STAGING FOR TUNNEL CONSTRUCTION AT SAN JOSE DIRIDON STATION

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ABSTRACT

The Santa Clara Valley Transportation Authority is currently expanding its light rail network. The new Vasona line will initially provide service from downtown San Jose to the City of Campbell, five miles to the southwest. The first part of Vasona to be constructed is the underground section at San Jose Diridon Station. The station is a major transportation hub serving Amtrak, local commuter lines, and UPRR freight traffic.

The underground section of trackway comprises a 1,600 foot-long, tightly-curved, double box tunnel. The tunnel passes under three city streets, a bus terminal, and twelve rail tracks and three platforms on the station property. The project also includes an extension to the existing pedestrian tunnel within the rail yard.

The tunnel structures are being built by cut-and-cover methods. The project involves an intricate series of staging operations in the rail yard to allow tracks to be taken out of service. Groups of tracks are isolated and removed for limited periods so that a trench, 30 feet wide and 20 feet deep can be excavated. The trench is supported by a soil-mix shoring wall with internal bracing. Tracks that must be maintained in their original location are supported on temporary bridges, founded on the shoring wall.

This paper covers the design and construction of the temporary bridges, development of the staging plan during construction, and coordination with the railroad companies. It further compares the relative merits of bridges and surface shooflies.

PROJECT OVERVIEW

The Vasona LRT extension arose out of a funding initiative approved by voters in 1996. Known as the Measure B Transportation Improvement Program, the initiative authorized a half-cent sales tax in Santa Clara county, expiring in 2006. It was anticipated that the tax would generate around $1.6 billion in revenue that would be used to fund a specific package of countywide transportation
improvement projects. Management of the sales tax is by the Santa Clara County Board of Supervisors. The Santa Clara Valley Transportation Authority (VTA) is the implementing agency for the 1996 Measure B Transportation Improvement Program. VTA is an independent special district responsible for bus, light rail and paratransit operations; congestion management; specific highway improvement projects; and countywide transportation planning.

Major improvements to the existing 30-mile LRT system funded by Measure B, include the construction of the Tasman East, Capitol and Vasona LRT lines, and the procurement of low-floor vehicles. Construction commenced first on Tasman East, followed by Capitol and Vasona. The Vasona line is planned to be constructed in two phases. Phase I will run 5.3 miles from downtown San Jose to Winchester Station in Campbell. Phase II will extend the line a further 1.5 miles to Vasona Junction in Los Gatos. There will be nine new stations in Phase I and two more in Phase II. The Vasona line is expected to carry an estimated 8,000 to 9,000 riders per day, with trains running at ten minute intervals during peak times. Travel time from Winchester Station to Downtown San Jose will be approximately 16 minutes.

The initial segment of the Vasona line from the existing Guadalupe line to just east of the San Jose Diridon main line station will be over city streets. At the station itself, the line will be in tunnel. Between San Jose Diridon Station and Vasona Junction, the line will follow the former Union Pacific Railroad (UPRR) right-of-way, recently acquired by VTA. The ROW is 50ft wide and carries a single-track industrial lead serving two freight customers. VTA negotiated the purchase of the ROW and ultimately bought the line to Vasona Junction, including the freight track. UPRR continues to utilize the track under agreement with VTA, which is responsible for its maintenance in the Phase I segment.

The capital cost of the Vasona line is budgeted at $321 million for Phase 1 and $59 million for Phase II. Of the total $380 million, $51.6 million is expected to come from Federal funding. Only Phase I is fully funded at present. The breakdown of the cost for Phase 1 is given in Table 1.
The schedule for the Vasona line envisaged public hearings being complete at the end of 1999, with the FEIR certification being awarded in May of 2000. Property acquisition, primarily the UPRR right-of-way, and design were expected to be complete in 2001. Construction was planned to start in 2001 and finish in July, 2004, thereby allowing for revenue service to begin in November, 2004. In fact, some of those activities have taken somewhat longer (see Figure 2). Not reflected in the schedule graphic, is a revision to the revenue service date. This is now scheduled for Spring, 2005. Delays have occurred primarily due to difficulties in completing the ROW purchase, and design revisions required by regulatory agencies.

The San Jose Diridon Tunnel segment of the Vasona line involves some 1,600 feet of trackway. This is comprised of 300 feet of approach ramp at the eastern end, and 400 feet of approach ramp at the western end. In between, there is 900 feet of tightly-curved, double box tunnel (see Figure 3). The tunnel is necessary to negotiate the railyard and other facilities at the historic Diridon Station. The station is used by three commuter services: Caltrain, with service between Gilroy in the south and San Francisco in the north; the Alameda County Express (ACE) between Stockton and San Jose; and the Capitol Corridor between Sacramento and San Jose. Amtrak’s Coast Starlight service between Seattle and San Diego, makes a daily stop in each direction at the station and UPRR runs frequent freight trains through the station. There are twelve tracks at the station and these various services utilize tracks 1 through 5. Track 1 is owned by UPRR and is used primarily for the freight trains. Because track 1 has an extended platform, it is also used for the Coast Starlight. The remaining tracks are owned by the Peninsula Corridor Joint Powers Board (JPB). There are platforms between tracks 2 and 3, and between tracks 4 and 5, and these are used by the commuter services. Tracks 6 through 11 are used for storage. Track 12 is used for train maintenance.

The tunnel project, designated Contract C345, involves an intricate series of staging operations in the railyard to allow tracks to be taken out of service so that construction can proceed. Groups of
tracks are isolated and removed for limited periods so that a trench 30 feet wide and 20 feet deep can be excavated from surface to accommodate the LRT tunnel. A second, smaller trench is excavated for the extension of the existing pedestrian tunnel under tracks 5 through 12. In some instances, the track is supported on a temporary bridge and the trench excavated beneath it.

DESIGN

The designer for the C345 project was the General Design Consultant (GDC). This comprised Parsons Brinkerhoff Quade and Douglas, in association with MK Centennial and Korve Engineering. Major subconsultants included Biggs Cardosa and Associates (structural), and Brian Kangas and Foulk (civil). Detailed design was completed in September, 2000. As part of the review process, the design submissions were routinely reviewed by JPB. UPRR was also consulted on matters affecting track 1.

In the early stages, consideration was given to traversing the railyard in conventional, bored tunnel. However, this was rejected due mainly to the cost, and to concerns from JPB about potential effects on the station. The main station building, and other elements including the platform canopies, are designated historic structures and must be preserved. The design therefore proceeded on the basis of a cut and cover tunnel. The design included the temporary shoring system for the open-cut excavation. Temporary shoring is normally left to the contractor, however, JPB’s requirement that they approve the system mitigated against leaving this item open in the bid documents. JPB does not allow the use of tie-backs on their property, and so VTA settled on a soldier pile system, with internal bracing. The shoring system, as designed required the installation of a low-strength concrete wall within the ground on either side of the trench prior to excavation commencing. The wall was made up of contiguous bored columns, with every second column reinforced with a steel beam. The system is known as soil mixed walls (SMW). The design required walings and struts to be installed during excavation and removed after placement of structural concrete.
A further aspect of the design was the inclusion of a staging plan for work in the railyard. Discussions with JPB had led to the development of a plan for removal and/or bridging of the tracks. Originally, it was thought that most of the tracks would need to be kept in service and therefore have to be placed on bridges. However, JPB reviewed their operational requirements and decided they could function with four through tracks. Discontinuous tracks were to be kept open at the south end so that they could be used for storage. VTA’s designer analyzed the storage requirement and this was factored into the staging plan. The plan also included the installation of a crossover within the maintenance area to increase switching capability. VTA elected to supply the crossover and switches under a separate procurement contract due to the long lead time for delivery.

Signaling work associated with the track movements was not included in the final design. JPB reserved the signaling design to themselves and this had not been completed at the time the project was issued for bid.

The subsurface, geotechnical information available to the designer was limited to the area outside the JPB property. Although a core-drilling and ground water monitoring program had been conducted, it had not been possible to access the railyard. The designer therefore interpolated for the railyard and completed the design accordingly. The generic soil profile indicated fine-grained sediments to a depth of 60 feet, underlain by coarse-grained sand and fine gravel to a depth of 90 feet. Stiff clay extended below that depth. The groundwater table was at a depth of 14 feet. Given the sensitive nature of the station terminal building and other structures in the immediate locale, it was decided to mandate a settlement monitoring program. This required installation of inclinometers outside the shoring wall, and establishment of elevation points on the buildings. Groundwater monitoring wells were also to be installed. These had all to be checked on a regular basis, with a proviso that action would be taken in the event of excessive change.
PROCUREMENT

The contract documents were issued for bid in September, 2000. The documents included a number of significant provisions related to work in the railyard:

- Construction to be complete within 15 months of commencement
- Four through tracks to be kept open at all times, for freight traffic, northbound and southbound passenger traffic, and access to the maintenance facility
- Substantial liquidated damages for train delays

Bids were opened in November, 2000. Three bids were submitted, ranging from $23 million to $26 million. The low bid was submitted by Condon-Johnson & Associates (CJA) of Oakland, California. Approximately $2 million of the cost was for trackwork (see Table 2).

The contract was awarded in February, 2001 with overall completion required in February, 2003. Construction management of the project was by VTA utilizing its own staff and staff drawn from the program manager, South Bay Transit Associates (SBTA). SBTA is a joint venture of Hatch Mott MacDonald and O’Brien Kreitzburg. Vali Cooper & Associates and Booz Allen also provided staff to the project as subconsultants to SBTA.

CONSTRUCTION

When the Contract commenced, not all the necessary agreements and permits had been finalized. Thorny legal and real estate issues had to be resolved, and this process continued into the early part of the project. While most of these issues had no direct effect on the work, there was one notable exception. Completion of the signal design by JPB ran late, thereby delaying implementation of the first stage of the signal work associated with the track staging plan.

At the commencement of construction, it was decided that weekly coordination meetings would be held to review the work in the railyard. These meetings took place on a Monday afternoon with the following parties represented at various times: JPB, Amtrak, UPRR, CJA, IRC (rail
subcontractor to CJA), QSC (signal subcontractor to CJA) and VTA. Amtrak was responsible both for its own services and as the contract operator for JPB’s Caltrain service. At these meetings, upcoming work was scheduled and discussed. These meetings were frequently used as brainstorming sessions where different ideas were put forward to minimize the impact of work in the yard on train service. Various cost and time-saving ideas came out of these meetings. JPB appointed a project manager and a construction inspector to the project and they represented JPB at the meetings.

All work done in the railyard had to be pre-approved by JPB. This was accomplished by the Contractor submitting a Site Specific Work Plan (SSWP) for approval up to four weeks prior to any work taking place in the yard. The approved SSWP would determine the working hours, whether and how many Amtrak flaggers were needed to provide train protection, and any other restrictions to the work due to equipment size or method of operation. For most of the project, JPB assigned two flaggers full time to allow the Contractor to work nearly continuously. Per the Contract, the working hours allowed were from 7:00am to 7:00pm. However, the heavy volume of commuter traffic in the morning and evenings meant that work that impacted the main rail lines was limited to the period 9:00am to 3:00pm.

Along the ROW, soil mixing has become JPB’s preferred method of installing shoring due to the low impact of the operation on adjacent rail lines. JPB is familiar with the methodology of soil mixing and as SMW installation progressed close to track 12, JPB allowed greater flexibility to the Contractor to continue working while trains were on the vehicle maintenance track (see Figure 4). This resulted in a decrease in downtime and increase in productivity for the SMW operation at this location.

**Underground Obstructions**

SMW installation is started by the excavation of a spoils trench, around 6 feet in depth. This basically captures the extra soil cement mix that is pushed out of the top of the pile by the mixing
operation. During the excavation of this trench in the yard, various underground obstructions were uncovered and removed, including the following, all of which were abandoned except where indicated:

- Tar-wrapped steam heating pipe
- Asbestos-wrapped steam heating pipe
- Redwood box conduit line with old steel conduits
- Steel signal and communication conduits
- Concrete communication and storm drain manholes
- Old signal foundations and various unknown concrete foundations
- Pre-1900, 45lb rail line, absent tie-plates and ties
- Live electrical line of indeterminate source, with sheathing indicating pre-1960 vintage

Also there were known obstructions to be negotiated. These included a fiber optic line and the main JPB signal line for the railyard. These lines had to be protected against damage and service disruption while the SMW was being installed. These live lines were first exposed by hand. Slack was generated by pulling the lines into the SMW starter trench from the conduits. The lines were then moved to one side to allow SMW to be installed. During excavation, the lines were suspended over the excavation in split conduits.

**Contaminated Material**

Since no soil sampling and testing was conducted in the railyard prior to the start of the project, there were concerns about the extent and nature of any contaminated material. However, to date, there have been only two locations in the railyard where apparently contaminated material was intercepted. These occurred in the west channel and in the area of tracks 1 and 2. In the latter location, sampling determined that there was a 6 inch thick layer of hydrocarbon-contaminated material at a depth of 3 to 4 feet from existing grade. Wherever suspect material was encountered, it was sampled in place. Once the test results were received, the material was hauled offsite and disposed of at an appropriate facility.
Staging

To facilitate tunnel construction in the yard, the work was broken into three phases, with sub-stages in each phase. Per the Contract drawings, Phase I was to the west, Phase II in the center, and Phase III to the east. Phase I called out for three different maintenance track configurations to complete the LRT and pedestrian tunnel sections. In April, 2001, CJA proposed the installation of a temporary rail bridge for one of the designated shooflies over a section of the uncompleted pedestrian tunnel. This would obviate the need for any further modifications to the track during Phase I and thereby improve the efficiency of the pedestrian tunnel construction. The Contractor proposed the bridge (see Figure 5) at his own cost, presumably due to perceived savings in cost and time. VTA and JPB agreed to the proposal and the Contractor proceeded to design and build the temporary bridge. It should be noted that the saving in track costs for the deleted work was around $75,000. The cost of a temporary bridge required by the Contract over the LRT tunnel was $100,000. However, that bridge had a much longer span than the one at the pedestrian tunnel, which could be expected to cost less.

VTA and JPB expedited approval of the bridge design and provided work windows in the railyard for installation. CJA originally proposed a cast-in-place concrete bridge but this was ultimately discounted due to concerns about clearances over the finished pedestrian tunnel. Instead, a steel beam bridge was used. Preliminary welding of the bridge components was commenced on site on 6/19/01. The pre-fabricated elements were then moved to the bridge location and field welding followed. As required in the Contract, CJA’s quality control consultant verified the welding per the AREMA bridge design code. At completion, a specific window for shoofly cut-over to the maintenance track had to be achieved. To meet this requirement, CJA scheduled work around the clock for two days to complete the bridge. The shoofly with the temporary bridge was cut-over to the maintenance track and opened up to rail traffic on the night of 7/1/01. Figure 6 illustrates the track and shoofly arrangement in the yard during Phase I construction.
Due to various factors, a decision was made to make the Phase III area available prior to commencement of Phase II, while Phase I was still in progress. Phase III included placing a temporary bridge at track 1, the UPRR main freight line. This temporary bridge was designed with two 56 feet long, W36x300 main beams, with 2¼ inch plate welded to the top flange and 1½ inch plate welded to the bottom flange. Cross bracing was W36x135 and diagonal cross bracing was WT7x26.5. The bridge sat on W14x211 cap beams welded to the tops of four adjacent SMW piles. The deck comprised 9 inch by 12 inch timbers. The track was spiked directly to the timbers. Total weight of the bridge was approximately 37 tons. A second, lighter bridge was designated for supporting the track 1 platform.

The intent of the Contract was that the bridge would be installed incrementally during weekend work windows. However, due to UPRR scheduling requirements, it was determined that the bridge could not be installed under traffic. This meant that an alternative route had to be found for the freights through the station so that track 1 could be taken out of service. This presented a difficult problem. The other four station tracks went through the platform area and were used for passenger trains. The platforms featured overhanging canopies that allowed insufficient clearance for the freights. The remaining yard tracks were not of sufficient standard to support freight traffic.

Various proposals were put forward to resolve the problem. Those given the greatest consideration were as follows:

- Removal of the canopies along one of the platforms to allow freight traffic. This was rejected due to the canopies coming under the auspices of the Historical Society, making it difficult if not impossible to obtain permission for modifications.
- Upgrading one of the yard tracks outside the platform area for freight traffic. There were two problems with this proposal. While freight traffic was using this track, it would block off both ends of the yard to commuter traffic. Also, all the remaining yard tracks had been
removed for Phase 1 construction and one would have to be reinstated on a temporary basis to support freights.

- Relocation of track 2 away from the platform and canopy overhang to the required clearance of 102 inches from the centerline of the track. This was deemed the most practical and expeditious solution and it was implemented, albeit at a substantial cost.

The situation was complicated by the Contractor having elected to install a temporary bridge on track 2 over the LRT tunnel. This temporary bridge (see Figure 7) allowed deletion of the bulkhead intended to separate Phases II and III. The bulkhead included 146 SMW piles that were to act as buttresses. By deleting the bulkhead and combining phases, the Contractor saw advantages for his operation. The close proximity of tracks 1 and 2 allowed CJA to utilize the track 1 bridge design contained in the Contract drawings. Adjustments had to be made to the SMW pile section under the bridge cap beams, and the angle of the end struts was modified. The bridge was ultimately moved slightly to accommodate the relocation of track 2. Once freight traffic had been diverted onto track 2, track 1 was taken out of service to allow the track 1 bridge to be installed.

It should be noted that all of the bridge work at tracks 1 and 2 was completed under JPB and UPRR live traffic. Installation of both bridges was done under Form B track protection and with the flaggers taking the tracks out of service for certain construction operations. The work was accomplished without delay to either JPB commuter trains or UPRR freights. Phase II construction commenced in July, 2002 and is expected to be complete in December, 2002.

**Train Storage**

From the outset, JPB made it known that train storage in the yard would be an important issue. Analysis was done during the design phase to confirm that normal storage could be maintained despite some track removal. However, with the onset of the 2002 baseball season, JPB leased additional trains for the purpose of servicing Giants’ games at PacBell park in San Francisco,
thereby increasing the storage space required. Originally, Phase I work was scheduled to be complete by this time but due to the delay factors mentioned earlier, it was still continuing, resulting in a shortfall of storage capacity. After discussion in coordination meetings, it was decided to provide off-site storage. This was established at the little-used Lenzen yard owned by JPB about a mile north of the San Jose railyard. Three tracks at Lenzen were refurbished by Amtrak for storage purposes. VTA had CJA install a chain link fence around the tracks with gates at each end for access. This allowed for two 8-car and one 5-car train sets to be stored there. Amtrak provides security for the site. This facility is scheduled to be used for only six months, until Phase II is complete. At that time, all tracks in the San Jose railyard will be restored to their original configuration.

Because of the additional storage requirement, JPB determined that they needed extra access options through the San Jose railyard during Phase II. This was achieved with a short shoofly between tracks 11 and 10. The original proposal was for a much more elaborate shoofly with a turnout and tie-ins to two existing tracks. However, more discussion at the coordination meetings led to the reduced scope, with a saving in installation cost of over $150,000, and a reduction in installation time. Figure 8 shows the track arrangement as it will be maintained during Phase II construction.

CONCLUSIONS

The project has included the installation of shooflies and temporary bridges. While they will not be interchangeable in all situations, their application here allows for a comparison of their relative merits. In terms of cost, it would appear that temporary bridges hold sway, given the Contractor’s decision to install two of his own accord. As to the relative effects on rail operations, the distinctions are less clear. The advantage of a shoofly is that it can be constructed largely off-line. The only disruption comes during cutover. In the longer term, however, the shoofly generally involves modification to track layout and there may be ramifications, as on this project where there was a reduction in storage capacity. A temporary bridge has the advantage that it maintains
the existing track configuration. However, bridge construction may have to be conducted during work windows with impacts for both the rail operator and the bridge constructor.

As to overall progress on the project, it has not been possible to complete the work in the railyard in the 15-month period specified. Various unknown and unanticipated factors, some detailed earlier, have conspired to delay progress. Even so, as at July, 2002, there is every expectation that the Contract will be completed in the original two-year period. VTA has been able to mitigate much of the delay, largely by restaging. VTA awarded the Contract knowing that certain elements of the project had still to be finalized. This was done to acknowledge the difficult nature of the tunnel work and to ensure the project started as early as possible so as not to delay completion of the overall Vasona line. This strategy would appear to have been vindicated.

Should timely completion be achieved, it will be a testament to the positive and cooperative approach adopted by all the parties. Major construction in an active railyard makes for a dynamic situation, placing a premium on the flexibility and creativity of those involved. Regular communication and discussion, and a commitment to the goals of the project have been key to making the process work.
### Table 1: Budgeted Cost for Vasona line

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**TABLE 1: Budgeted Cost for Vasona Line**

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**TABLE 2: Trackwork Bid Items**
FIGURES

Figure 1: Plan of Vasona LRT Project
Figure 2: Schedule for Vasona line as at March, 2002
Figure 3: Layout of San Jose Diridon Tunnel project
Figure 4: Soil mixing adjacent to track 12
Figure 5: Temporary bridge at pedestrian tunnel
Figure 6: Phase I track configuration
Figure 7: Track 2 bridge during construction
Figure 8: Phase II track configuration
Figure 2: Schedule for Vasona line as at March, 2002

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Figure 3: Layout of San Jose Diridon Tunnel project
Figure 4: Soil mixing adjacent to track 12
Figure 5: Temporary bridge at pedestrian tunnel
Figure 6: Phase I track configuration

[Diagram showing track configurations and stages of construction]
Figure 7: Track 2 bridge during construction
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