ABSTRACT: The Walsh Avenue Trunk Sewer project in Santa Clara, CA involved the construction of over 10,000 feet of 24 to 30-inch trunk sewer. The majority of the sewer was installed using traditional open cut construction methods. The trunk sewer crosses San Tomas Aquino Creek using an inverted siphon. The inverted siphon is a twin barrel siphon (15.2-inch each) with a 23.6-inch air jumper. The original design included open cut installation of the legs of the siphon with the creek being crossed using microtunneling. Two-thirds of the way through the design, the design was changed to open cutting the entire crossing. During construction, the Contractor requested to use auger boring to install the upstream and downstream legs of the siphon. Since one of the legs of the siphon is much steeper than typically constructed, this presented construction challenges which will be presented and discussed. The creek was crossed using open cut construction methods.

1. SETTING AND BACKGROUND

The City of Santa Clara is located on the south end of San Francisco Bay, adjacent to the cities of San Jose, Cupertino, and Sunnyvale, and has a population of about 118,000. Starting in the fall of 2014, the San Francisco 49ers will play football in their new stadium currently under construction in the City.

The City’s wastewater collection system includes approximately 270 miles of sewer pipelines. The system conveys wastewater to the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP), located north of Highway 237 in San Jose. In 2007 the City completed a Sanitary Sewer Capacity Assessment that identified the need for capacity improvements to the trunk sewer system to serve future growth and redevelopment. One of the key components of the recommended capacity improvement plan was construction of a major new west-to-east trunk sewer along Walsh Avenue. The Walsh Avenue sewer would divert a portion of the flow that would otherwise need to be conveyed north in existing, capacity-limited trunk sewers in Bowers Avenue and Great America Parkway to the City’s Rabello and Northside Pump Stations, which pump the flow to the SJ/SC WPCP. Instead, up to about 4.5 MGD of peak wet weather flow (based on 10-year design storm) would be diverted to the Walsh Avenue Trunk Sewer and conveyed east through the City’s Trimble Road trunk sewer to San Jose’s interceptor pipelines in Zanker Road. The City initiated design of the Walsh Avenue project in 2008, construction started in August 2010, and the project went on-line in September 2011.

2. DESCRIPTION OF SAN TOMAS AQUINO CREEK

San Tomas Aquino Creek right-of-way is 150 feet wide with a bike trail on one side and a maintenance road on the other. The creek channel is 21 feet deep and lined with concrete in the vicinity of Walsh Avenue. The creek flows south to north with office building development on both sides. The soil borings indicate lean clay with blow counts ranging from 13 to 30 blows per foot. The soil boring on the east side of the creek transitions from lean clay with sand to sandy clay at a depth near the bottom of the channel. The soil borings are attached at the end of this paper.
A new bike trail with retaining walls and footings was being constructed on the west side of the channel while the sewer project was under design. The retaining walls are decorated with cast-in-place artistic creek scenes. A 15-inch sewer and a 4-inch nitrogen pipe run parallel to the creek on the west side of the channel. The east side has the following buried utilities: 24-inch water, electrical duct bank, 8-inch water, and 18-inch storm drain. The west side has a line of trees ranging in size from 3 to 21 inches in diameter. The east side has trees that range in size from 18 to 22 inches in diameter in a small landscaped area. Photos of the creek are included at the end of the paper.

3. DESCRIPTION OF SIPHON

The sewer upstream of the inverted siphon is 30 inches in diameter, and the downstream sewer is 27 inches. The inverted siphon has two barrels with each barrel consisting of high density polyethylene (HDPE) DR 13.5 pipe with an outside diameter of 18 inches and an inside diameter of 15.2 inches. An air jumper was also part of the siphon. The air jumper is a 28-inch outside diameter, 23.6-inch inside diameter HDPE DR 13.5 pipe. Both the siphon inlet and outlet structures consist of t-lock lined precast concrete boxes on cast-in-place concrete bases.

4. DESIGN PHASE

The original plan identified the crossing as a trenchless crossing. The 30% design phase specified microtunneling for the entire crossing with the siphon up leg and down leg located inside the jacking and receiving shafts and extended as necessary with open cut construction. Permits were applied for from the California Department of Fish and Game (now California Department of Fish and Wildlife) and the Santa Clara Valley Water District. As the design evolved and easement negotiations with the private property owners moved forward, the design team and the City decided to evaluate the permitiability of an open cut crossing. An open cut crossing would improve hydraulics by allowing the siphon to be less deep and allow the up leg and down leg to be straighter in their horizontal alignments and less steep in their vertical alignments. An open cut configuration would also allow future maintenance activities to be conducted more easily.

Discussions were held with the resource agencies, and permit applications were modified. Permits were obtained for an open cut crossing. Across the bottom of creek, the three pipes would be encased in concrete with the distance between the bottom of the creek and the top of the concrete encasement to be 5.5 feet. This distance was necessary to allow for the potential of a future creek project that would lower the bottom of the creek. A figure showing the “as bid” version of the creek crossing is attached.

5. BID PHASE

The project was released for bidding in 2010 and bids were opened on June 30, 2010. Seven bids were received. The low bidder was K.J. Woods Construction based in San Francisco. The bid item for the creek crossing ranged from about $400K to $1.3M.

6. CONSTRUCTION PHASE

Through a series of modified and re-modified proposals, the Contractor received approval to implement a no cost change order to install both legs of the siphon using traditional auger boring equipment. The main incentive to use a trenchless construction method was to avoid the recently constructed trail including the decorated retaining wall on the west side of the channel. Since the trenchless subcontractor would already be mobilized for the west side, the east side was added to avoid deep (25-foot) trenching on a slope.

Since the east side was now to be tunneled, the design team took this opportunity to align the pipe so as to tunnel under the trees and straighten the leg, thus improving hydraulics and increasing the ease with which the siphon could be cleaned. A figure showing the final alignment is attached.

The tunneling on the west side of the channel included 42- and 36-inch diameter steel casings. The length of the casings was 49 feet and vertical angle was 24.5 degrees. The steel casings were tunneled from a jacking shaft at the top of the channel.
The tunneling on the east side consisted of one 54-inch diameter steel casing. The length of the casing was 134.5 feet and vertical angle was 4.8 degrees. Similar to the other side, the steel casing was tunneled from a jacking shaft at the top of the channel.

After the tunneling was completed, the 18-inch OD HDPE siphon pipes were fused and pulled down through the 54-inch casing, across the open trench at the bottom of the channel, and up the steel casings on the west side. The 28-inch OD air jumper was inserted into the 54-inch steel casing on top of the two smaller pipes on the east side. On the west side, the 28-inch air jumper was pulled into the 36-inch casing. A condensate sump on the air jumper was installed, and the air jumper was fused together in the channel. A figure showing the Contractor’s profile submittal and the configuration of the HDPE pipes inside the steel casings is attached.

After the HDPE pipes were installed, the reinforced concrete encasement was constructed. Later the open cut portion was backfilled, and the concrete channel lining was repaired. In order to allow construction activities to occur in the channel, the flow in the channel was diverted into a temporary pipe around/across the area. Photos of the construction phase are attached.

7. LESSONS LEARNED

The design team offers the following “lessons learned” from the San Tomas Aquino Creek crossing:

- When designing a creek crossing, take a mental step back and consider open cut construction. In some locations, it may be applicable.
- Always consider splitting the crossing into parts and using different construction methods for each part.
- In this situation, auger boring was used on a steep slope and should be considered in other similar situations.

ATTACHMENTS

The following items are attached:

- Photos.
- Cost information.
- As-Bid Drawing of Siphon
- Record Drawing of Siphon
- Drawing Produced by Contractor
- Soil Borings
Photo 1. Trail being constructed during the design phase of the trunk sewer.

Photo 2. Crossing location for San Tomas Aquino Creek.
Photo 3. Trees on east side of creek.

Photo 4. Water in San Tomas Aquino Creek was diverted around construction site using temporary berms and a diversion pipeline (looking north).
Photo 5. Water from small dewatering pumps was pumped into settling tanks before discharging into the creek (looking south).

Photo 6. The creek diversion had different configurations during the project depending on the construction activities being performed.
Photo 7. Receiving shaft on west side of creek.

Photo 8. Steel casing with auger segment inside.
Photo 9. Steel casing showing “steering doors” or “steering flaps”.

Photo 10. Auger rig on west side of channel set with a 24.5 degree downward angle.
Photo 11. Auger rig pulled back ready to receive the next casing segment.

Photo 12. Auger rig was chained to the shoring to keep it from sliding down the slope.
Photo 13. Front of jacking shaft.

Photo 14. Steel casing with support struts to support HDPE pipe.
Dig that Creek or Tunnel that Creek?

Photo 15. Restored creek looking south.

Photo 16. Restored creek looking north.

Dig that Creek or Tunnel that Creek? - 11
COST INFORMATION

Bids were opened on June 30, 2010. Tabulations of various bid items are shown below.

Table 1. Comparison of the San Tomas Aquino Creek Crossing Bid Item

<table>
<thead>
<tr>
<th>Item: San Tomas Aquino Creek Crossing</th>
<th>Bid Amount (Lump Sum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Bidder</td>
<td>$916,325</td>
</tr>
<tr>
<td>Bidder #2</td>
<td>$750,000</td>
</tr>
<tr>
<td>Bidder #3</td>
<td>$395,000</td>
</tr>
<tr>
<td>Bidder #4</td>
<td>$480,000</td>
</tr>
<tr>
<td>Bidder #5</td>
<td>$725,000</td>
</tr>
<tr>
<td>Bidder #6</td>
<td>$600,000</td>
</tr>
<tr>
<td>Bidder #7</td>
<td>$1,300,000</td>
</tr>
<tr>
<td>Engineer’s Estimate</td>
<td>$610,000</td>
</tr>
</tbody>
</table>

Table 2. Comparison of Various Trenchless Crossing Bid Items

<table>
<thead>
<tr>
<th></th>
<th>Caltrain Trenchless Crossing (Length = 200 ft) (per LF)</th>
<th>San Tomas Expressway Trenchless Crossing (Length = 190 ft) (per LF)</th>
<th>UPRR Trenchless Crossing (Length = 86 ft) (per LF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Bidder</td>
<td>$900</td>
<td>$1,100</td>
<td>$1,300</td>
</tr>
<tr>
<td>Bidder #2</td>
<td>$1,200</td>
<td>$1,500</td>
<td>$2,000</td>
</tr>
<tr>
<td>Bidder #3</td>
<td>$1,950</td>
<td>$1,950</td>
<td>$2,250</td>
</tr>
<tr>
<td>Bidder #4</td>
<td>$1,696</td>
<td>$1,996</td>
<td>$2,196</td>
</tr>
<tr>
<td>Bidder #5</td>
<td>$1,440</td>
<td>$1,610</td>
<td>$1,885</td>
</tr>
<tr>
<td>Bidder #6</td>
<td>$950</td>
<td>$1,100</td>
<td>$1,400</td>
</tr>
<tr>
<td>Bidder #7</td>
<td>$1,050</td>
<td>$1,330</td>
<td>$1,167</td>
</tr>
<tr>
<td>Engineer’s Estimate</td>
<td>$2,350</td>
<td>$2,661</td>
<td>$2,945</td>
</tr>
</tbody>
</table>

Note: These three crossings all had a 5/8-inch thick, 42-inch diameter steel casing installed using pilot tube guided auger boring (sometimes referred to as “pilot tube microtunneling”). Each bid item included a jacking shaft, receiving shaft, steel casing, and PVC sewer pipe.
PLAN AND PROFILE

STA 81+75 TO STA 76+25

PP-7

PROJECT No. CE 07-08-11
ACCOUNT No. 594-4443-8030-1909
DATE No. REVISION BY
DESIGNED BY
DRAWN BY
CHECKED BY
AS BUILT BY
INITIAL DATE
APPROVED BY

CITY OF SANTA CLARA
ENGINEERING DEPARTMENT

WALSH AVENUE SANITARY SEWER AND RECYCLED WATER IMPROVEMENTS

As-Bid Drawing

WALSH TRACING No. 11,657-D

PLAN AND PROFILE
STA 81+75 TO STA 76+25

WORK PERIOD RESTRICTIONS APPLY IN THIS AREA. SEE NOTES ON THIS SHEET.
SAN TOMAS CREEK CROSSING PLAN
TEMPORARY FLOW DIVERSION & DEWATERING

SHEET 1 - GENERAL LAYOUT PLAN & PROFILE
SHEET 2 - PROPOSED GRADE VARIANCE, STA 80+75
SHEET 3 - TEMPORARY CREEK FLOW DIVERSION PLAN
SHEET 4 - DEWATERING PLAN
SHEET 5 - DEWATERING EQUIPMENT DATA

NOTES:
1. SHORING PLANS REFLECTING THESE PLANS WILL BE SUBMITTED UNDER SEPARATE COVER.
2. THESE PLANS ARE INTENDED TO SUPPLEMENT DESIGN DATA IN THE CONTRACT DOCUMENTS. IN CASE OF CONFLICT, DATA AND REQUIREMENTS SHOWN IN SVG PP-7 AND RELATED PLANS AND CONTRACT DOCUMENTS SHALL GOVERN.
3. SEE SHT. 2 FOR PROPOSED DESIGN VARIANCE BETWEEN STATION 80+75 AND 81+25.

Plan
1"=30'

Profile Along SS
Hi 1"=30' V1 1"=30'

Open cut alternative was 26 degrees,
The trenchless alternative is 4.8 degrees.

K. J. WOODS CONSTRUCTION, INC.
SAN TOMAS CREEK CROSSING PLAN
CITY OF SANTA CLARA
WALSH AVE SS & RW PROJECT

REV: 1 DATE: 4/6/11 SHT: 1 OF 5
**LOG OF BORING B-6**

**LOCATION:** 2400 Walsh Avenue parking lot, west of San Thomas Aquino Creek (see Plate I-2).

**GROUND SURFACE:** Approx. El. 44.5

---

**DESCRIPTION**

**FILL - SANDY LEAN CLAY (CL)**
- dark brown
- fine sand
- trace gravel and organics
- medium plasticity
- dry

---

**LEAN CLAY (CL)**
- very dark gray and gray mottled
- trace sand
- dry to moist

---

**LEAN CLAY (CL)**
- light olive and olive brown mottled
- locally contains few to some fine sand
- medium plasticity
- stiff
- moist

---

**LEAN CLAY WITH SAND (CL)**
- dark gray and olive brown mottled
- fine sand
- little to some silt
- medium plasticity
- stiff
- moist

---

**LEAN CLAY WITH SAND (CL)**
- dark gray and olive brown mottled
- trace organics
- trace coarse sand/fine gravel sized concretions
- little to some silt

---

**BORING CONTINUED AT 26.5 FEET ON SHEET 2 OF 2**

---

**REMARKS:**
① Boring drilled on September 18, 2008. See Plate A-1 in Appendix A for definitions of terms.
② Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
③ Gravity-fed sanitary sewer pipeline.
④ Siphon pipelines. Shown at creek undercrossing depth.
### Location
2400 Walsh Avenue parking lot, west of San Tomas Aquino Creek (see Plate I-2).

### Ground Surface
Approx. El. 44.5

### Remarks
1. Boring drilled on September 18, 2008. See Plate A-1 in Appendix A for definitions of terms.
2. Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
3. See sheet 1 of 2 for groundwater notes.

### Log of Boring B-6 (Continued)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Type</th>
<th>Penetration Resistance (blows/ft)</th>
<th>Groundwater Depth (feet)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7</td>
<td>Lean Clay with Sand (CL)</td>
<td>14</td>
<td>8</td>
<td>- dark greenish gray - trace to few sand and gravel-sized concretions - sand content varies - little to some silt - medium plasticity - stiff to very stiff - wet within unit</td>
</tr>
<tr>
<td>8-9</td>
<td>Lean Clay (CL)</td>
<td>23</td>
<td>10</td>
<td>- dark greenish gray - trace fine gravel - few medium to coarse sand - medium plasticity - stiff to very stiff - wet</td>
</tr>
<tr>
<td>10-11</td>
<td>Sandy Lean Clay (CL)</td>
<td>19</td>
<td>10</td>
<td>- dark greenish gray - fine to medium sand - unit gradually grades coarser with depth (transitions from CL to SC) - medium plasticity fines - very stiff (clay) - medium dense (sand) - wet</td>
</tr>
<tr>
<td>12-13</td>
<td>Clayey Sand (SC)</td>
<td>15</td>
<td>15</td>
<td>- dark greenish gray - may locally classify as a poorly graded sand (SP) - fine grained sand - medium dense to dense - wet</td>
</tr>
<tr>
<td>14-15</td>
<td>Lean Clay (CL)</td>
<td>18</td>
<td>15</td>
<td>- dark greenish gray - trace gray coarse sand sized concretions - medium plasticity - very stiff - wet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- locally sandy sections in Sample 15</td>
</tr>
</tbody>
</table>

### Corrosion Test
Sample B6-9
See Plate C-5

### Fines
- 37% Silt
- 55% Clay

### Direct Shear
- 30% Silt
- 20% Clay

### Water and Environment Plate No.
RMC WATER AND ENVIRONMENT
City of Santa Clara
Walsh Avenue Trunk Sewer Improvements Project
Santa Clara, California

### Plate No.
B-6

### Log of Boring B-6 File No.
J-5079-1

### December 2008
LOG OF BORING B-7

LOCATION: 2390 Walsh Avenue parking lot east of San Tomas Aquino Creek (see Plate I-2).

GROUND SURFACE: Approx. El. 45.5

 DESCRIPTION  

PARKING LOT: 5 inches asphalt concrete over 4 inches aggregate base

FILL - LEAN CLAY (CL)  
- very dark grayish brown  
- locally intermixed with black and olive brown  
- trace sand and gravel  
- medium plasticity  
- dry to moist

LEAN CLAY WITH SAND (CL)  
- olive brown mottled  
- fine grained sand  
- little to some silt  
- stiff  
- moist to wet

CLAYEY SAND (SC)  
- olive brown and dark gray mottled  
- fine sand  
- medium plasticity fines  
- medium dense  
- wet

LEAN CLAY (CL)  
- olive brown and dark gray mottled  
- trace sand  
- medium plasticity  
- very stiff  
- wet

BORING CONTINUED AT 27 FEET ON SHEET 2 OF 2

REMARKS:  
1 Boring drilled on September 17, 2008. See Plate A-1 in Appendix A for definitions of terms.  
2 Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).  
3 Gravity-fed sanitary sewer pipeline.  
4 Siphon Pipelines. Shown at creek undercrossing depth.
**LOG OF BORING B-7 (Continued)**

**LOCATION:** 2390 Walsh Avenue parking lot east of San Tomas Aquino Creek (see Plate I-2).

**GROUND SURFACE:** Approx. El. 45.5

---

### DESCRIPTION

- **LEAN CLAY (CL)**
  - dark greenish gray and olive brown mottled
  - trace organics in Samples 9 and 10
  - unit contains varying amounts of fine to medium sand (i.e., may locally classify as a lean clay with sand)
  - medium plasticity
  - stiff to very stiff
  - wet

  - unit contains thin layers of clayey sand (SC)
    - **CLAYEY SAND (SC)**
      - dark greenish gray
      - fine to medium sand
      - medium dense
      - wet

  - becoming coarser (gradual transition to unit below)

- **LEAN CLAY WITH SAND (CL)**
  - dark greenish gray and olive brown mottled
  - fine sand
  - little to some silt
  - stiff
  - wet

- **LEAN CLAY (CL)**
  - dark greenish gray
  - trace to few fine sand
  - stiff to very stiff
  - wet

---

**BOTTOM OF BORING AT 51.5 FEET**

**REMARKS:**

1. Boring drilled on September 17, 2008. See Plate A-1 in Appendix A for definitions of terms.
2. Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
3. See sheet 1 of 2 for groundwater notes.
4. Unconfined compressive strength artificially low due to presence of a sand layer in the sample.
5. Siphon pipelines. Shown at creek undercrossing depth.