



The Mystery of the **UPGRADIENT** Contaminant

Given that PCE was in the groundwater, finding the source turned into a real detective activity.

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The Big Pine Indian Reservation comprises 279.08 acres of land adjacent to Big Pine, Calif., approximately 238 miles north of Los Angeles and 17 miles south of Bishop, in the central portion of the Owens Valley between the Sierra Nevada and White Mountain Ranges (see **Figure 1**). The terrain is relatively flat, sloping easterly towards the Owens River at grades ranging from 1 to 4 percent. The reservation's highest elevation of 4,050 feet is located at the extreme southwest corner of the property.

Two community water systems exist on the reservation. The first consists of two community-owned wells (Wells 1 and 2), which supply groundwater to 139 service connections. The second system is a privately owned well that supplies groundwater to 35 service connections in a trailer

park (see **Figure 2**). The population of the reservation is approximately 456.

Although groundwater quality met most of the national primary and secondary standards, perchloroethylene (PCE, a chlorinated solvent) had been detected in the two water supply wells when a monitoring program began in 1995 to comply with the federal Safe Drinking Water Act. The detection of PCE was unexpected considering the location of the water supply wells. Located 0.70 miles southwest of the town, topographically the wells were 100 feet higher than the town. Likewise, the wells were located at the highest point of the area. In essence, they were higher in elevation than all of the downgradient locations where potential contaminating activities (PCAs) could have occurred.

As a result of these topographical differences, there was an immediate con-

cern that the reservation's source water had become vulnerable to possible illegal dumping of PCE that could have been occurring somewhere within the radius of influence of the supply wells. A systematic approach was undertaken in an effort to better understand the shape of the capture zone under pumping conditions, so that potential sources of PCE could be mapped and mitigation measures might be developed.

Environmental assessment

A reservation-wide environmental assessment (EA) was performed on April 27, 1999, by SCS Engineers, Long Beach, Calif., as part of the work performed under a General Assistance Program (GAP) grant from the EPA Region 9. As part of the assessment, a preliminary evaluation was made of any potential sources of PCE in

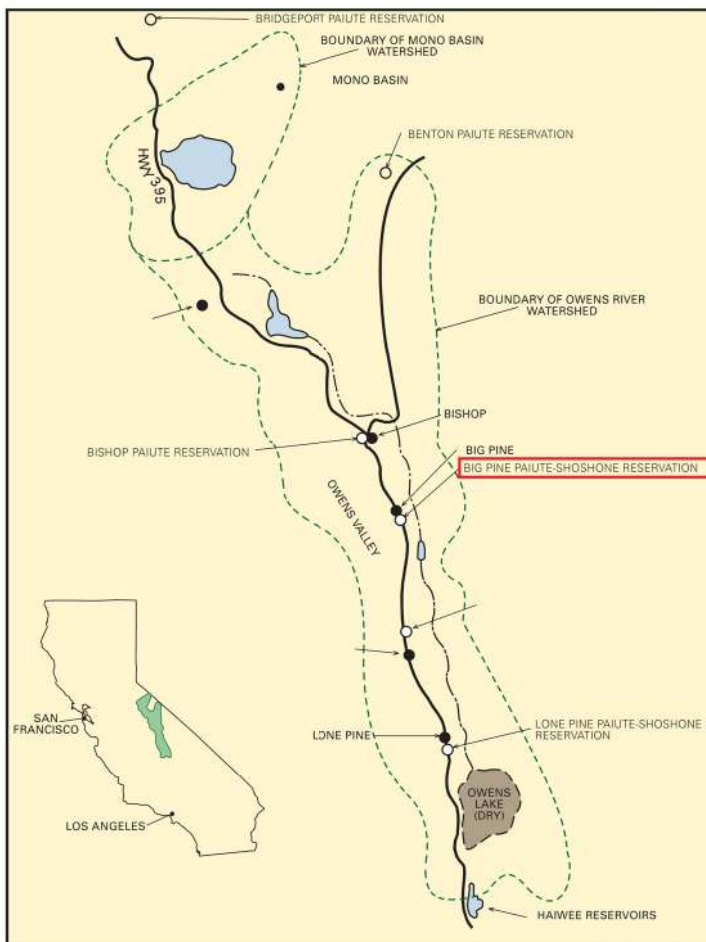


Fig. 1: Location of Big Pine Indian Reservation.

groundwater that could affect the wells. Areas identified as potential sources of PCE contamination included:

- The A&R Anchor (A&R) facility, located 0.65 miles east-southeast of the well field and 106 feet lower in elevation. A&R was a privately owned business that had a lease with the reservation and produced bathroom fixtures. As part of the manufacturing process, brass fixtures arrived at the facility where they were buffed and then soaked in a heated degreasing solution of PCE. After cleaning, a powder coating was applied then baked on in an oven. Some fixtures also received a polyurethane coating.
- A closed public landfill, 0.7 miles south-southeast of the well field. While the landfill was 40 feet higher in elevation than the well field, it was considered cross-gradient from a regional groundwater flow perspective.
- An old, exposed subterranean water tank, situated next to the well field about 20 feet away in the downgradient direction. The tank was formerly covered, but had been left open for years. The bottom of the tank showed evidence of random dumping. The tank was viewed as a possible source of PCE because of its proximity to the well field.
- A junkyard, which formerly existed across the street from Well 1, about 100 feet away and topographically 5 feet lower than the wellhead elevations. While the junkyard's existence was confirmed by Mr. Arnie Manriquez (the water system operator), few details of the types of waste dumped there were known. At the time of the assessment, the junkyard had long since been cleaned up and removed.

Phase I EA

After the assessment was completed, a Phase I EA was conducted at the A&R facility on April 30, 1999. The site's owner was present during the site visit, and answered questions about the operation. When asked about PCE, he responded that the compound had been used as a degreasing agent to clean parts before applying a powder coating; but that the operation had been changed and no longer included use of that solvent.

Initially the owner refused to allow inspection of a small room with a closed door during the facility walkthrough. When pressed he permitted entry and a large-capacity vat, filled with PCE, was observed in the room. When questioned about it, the owner stated he was in fact still using PCE, but was distilling spent solvent to regenerate clean solvent, and so avoided the generation of waste. However no distilling equipment was observed on the premises. Sludge generated in the degreasing process was being removed from the vat and managed as non-hazardous waste, and ultimately disposed of at the municipal landfill in Bishop. This practice was in violation of hazardous waste management regulations.

A review of available records showed that between 1994 to mid-1998, the company had contracted with Safety Kleen to remove and recycle spent PCE solvent and to replenish the facility with new solvent product. About 15 to 20 gallons per month of solvent continued to be utilized in the facility's operations. The

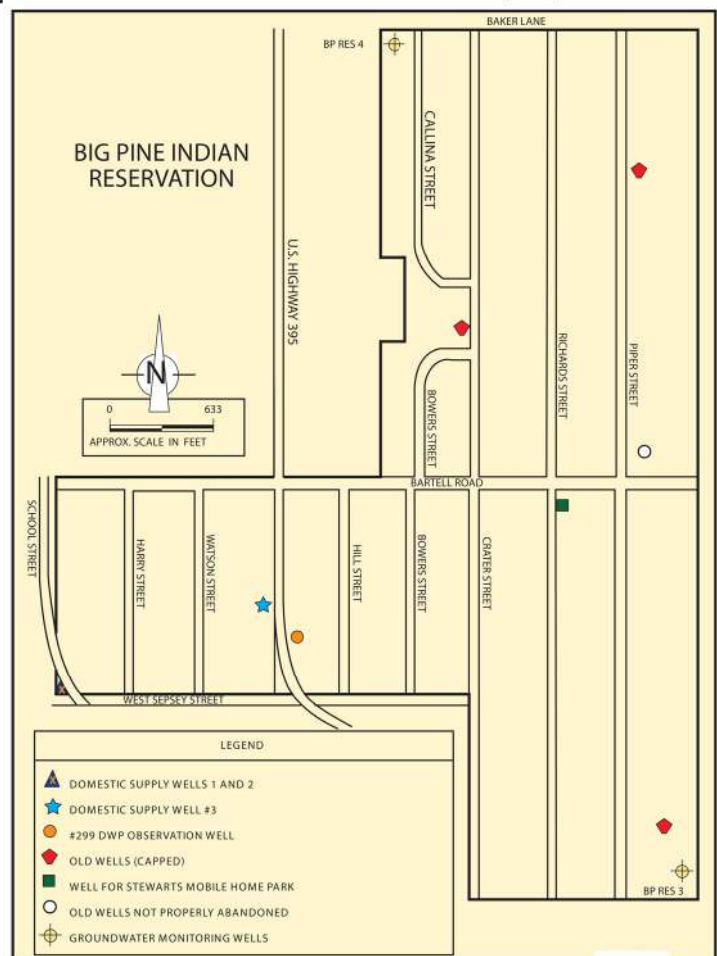
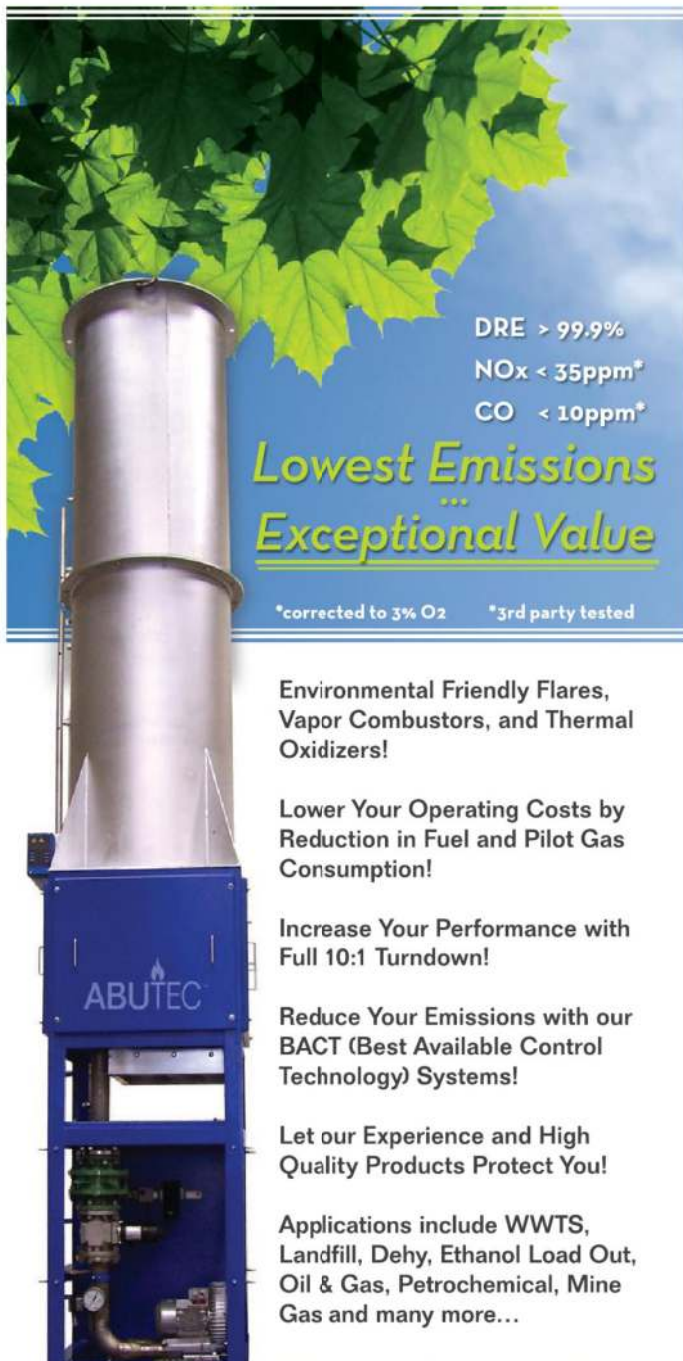


Fig.2: Above is a map of the neighborhood well locations.



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The proximity of the former cistern to the water supply well can be seen in this photo.

contract was terminated in 1998, but presumably PCE was still being used as it had been before.

The results of the Phase I study immediately raised concerns about disposal practices of spent PCE that was generated. With assistance from the Bureau of Indian Affairs, the lease with A&R was terminated because of continued mismanagement of hazardous waste at the facility.

The owner of the facility lived on an 8-acre parcel of land that was contiguous with the northwest corner of the reservation, and it seems plausible that the owner may have been dumping spent solvent in the remote alluvial fan area west of the reservation. The owner denied this when questioned about it. Nevertheless, he was put on alert by the tribe that illegal dumping of hazardous waste onto the ground is a federal violation.

Drinking water source assessment

In September 2000, as part of a Wellhead Protection Program, a drinking water source assessment was conducted at Wells 1 and 2. The source assessment was developed to accomplish the following:

- Define groundwater source locations.
- Inventory PCAs within a one-mile area around the two main supply wells.
- Provide a vulnerability analysis.
- Delineate a source area protection zone around the well field.

Methods used for the source assessment were taken directly from the Drinking Water Source Assessment and Protection Program, which was developed by the California Department of Health Services, Division of Drinking Water and Environmental Management, in January 1999.

Table 1. Groundwater Protection Zones Based on Time-of-Travel

Zone	Time-of-Travel	Distance to Wellfield	DHS Recommended Minimum Distance
Well Site Control Zone	NA	NA	50 feet
A	2 years	214 feet	600 feet
B5	5 years	535 feet	1,000 feet
B10	10 years	1,070 feet	1,500 feet
Buffer Zone	20 years	2,140 feet	NA

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Aquifer pumping test

As part of the assessment, an aquifer pumping test was performed on Well 1 to observe and measure the aquifer's response to pumping. By comparing the drawdown curve of the pumping well to a Theis type curve, a recharge barrier could be observed, and a graphical expression of the influence of Big Pine Creek on local recharge developed. Test results provided the data necessary to calculate aquifer characteristics, such as transmissivity, the storage coefficient, and the radius of influence. These parameters were utilized to evaluate wellhead protection parameters, including the source area and protection zones.

Groundwater gradient and flow direction

Pre-aquifer monitoring of the water table elevations under static conditions revealed that regional groundwater at the well field flowed to the southeast at a rate of about 0.30 feet per day. Big Pine Creek acted as a local groundwater divide. Groundwater flowed southeast towards the Reservation on the south side of the creek, and flowed northeast towards town on the north side of the creek. The creek provided a constant source of groundwater recharge over this portion of the alluvial fan, and is the principal source water to Wells 1 and 2 (see Figure 4).

Well field protection zone

The protection zone around the well field was calculated using uniform flow equations for determining the area of contribution to a pumping well. The shape of the protection zone is an ellipse that terminates at Big Pine Creek. The point of stagnation is 115 feet southeast (downgradient) of the pumped well (Well 1). This is the point at which any contaminant that passes cannot be pulled back into the well or captured (see Figure 4). Additionally,



Fig 4: The zone of influence for the water supply well on the reservation is shown in the graphic above.

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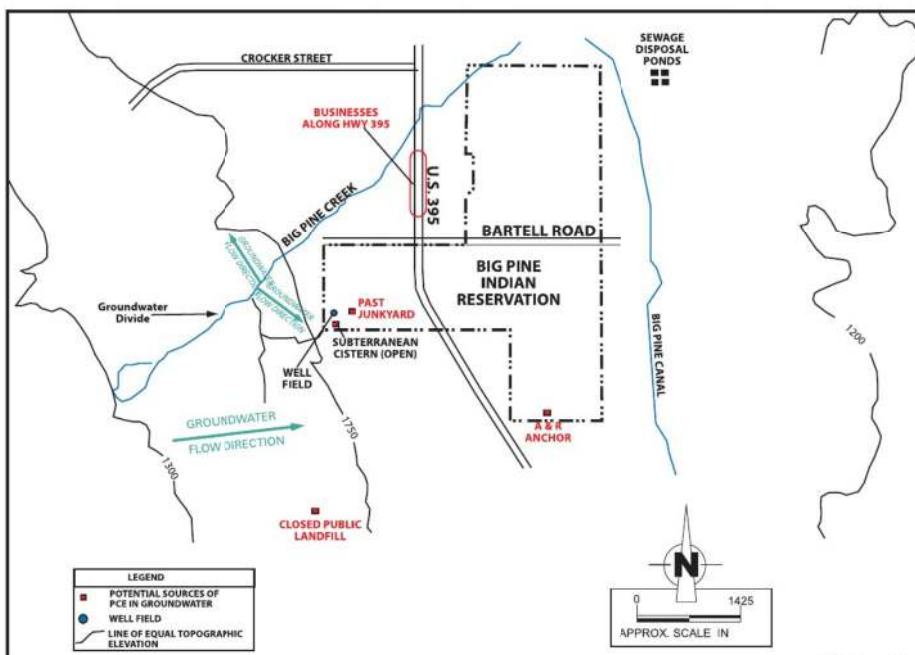


Fig 3: Potential sources of PCE in the groundwater near the reservation are shown in the graphic above.

other sources of contaminants further downgradient from this point will also not affect the well.

Table 1 shows protection zones based on time-of-travel to the well field per results of the aquifer analysis and in comparison to California DHS recommended minimum distances. A map showing the elliptical zone and the subzones is provided as Figure 4.

PCA evaluation

An initial list of PCAs within a one-mile radius of the supply wells was included in the EA performed at the reservation by the engineering consultant in 1999. These included businesses such as gas stations and auto repair shops in the town, a closed public landfill south of the well field, and the A&R facility (see Figure 3). Though further assessment was performed by the tribe at the Anchor facility, and PCE was detected in soil and groundwater, the facility, like nearly all of the identified PCAs, was located outside of the radius of influence of the supply wells. Only two PCAs inside the source area of the supply wells were observed:

- The old subterranean water tank
- The former junkyard

These potential sources of contamination are situated directly within the zone

of influence of the pumping well, and contaminants entering the aquifer system from these locations would be captured by the well. No other PCAs are known to exist within the source area (zone of contribution). Surface waters from Big Pine Creek were also sampled and evaluated in an initial assessment under Section 106 of the federal Clean Water Act. The water was found to be contaminant-free.

Four potential sources of contamination remained to enter groundwater, as follows:

- The old, open-topped water tank could have been used as a dumping ground by one or more persons. Solvents could potentially have been discarded in the tank.
- The former junkyard could have contained discarded oils and solvents in sufficient concentrations that, over time, could have percolated into the soil and reached the aquifer.
- Some combination of the two above-listed scenarios could have contributed to contamination at the Reservation.
- PCE could have been dumped on open ground in sufficient quantities within the zone of contribution, percolated into the aquifer, and reached the reservation's supply wells.

Knowing that the owner of A&R Anchor had terminated his contract with

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Safety Kleen in 1998, and also that PCE had been detected in the supply wells since 1995 (approximately 5 years before the assessment was performed), it was considered most likely that any dumping to the ground would have taken place inside the B5 zone (given a 5-year travel time) and within 535 feet of the well.

A foot search was conducted over the B5 zone, looking for evidence of PCE dumping. Since the compound is extremely volatile when exposed to the atmosphere (especially during hot summer months), the PCE can be especially hard, if not impossible, to detect. Nothing was ever found to confirm the practice of PCE dumping on the ground.

From December 1995 to June 2003, PCE levels consistently exceeded the MCL at the two water supply wells. The MCL for PCE is 5 parts per billion (ppb), and both wells at various times had PCE concentrations in excess of 20 ppb. In December 2000, PCE levels began to drop, with concentrations approaching the MCL; by September 2005, PCE was no longer detected in the water supply wells. In order to protect the health of residents on the reservation, a new well was completed and connected to the community water system in 2004. No PCE has been detected in the new well.

The reservation continued to investigate PCAs by collecting air, soil and liquid samples at various sites. Sampling results indicated that the A&R facility had elevated concentrations of PCE; as a result, remedial activities were conducted to remove PCE-impacted areas. Monitoring wells were installed at and around the facility to determine if PCE had infiltrated groundwater, but results for PCE were non-detect. Soil-vapor wells were installed at the location of the former junkyard; results of PCE sampling there were also non-detect. It appears that PCE concentrations at the reservation have degraded to non-detectable levels; consequently, no further delineation has been conducted. **PE**

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