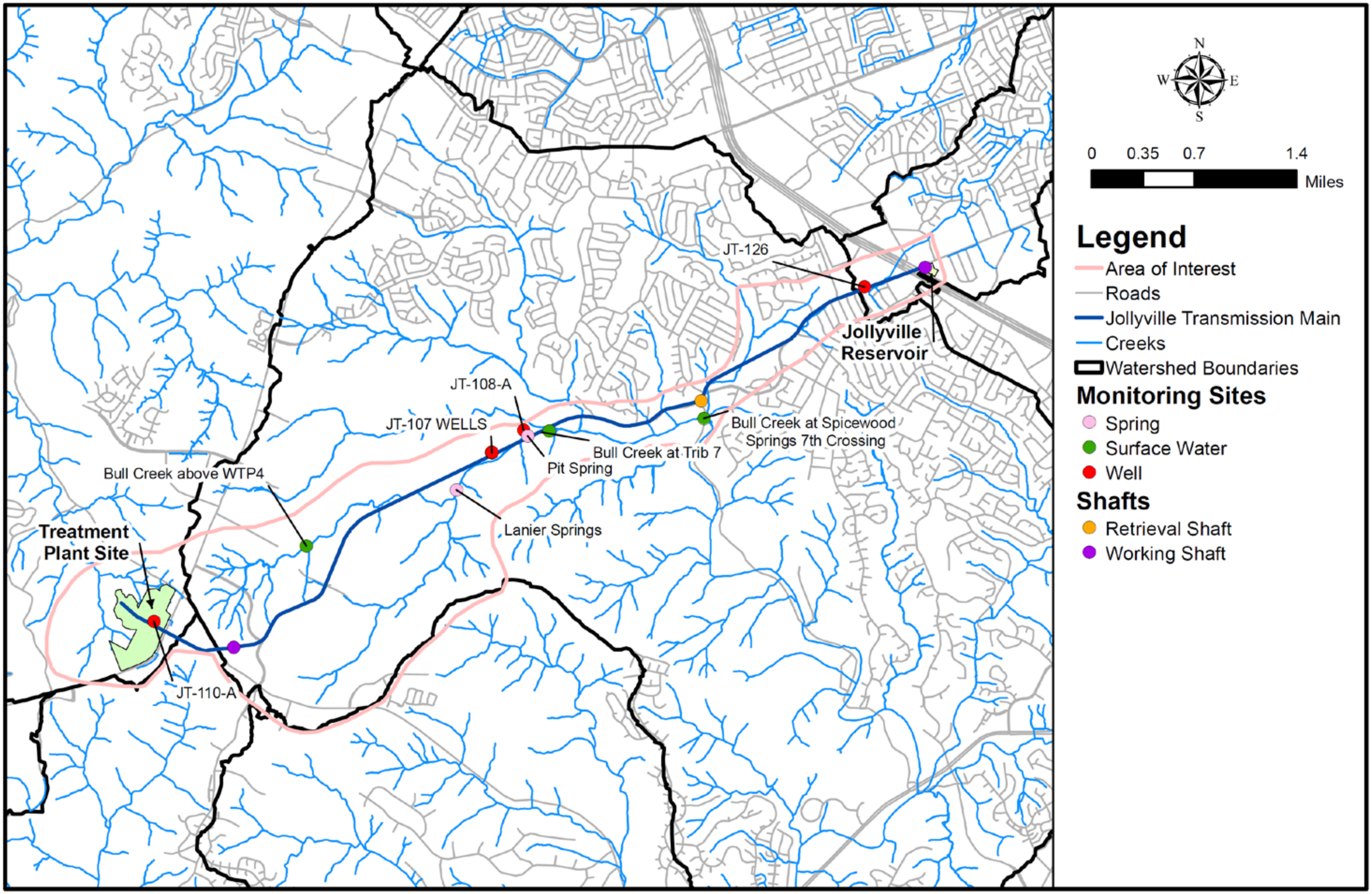

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FIGURE 4-3

Proposed Monitoring Sites: Jollyville Transmission Main

June 2011

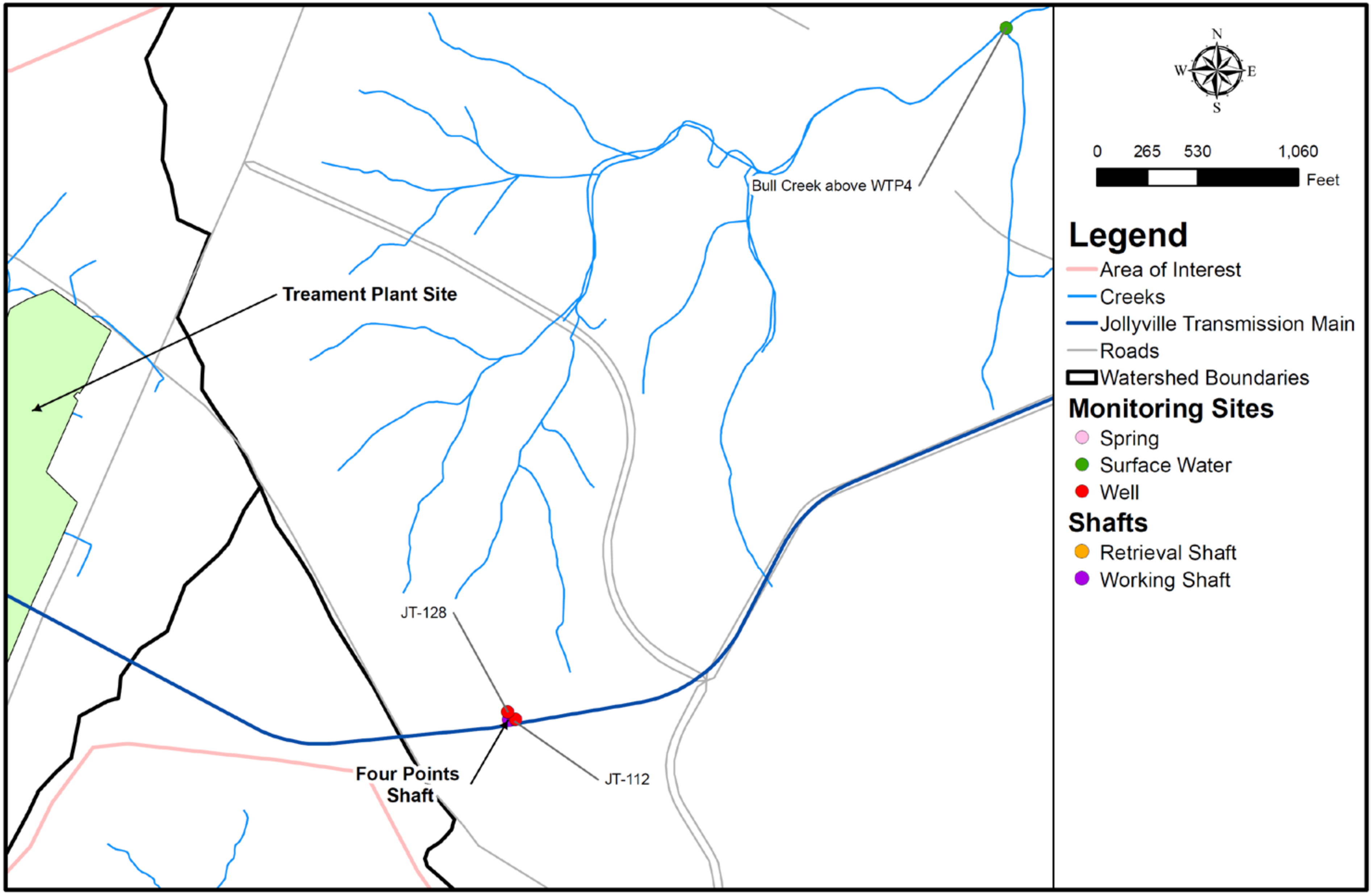

FIGURE 4-4

Proposed Monitoring Sites: Four Points Shaft

June 2011

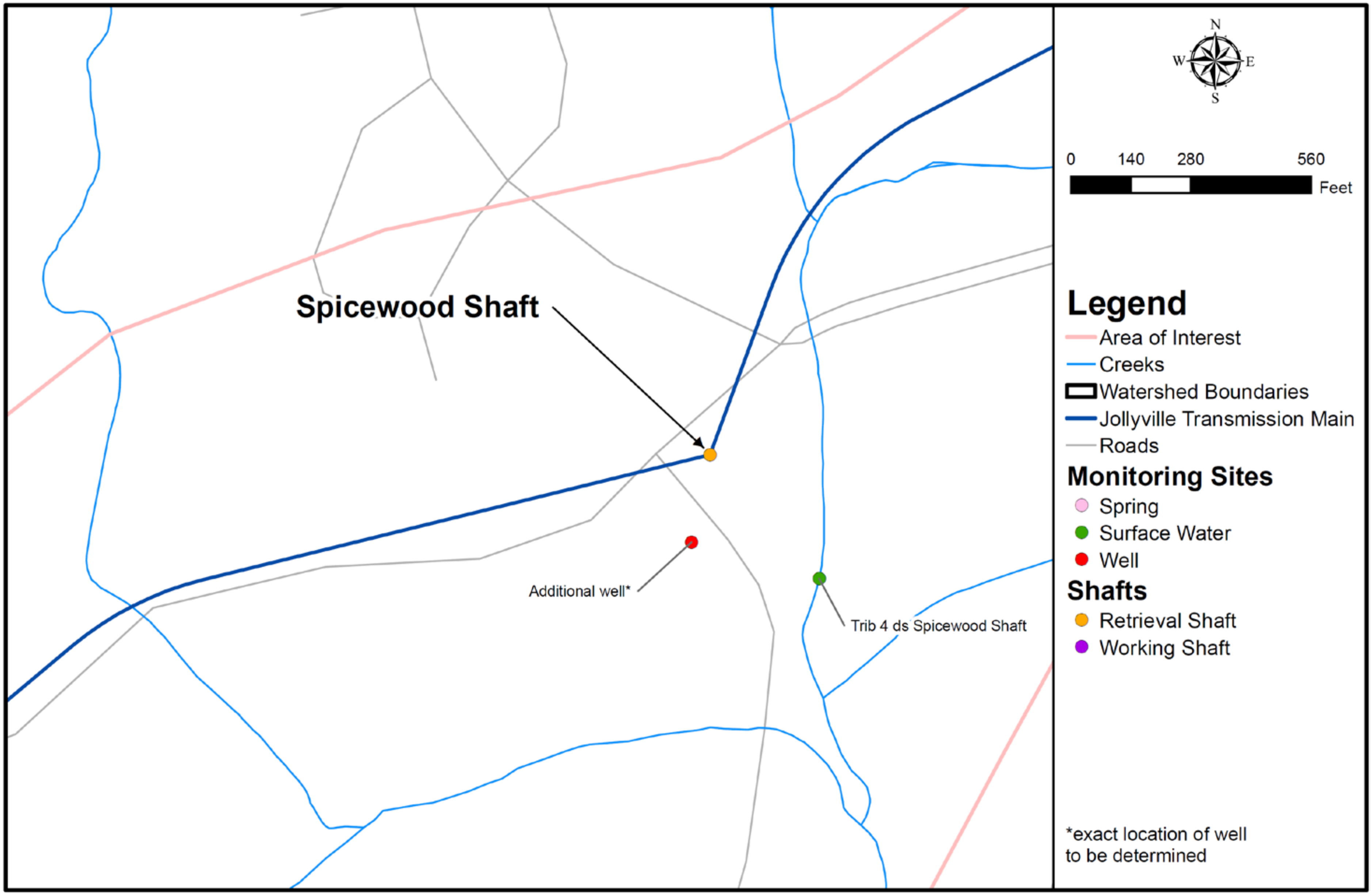

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FIGURE 4-5

Proposed Monitoring Sites: Spicewood Shaft

June 2011

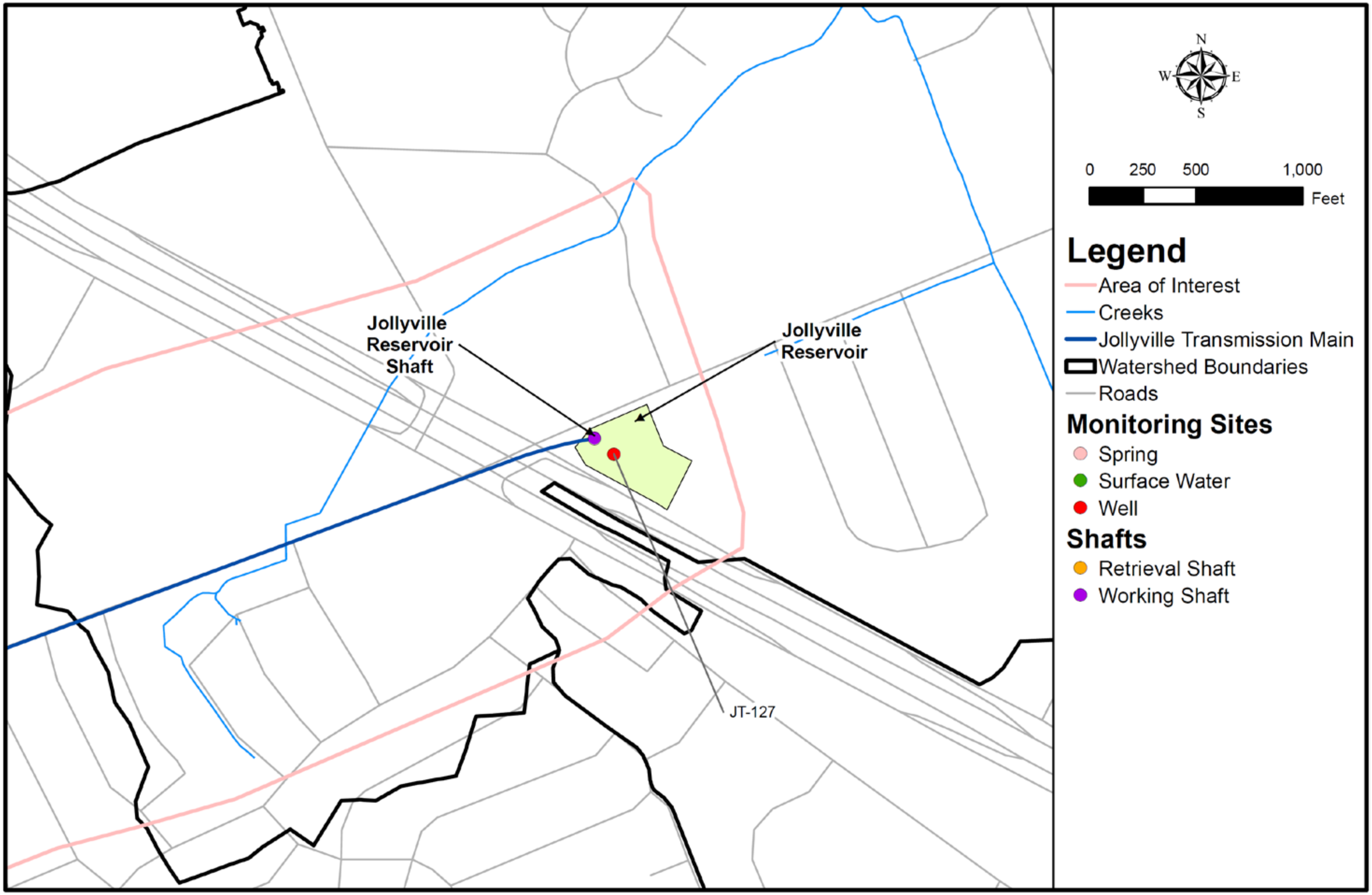

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FIGURE 4-6

Proposed Monitoring Sites: Jollyville Reservoir Shaft

June 2011

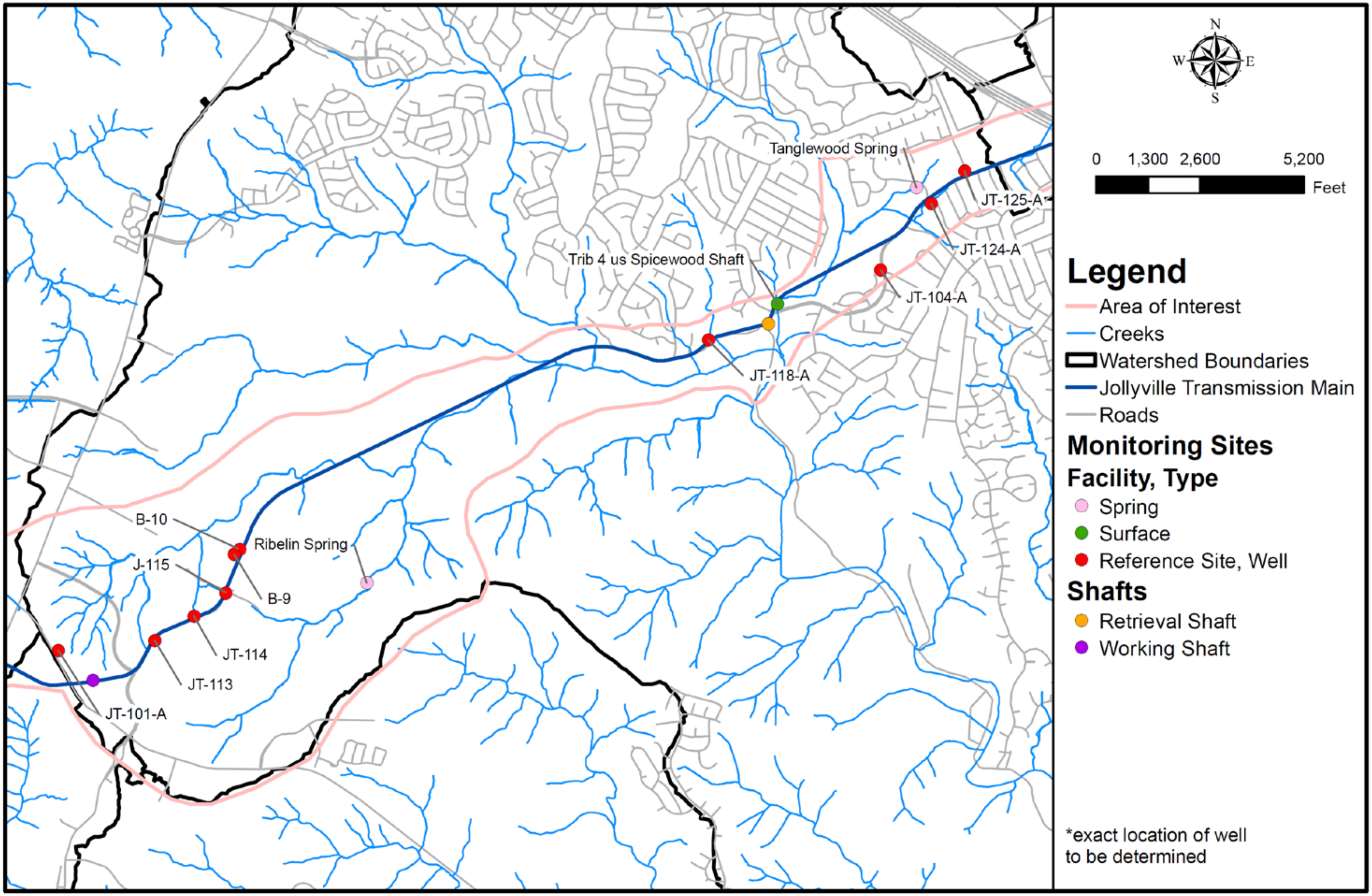

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FIGURE 4-7

Proposed Monitoring Sites: Reference Sites

June 2011