cavern excavated mostly from below. The feasibility of this could be determined only after soil borings and detailed geotechnical analysis were undertaken. Even with excavated caverns, one or more small-diameter shaft(s) would be needed, drilled from above for soil stabilization, insertion of equipment and muck removal. Such shafts would also be essential if a tunnel boring machine is to be used. The outline indicated in Figure 7-D is that of the largest size pit that would be expected at this location, about 100 feet by 200 feet.

The other station segments might be tunneled from below in order to save property impacts and buildings. The station segment of 250 feet between the main pit and the north pit could be tunneled from below using manual mining techniques and perhaps 'microtunnels' to form their roofs. Its two large-diameter tunnels would each accommodate one track and the adjacent platform. This can be seen in the cross-section in Figure 7-E for Alternative 'A' and in Figure 7-F for Alternative 'B'. A similar station segment could be tunneled south of the main pit, leading to the south approach tunnels (or to the 'wishbone' pit for the Alternative 'A' pocket track option).

Property Acquisition: The approximate number of properties likely to be taken or occupied at each location is as follows:

Excavation	**Alternative 'A'** Basic	**Alternative 'A'** with Pocket Track	**Alternative 'B'**
Main Pit	6	6	6
North Pit	11	11	19
South Pit	6	6	6
'Wishbone' Pit	--	9	--
Total Number of Properties Taken	23	32	31
Total Private Property Area Taken	76,000 sq. ft.	98,000 sq. ft.	104,000 sq. ft.

The north pit excavation is oriented to minimize property takes on the west side of Mission; however for Alternative 'B', it does require the largest number of properties and these are mostly on the east side. In addition, there would be numerous buildings along Mission Street and properties above the south approach tunnels that would not be physically disturbed, but would be tunneled beneath within a subsurface right-of-way easement.

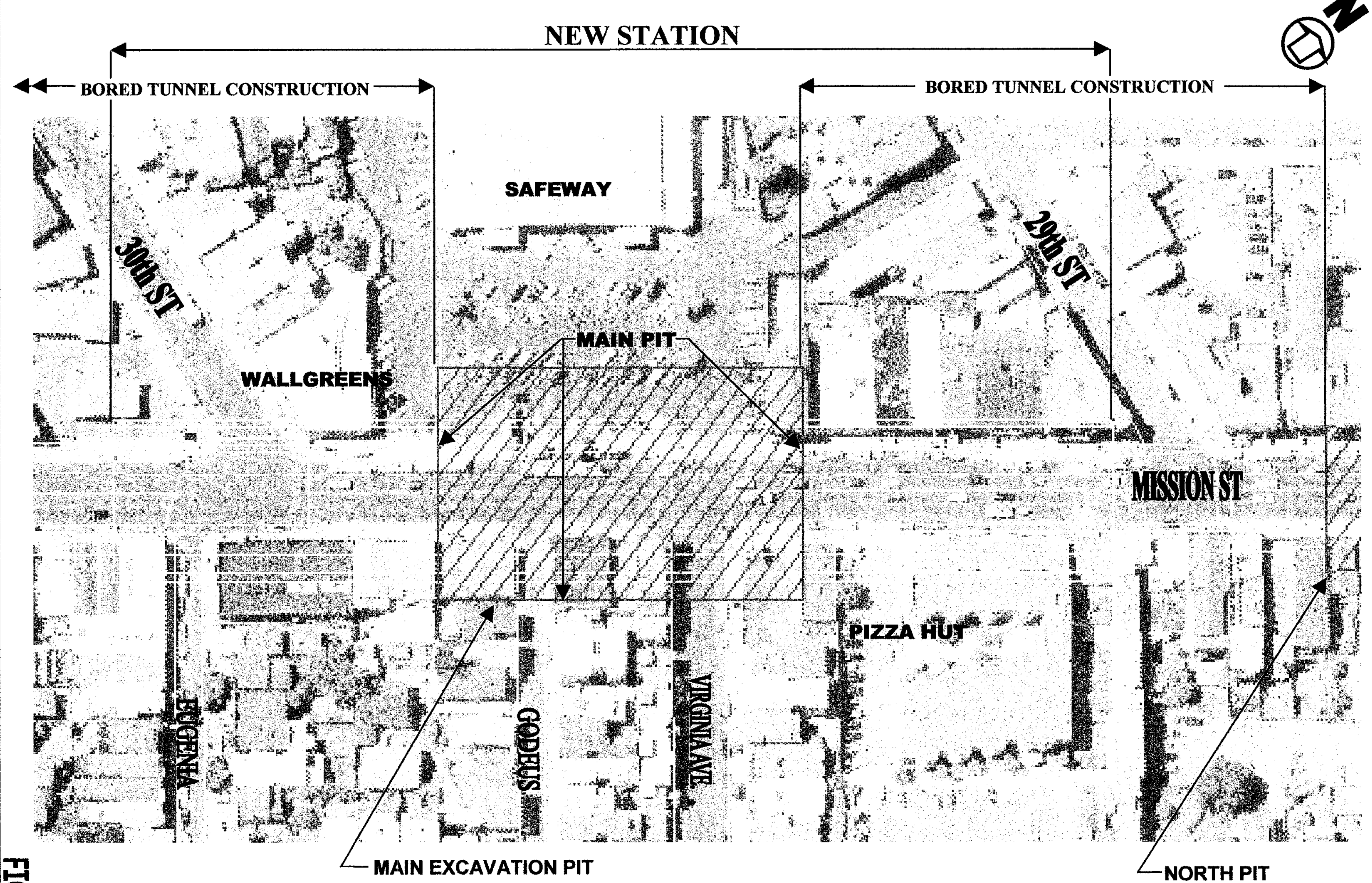

FIGURE 7-A
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FIGURE 7-A

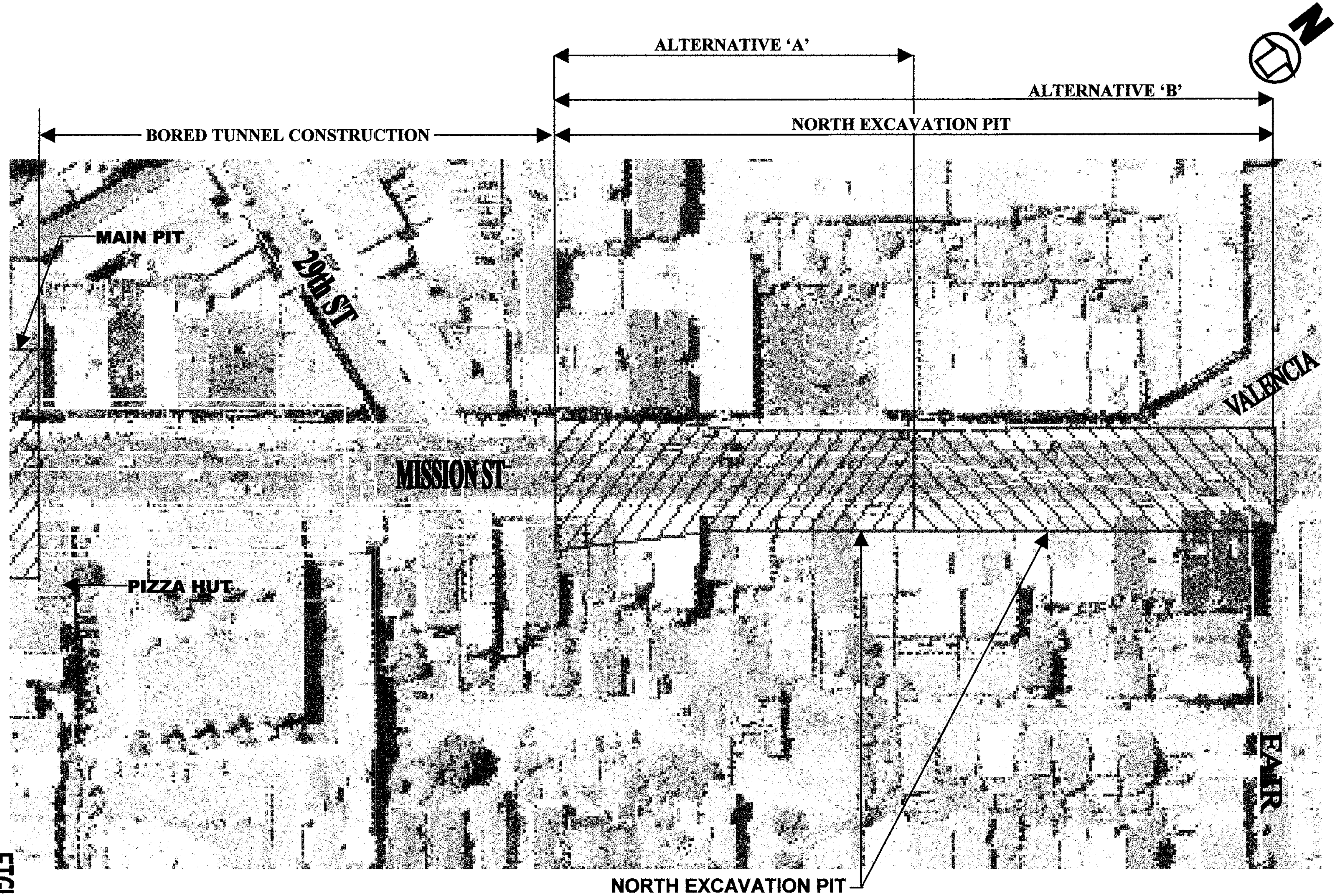

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FIGURE 7- B
30TH & MISSION BART INFILL STATION STUDY
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FIGURE 7-B

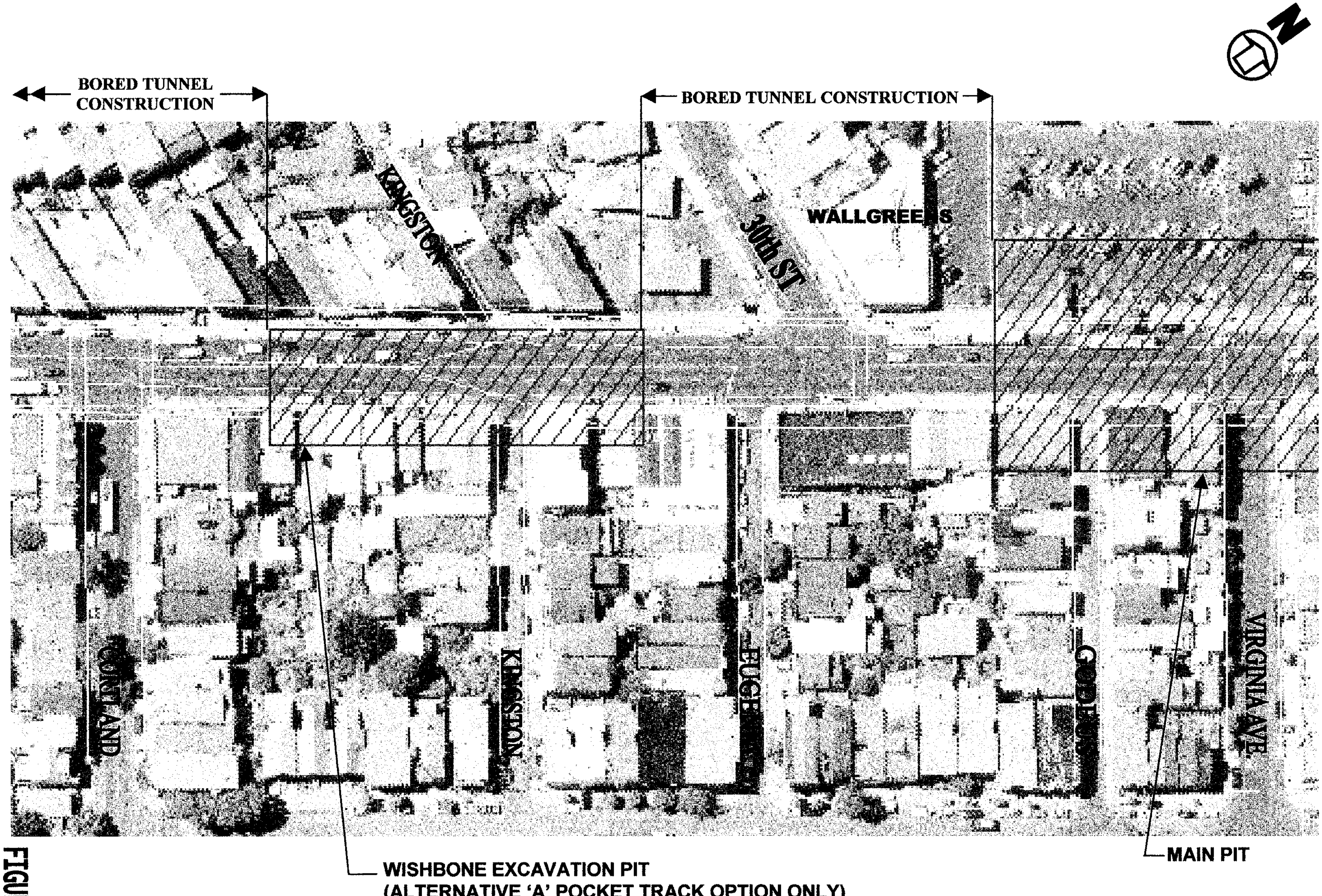

FIGURE 7- C
30TH & MISSION BART INFILL STATION STUDY
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FIGURE 7-C

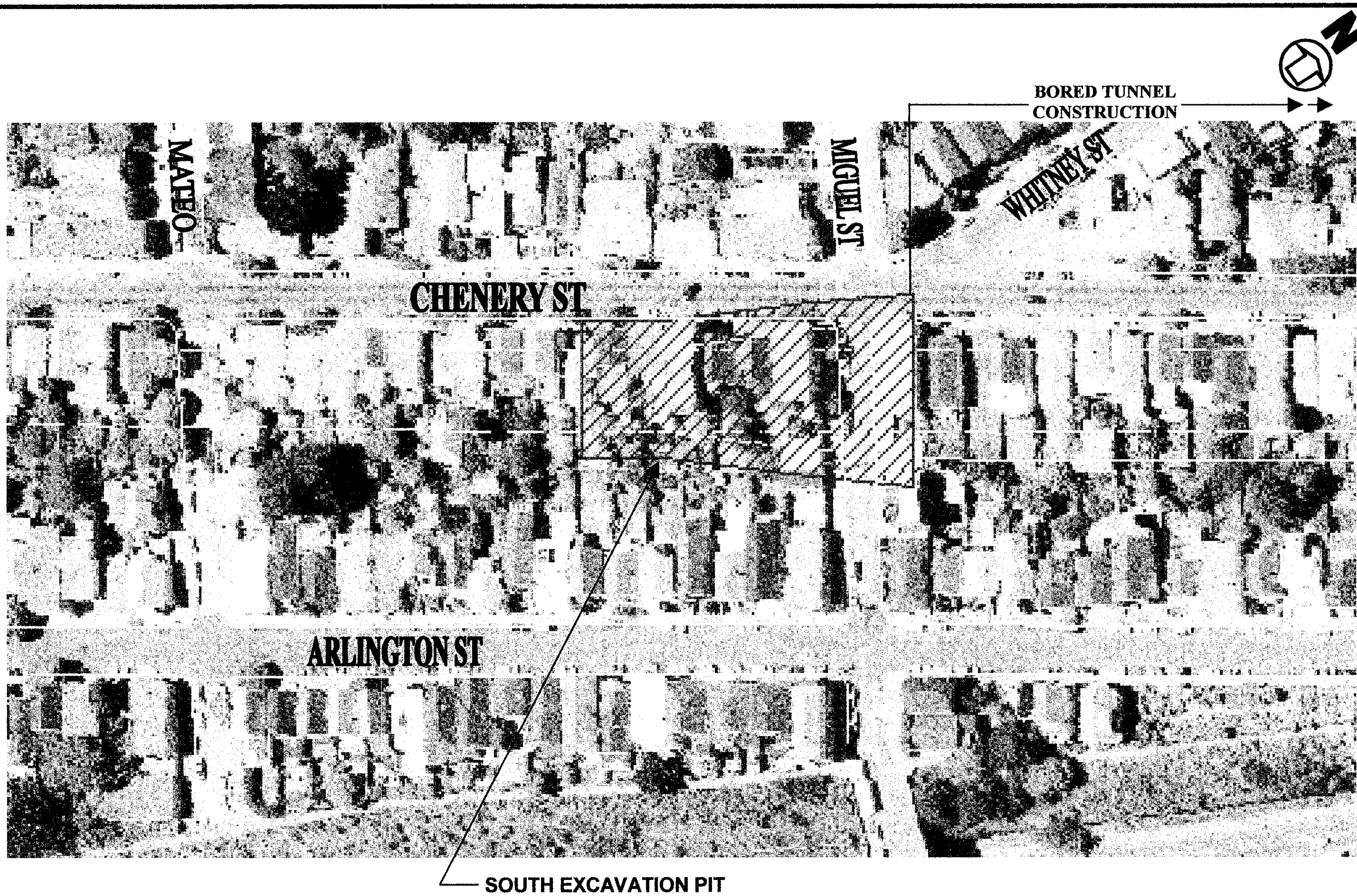

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FIGURE 7- D
30TH & MISSION BART INFILL STATION STUDY
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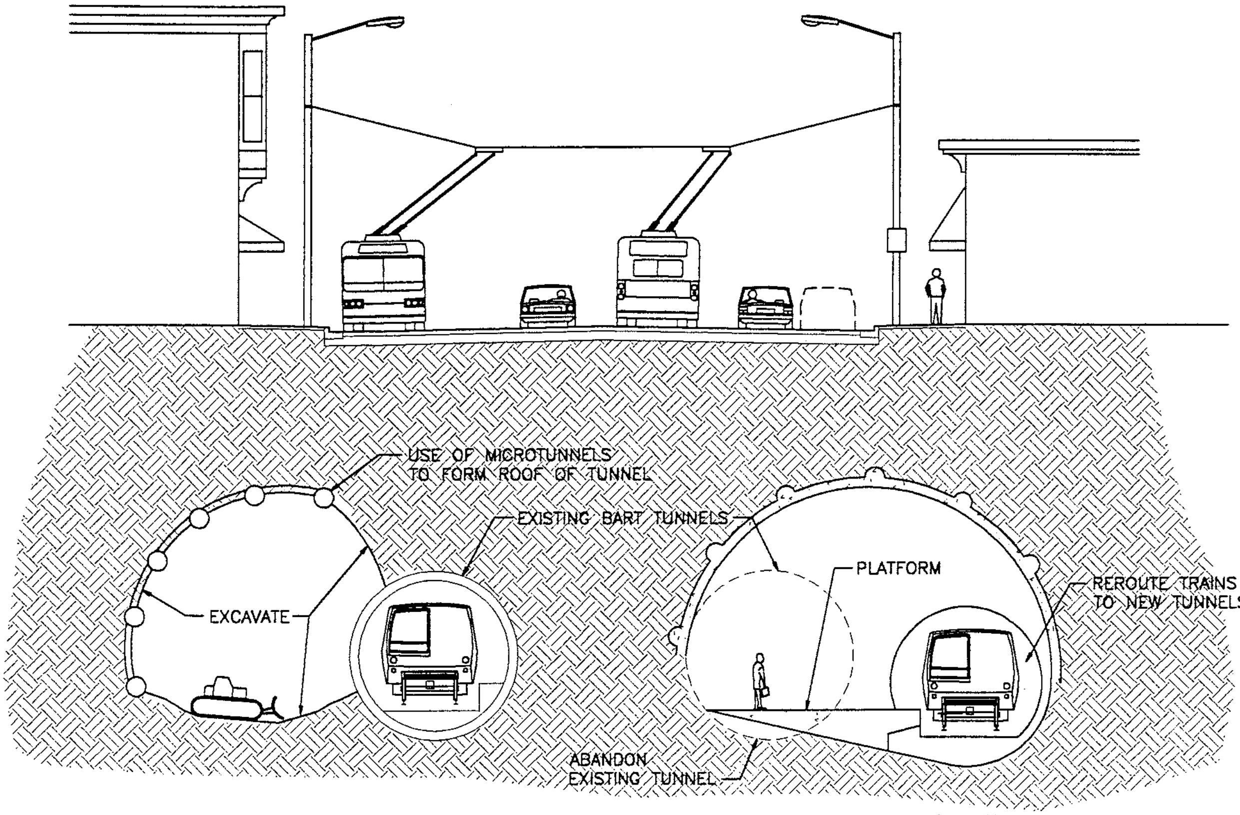
FIGURE 7-D

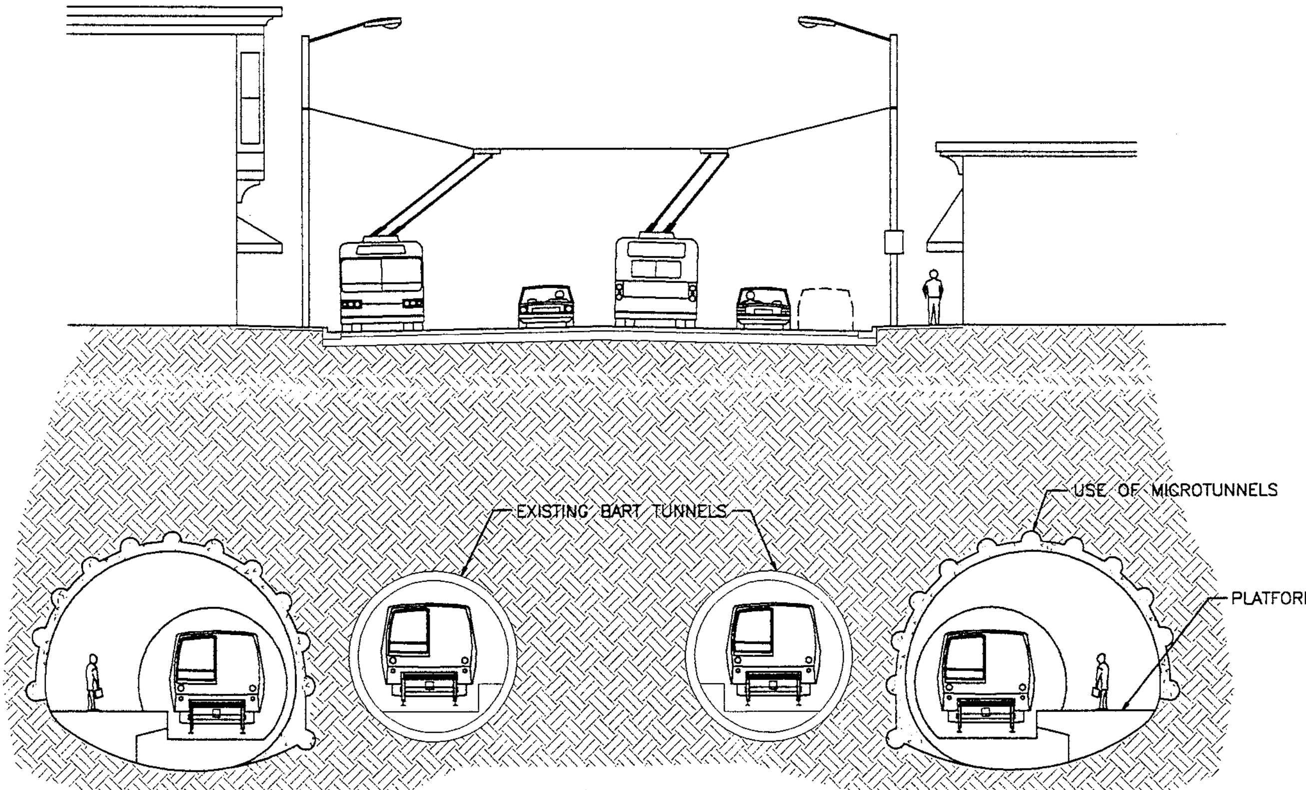


STAGE I

STAGE II—COMPLETE

ALTERNATIVE 'A'

FIGURE 7-E



CROSS SECTION A—A
TUNNELED STATION—PLATFORM SEGMENT BENEATH BUILDINGS

ALTERNATIVE 'B'

FIGURE 7-F

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Fig-7f.DWG

A considerable amount of the property needed for construction would be obtained from the Safeway parking lot. However, most of the Safeway lot and other properties could be restored to previous types of use following completion. Some of these evacuated parcels are along the east side of Mission and would remain buildable for new structures along a new set-back after the station completion.

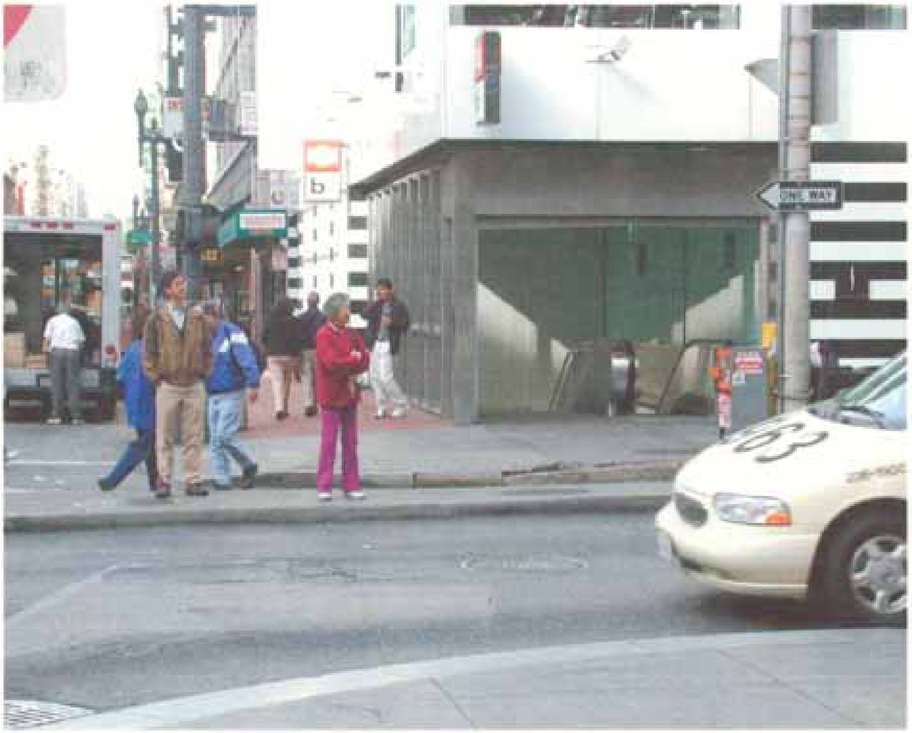


FIGURE 8

Certain details of property acquisition must await further progress in the design. For example, it would be desirable to develop several pedestrian entrances to the new station from each side of Mission Street at the north end, the south end and along the sides of the station. Such entrances are more convenient for patrons if they extend further away from the street so as to facilitate pedestrian access without crossings of nearby streets. However, to develop such convenient entry points, more right-of-way would be required.

To minimize right-of-way for station entrances, it might be possible to integrate one or more entrances into adjoining buildings. A photograph of such an entrance is shown in Figure 8. Usually this type of treatment is limited to a larger or more modern building. Thus it might be feasible for use with some of the new replacement building that could be built over and around the new station after station completion. It might also be possible to connect new adjoining buildings directly from their basement levels to the new station mezzanine. These concepts are called 'joint-development'.

Alternatives: Alternative 'B' would require more substantial width than Alternative 'A' due to the extra space needed to construct the new platforms completely outside the envelope of the existing tunnels. Accordingly, there would be an increase in overall width needed and an over-wide mezzanine would also be a result.

6. CONSTRUCTION IMPACTS AND SEQUENCING

Construction Methods

As indicated above, the majority of the construction of the BART underground facilities would be accomplished away from the pre-existing operating tracks. Only during construction of the tunnel merge locations and track connections would BART operations be affected.

Utility Relocation: Relocation of utilities is usually the first construction work to be initiated. In general, certain of the smaller utility lines, such as water and gas pipes that function under pressure, and also most electric utilities, are rerouted around the excavation site where possible, or supported from the shoring. Larger utilities such as major sewers that operate by gravity flow cannot be easily rerouted so instead would be reinforced in situ, underpinned and supported by attachment to the shoring framework. Utility relocation would be less for Alternative 'A' and more for the alternatives with the larger pit excavations.

Excavation and Shoring: The station box structures themselves, which would accommodate the station platform and mezzanine and also the north tunnel-merge structures, would have to be constructed by cut-and-cover means. This is the same method that was used to construct the other original stations along Mission and Market Streets. Under the conventional method, steel pilings (soldier piles) are drilled and installed vertically from the street surface around the periphery of the station site. The piles are then in-filled with timber lagging materials to retain the earth. Another conventional method, Bentonite slurry wall construction, is very costly and has environmental disadvantages.

A newer excavation method that has been developed and used in recent projects could be applied to this construction. This technique is called 'soil-mix' technology, and was developed by the Japanese company, Seiko Kogyo Company, Ltd. This method has been previously used on at least one other BART project and also on the Islais Creek project in San Francisco.

With soil-mix construction, the walls of the site excavation are created by drilling a row of closely spaced holes, which are filled by a mix of injected cement and native soil. These walls would penetrate about one-third deeper than the invert slab (bottom floor) of the completed station.

The soil-mix method could be used instead of the more conventional soldier piles, because it has the following advantages:

- The soil mix walls are thinner than conventional ones, thus saving space and right-of-way
- The construction shoring can be used as a component of the formwork for the later concrete pours used to create the new station walls
- The construction shoring can become part of the permanent structure, thus saving both space, time and cost by obviating the need to extract temporary steel piles or timber lagging

- This type of construction is nearly waterproof, so continuous pumping out of ground water seepage and silt is greatly reduced
- Cost of the soil mix construction is not substantially greater than conventional soldier-pile and lagging methods. It is less expensive than the Bentonite slurry wall method.

Due to the extreme depth of the southerly tunnel-merge location, excavation of the large pit shown in Figure 7-D, all the way down from the surface might not be feasible or desirable. If such is the case, the underground excavation would need to be accomplished working mostly from below. This would be facilitated by one or two relatively small-diameter access shafts bored down from the surface. The shafts would be used for construction access and material removal. Such shafts could be bored beneath Miguel Street, thus keeping building takes to a minimum. The exact requirements for this are subject to further study.

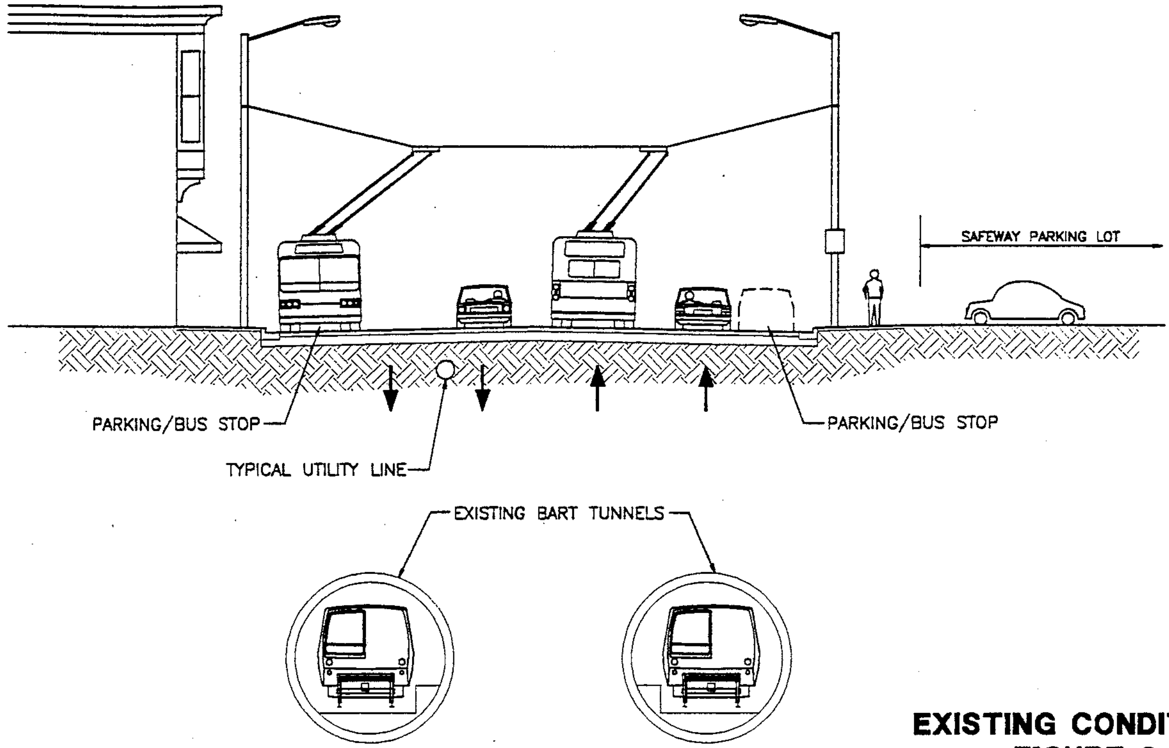
All the excavated earth material from the pit excavation and the bored tunnels would be lifted to the surface and removed from the site in dump trucks. This operation would occupy substantial space at street level and generate significant traffic.

Temporary Decking: When completed, the drilled walls of the main excavation would be tied together with a steel framework of spreaders, 'walers' and girders, which would then be used to support a temporary timber deck for vehicular traffic and pedestrians. During this time, any utilities not already relocated would be underpinned or tied to the temporary shoring structures. Meanwhile, further excavation would proceed beneath the deck to the full station depth.

The temporary timber decking is usually first constructed along one half of the street at a time, and during a period of about one year, street traffic would have to be constrained to one lane in each direction. On-street parking would be prohibited during the entire project. Temporary poles would be used to support traffic signals, streetlights and the MUNI trolley bus wire system. The methodology for all this is well-tested and was used for previous construction on the original BART Mission and Market Street stations.

Staging and Sequencing:

The Figure 9 series of illustrations show the basic sequencing of construction of the main pit at the Safeway parking lot. This sequencing is for Alternative 'A', with Alternative 'B' being similar, although not identical. First, utilities are relocated. Figure 9-A shows the next stage during which the soil mix walls are drilled along one side of the street and along the center of the street, followed by excavation between them as in Figure 9-B. Then as shown in Figure 9-C, a temporary deck would be constructed along one half of Mission Street while two lanes of traffic are rerouted onto the other half of the street. Excavation would proceed below. After traffic can be redirected onto the completed temporary decking, the second half of the street would be drilled and decked as in Figure 9-C and 9-D. The excavation could then proceed to completion beneath the full-width temporary decking, and at that time, also as shown in Figure 9-D, all four traffic lanes could be restored to Mission Street. Sidewalks could similarly be maintained using decking, with some rerouting around the periphery of the excavation.



EXISTING CONDITIONS
FIGURE 9

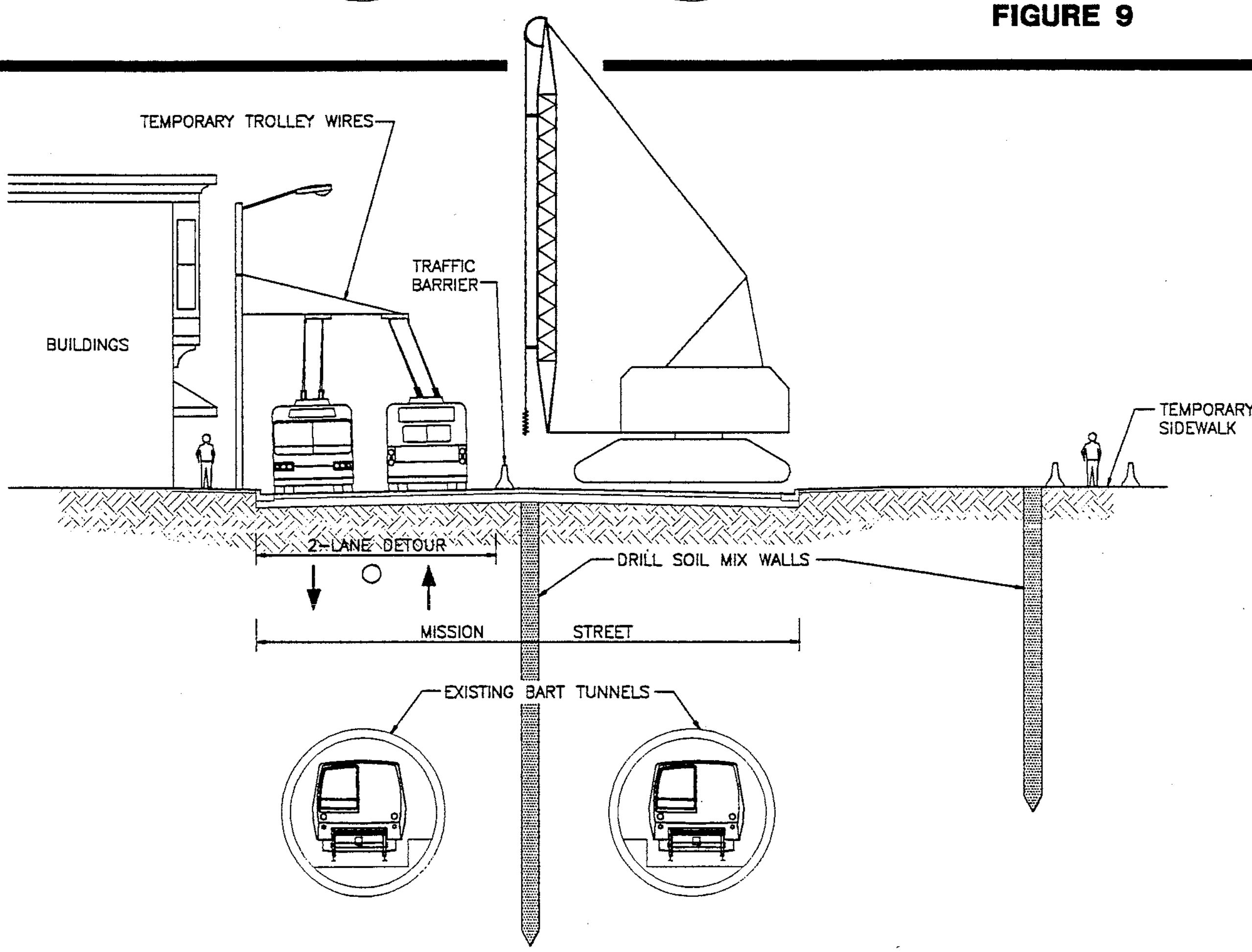


FIGURE 9-A

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Fig-9.DWG

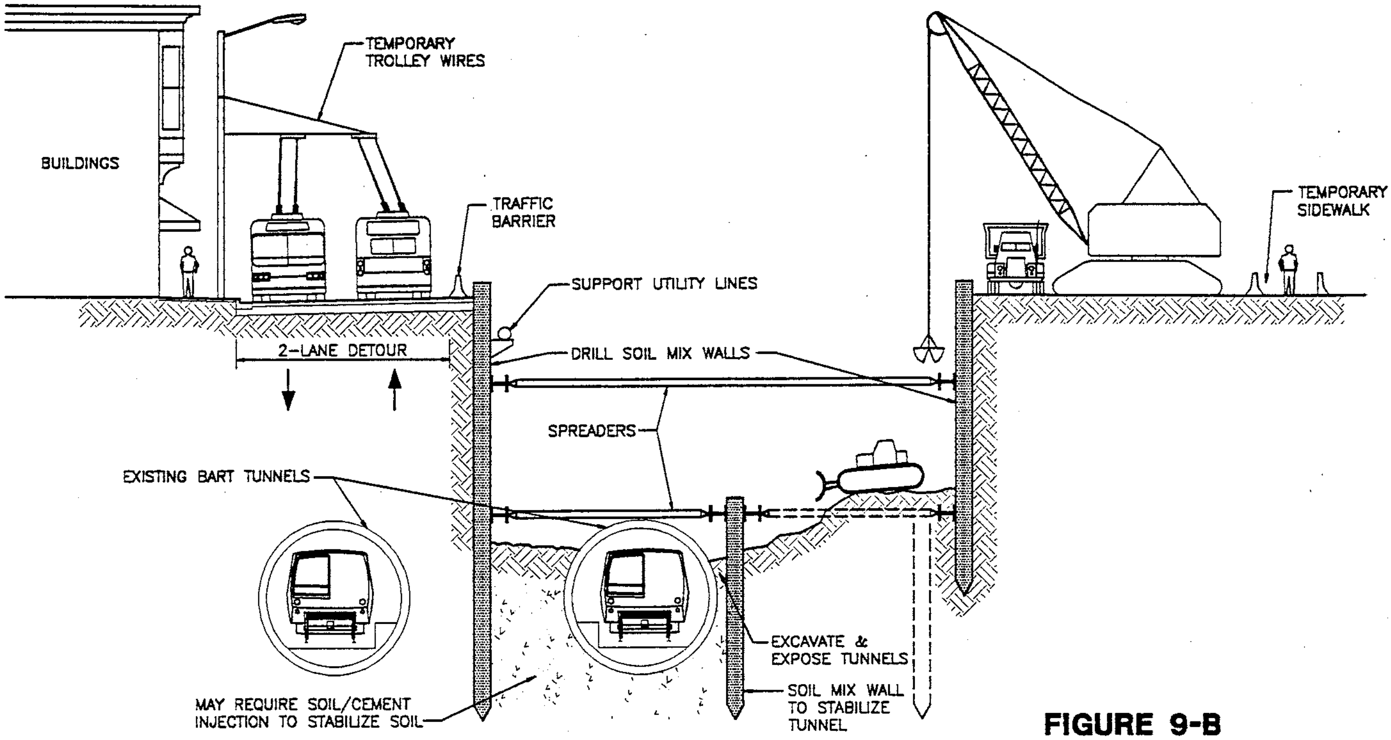

FIGURE 9-B

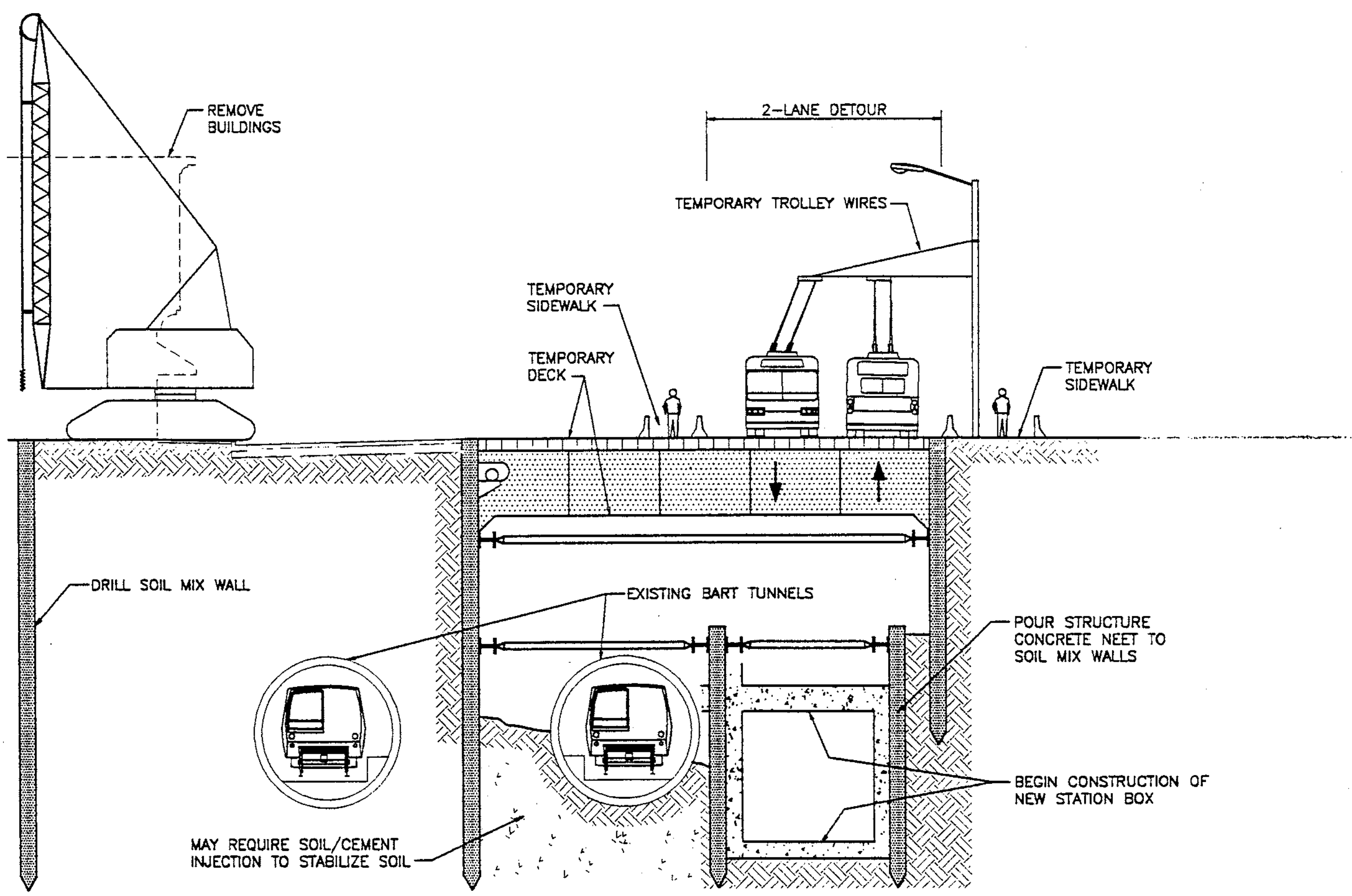

FIGURE 9-C

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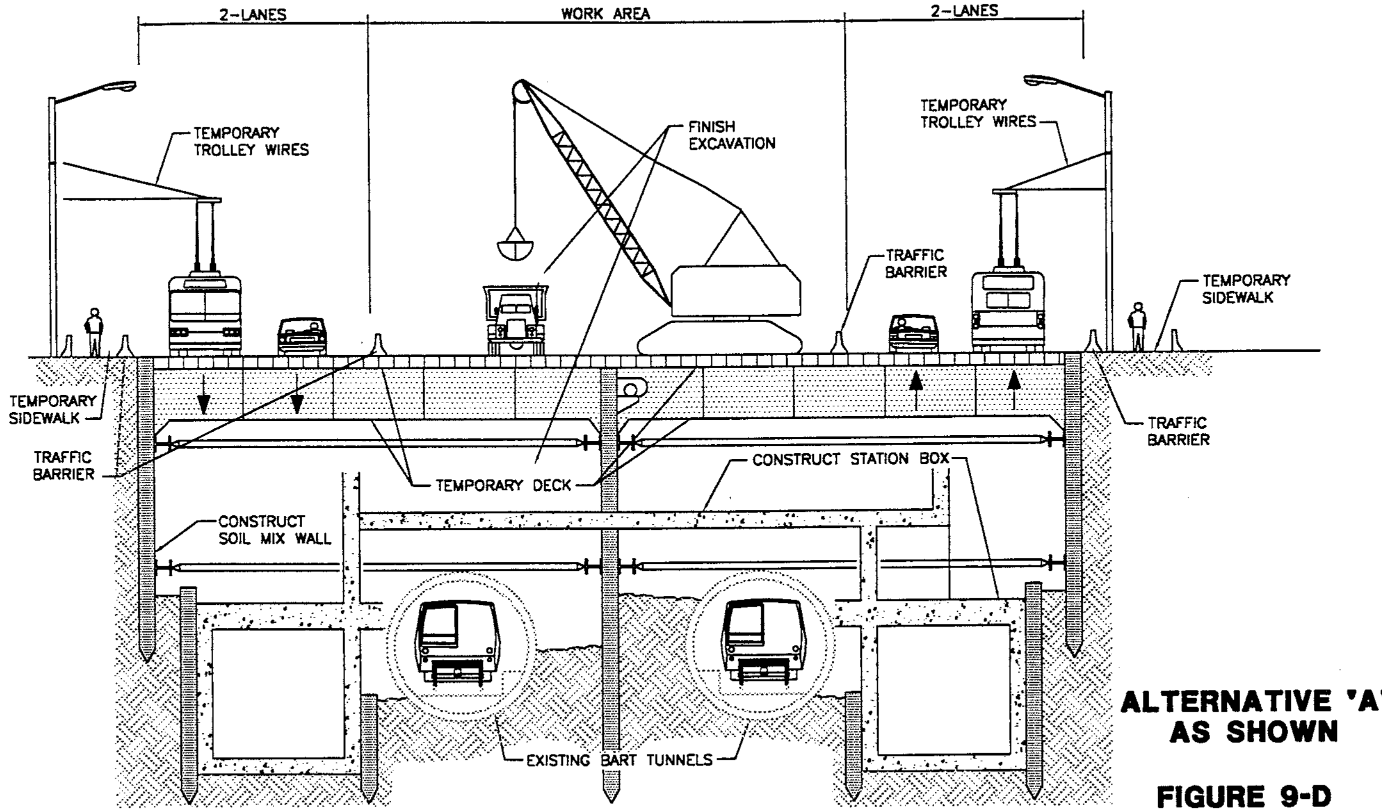
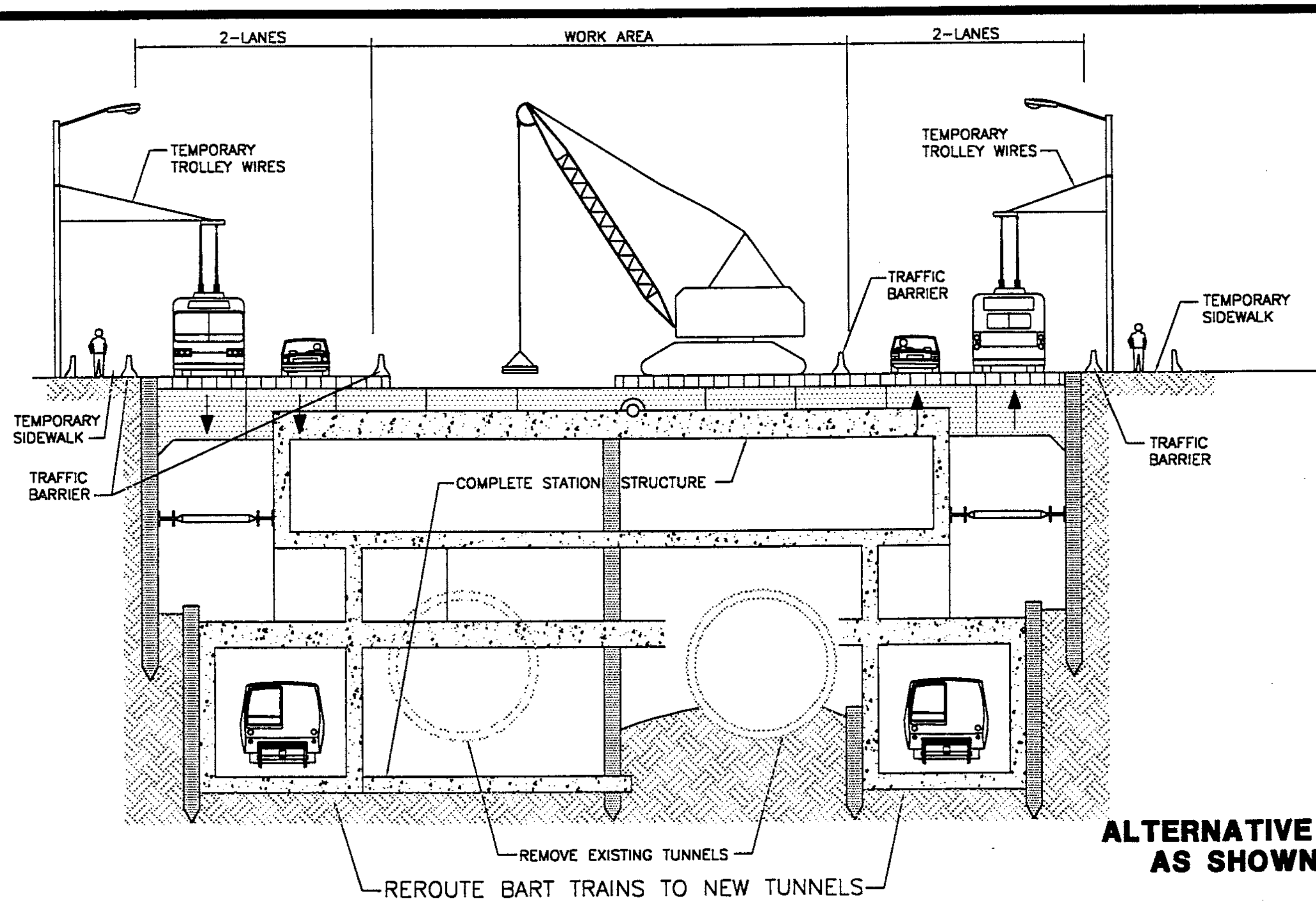
Fig-9a.DWG



ALTERNATIVE 'A' AS SHOWN

FIGURE 9-D



ALTERNATIVE 'A' AS SHOWN

FIGURE 9-E

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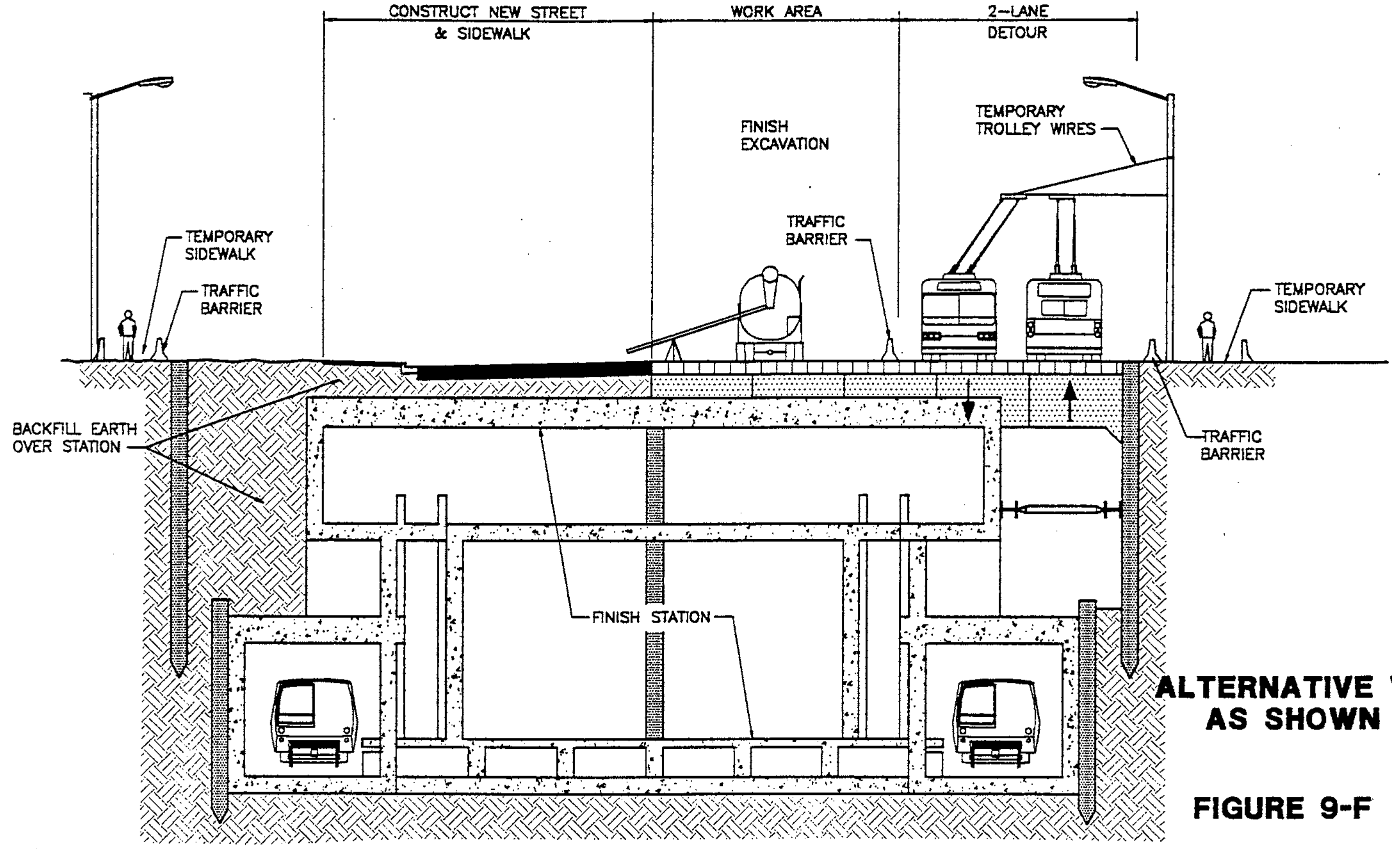
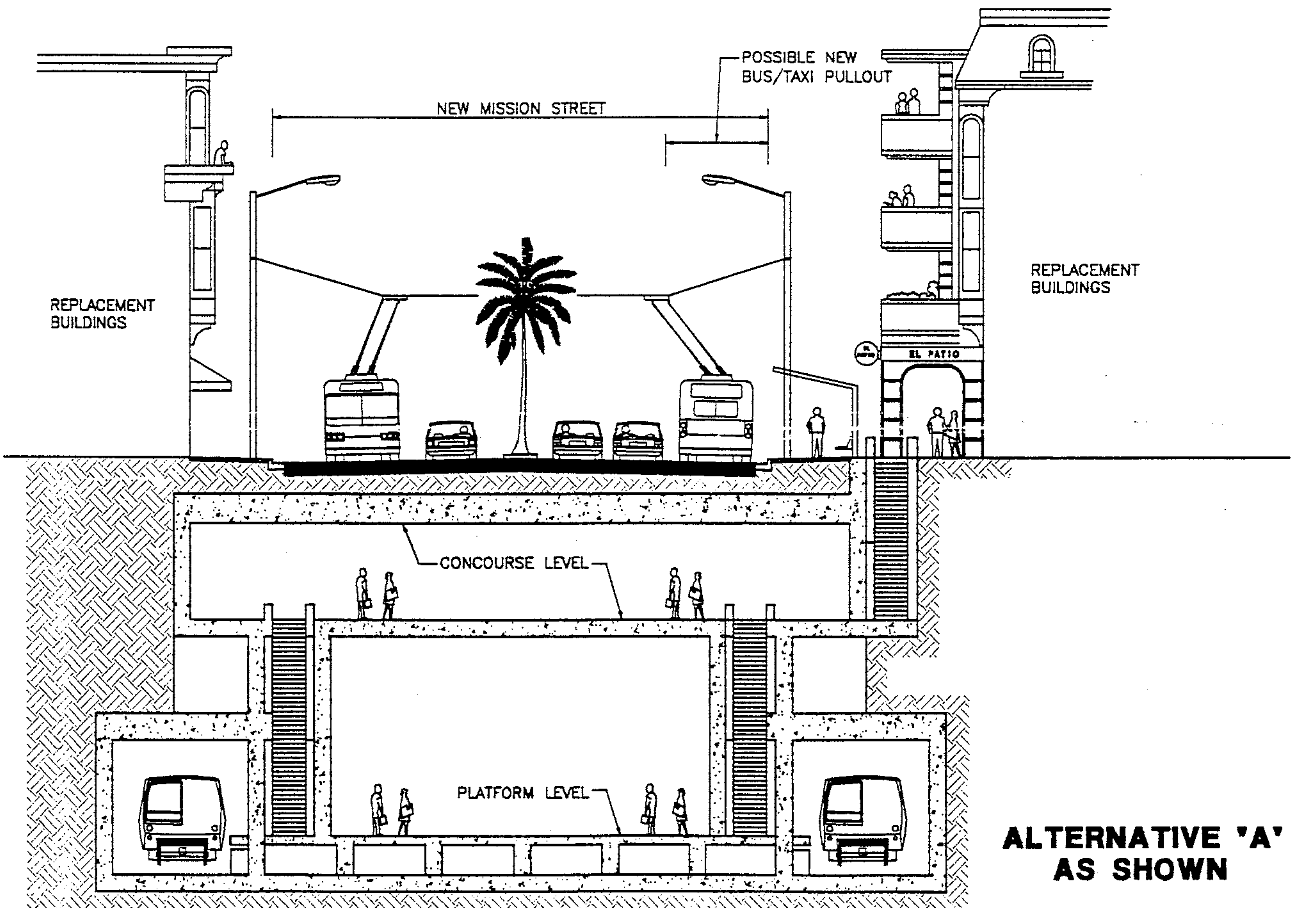
Fig-9b.DWG



ALTERNATIVE 'A' AS SHOWN

FIGURE 9-F



ALTERNATIVE 'A' AS SHOWN

PROJECT COMPLETE

FIGURE 9-G

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Fig–9c.DWG

After the excavation had reached its full depth, the bottom slab, walls, roof and other components of the station box structure would be formed and completed. Also at that time, the two tunnels between the station excavation pits and between the station and the south merge location would be bored outward from the main excavations.

In order to stabilize and protect the existing BART tunnels during construction of the station, soil/cement grout mixture would be injected beneath and around the tunnels. Additional soil-mix walls might also be drilled along the sides of the tunnels to protect them.

For Alternative 'A', construction of the station box would proceed as shown in Figure 9-D with the existing BART tunnels retained in service while the mezzanine level above was constructed over them. This would permit advancement of the work to complete the station shell and also rebuild the surface street independent of progress on the new tunnels, structures and tracks below. Thus there would be no schedule dependency (i.e., no 'critical path' relationship) between rerouting the BART trains to the new tunnels (as in Figure 9-E for Alternative 'A') and finishing the top of the box structure in order to backfill the excavations and restore Mission Street. After the BART trains could be rerouted to the new tunnels, the station platforms could be completed.

Tunneling and 'Cut-In' to the Existing Tunnels: The new southern approach tunnels would be constructed from below grade so that the surface could remain undisturbed. The large-diameter bores between the main excavation pit and the north pit, and also the segment just south of the main pit would also be tunneled as shown in Figures 7-E and 7-F.

The south approach tunnels are smaller diameter but may not be sufficiently long to economically justify the use of a special tunnel-boring machine (TBM). A TBM can bore faster and cheaper than manual mining. However, a TBM is itself costly, takes about one year to manufacture and also requires adequate space for its launching and extraction. The project configuration would not permit easy extraction of a TBM at the south end. Use of a single TBM would also require that the two tunnels be bored consecutively rather than concurrently, thus doubling the time requirement.

However, with an access pit or access shafts at the south tunnel merge location, extraction of a TMB would be feasible. Manual tunneling would also be facilitated by south pit surface access, as the tunnels could be excavated from both ends toward the middle, on four working faces. This would cut the manual tunneling time in half.

At the extreme ends of the new tunnels and trackage, these would have to be connected into the existing tunnels as shown in Figure 10. When complete, the new work must be switched over to or 'cut-in' at the limits of the new construction. There are two such locations along each track direction, totaling four 'cut-in' merge points. Each of these would resemble a branch in the tunnel configuration.

The merge construction of the project is highly problematic as it involves potential interruption of train traffic and single-tracking of train service while the work proceeds. The underground

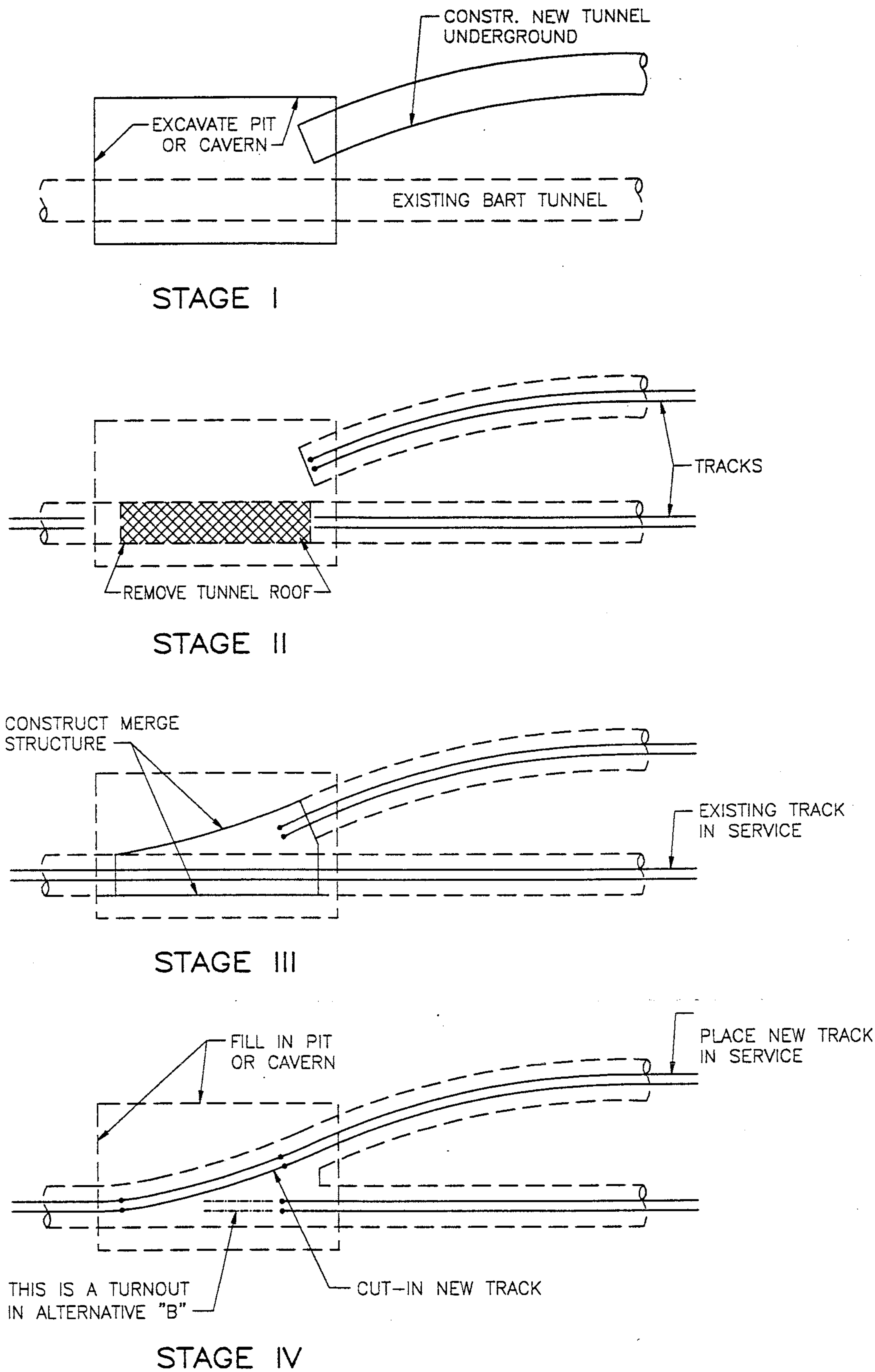

FIGURE 10

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Fig-10.Dwg

location of all the construction also entails extreme difficulty because work area is limited and work access is very awkward. Much of the construction work at the four merge locations (and also at the track crossover of Alternative 'B') would be in close proximity to the operating tracks and could only be safely performed while BART service is suspended during very limited schedule windows or during single-tracking operations. Needless to say, this is a major disadvantage, and BART service interruptions would need to be minimized. To do so, the basic approach would be to minimize the size of each merge location as much as possible so as to permit its quickest possible construction.

(Further description of the BART service interruptions, single-track operations and bus service substitution is included a following section.)

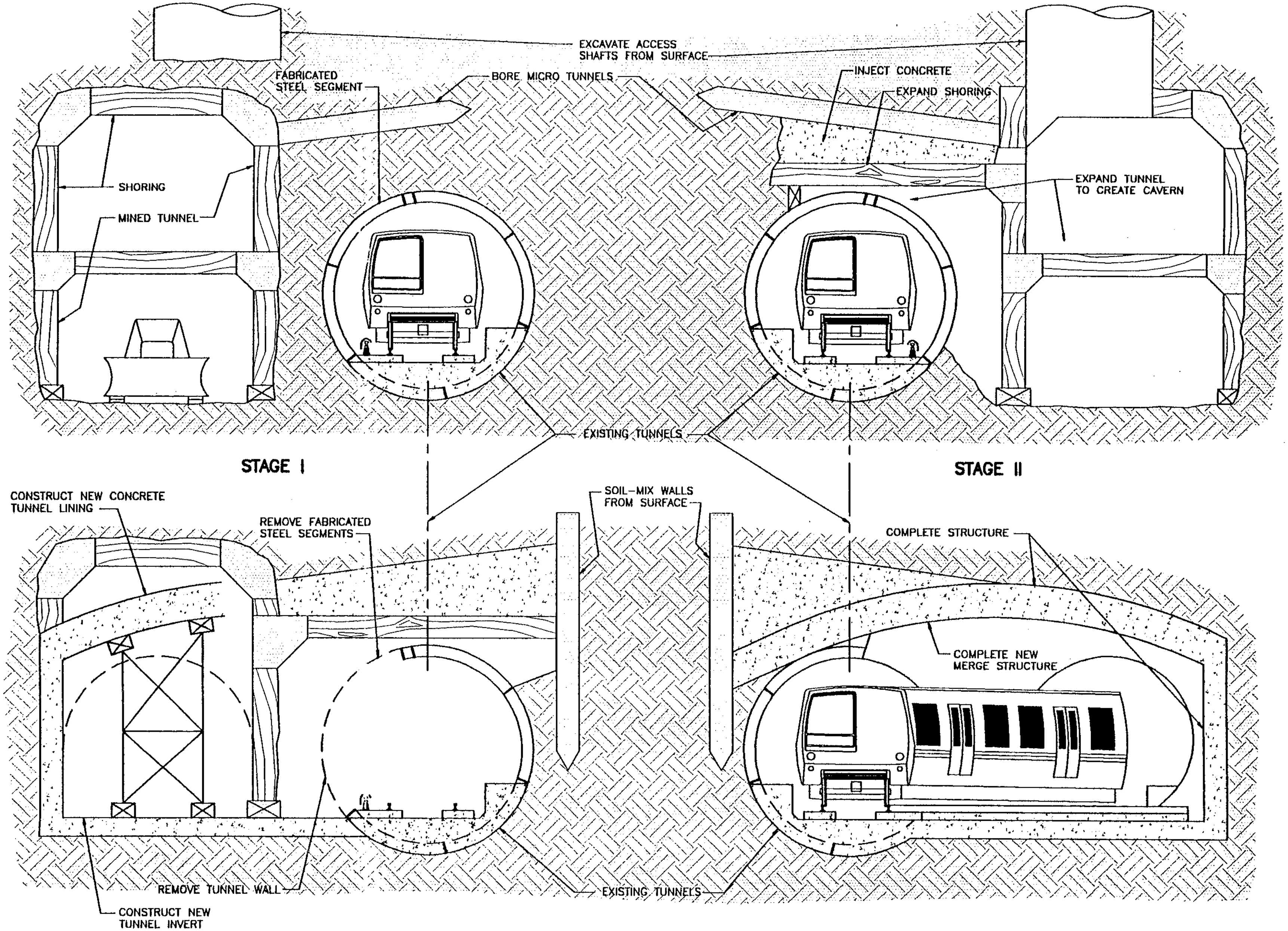
Before the main work could proceed at the tunnel merge points, certain existing BART systems would have to be rerouted away from the work zones. These features include electric power distribution cables, communication and signal lines and the conduits and raceways that contain them. Segments of the concrete emergency walkways would also have to be removed and replaced with temporary timber walkways through the construction areas.

At each location, as shown in the sequence in Figure 10, first the existing tunnels would be exposed and the tunnel roofs removed. For safety, the latter work could be done only during suspended service or reduced-service windows. The new structure of the tunnel merge would then be constructed. This work, which is over and immediately adjacent to the operating tracks, would also be limited to times during service suspension.

The track merge locations north of the station would be constructed in a box similar but somewhat narrower than the main box structure. The southern merge location is more distant from the station and also at great depth below the surface. So these merge points might have to be installed in specially excavated caverns if a large pit is to be avoided. Instead, smaller diameter shafts would be bored from above. Then to construct a cavern as shown schematically in Figure 11, the earth above the existing tunnels might first need to be consolidated by injection of cement grout or other special materials by drilling from above. Other techniques such as insertion of horizontal support girders or boring horizontal 'micro-tunnels' laterally over the existing tunnels might be needed as well. These are complex, difficult and costly tasks, and the special requirements for them would be subject to further study.

Track Construction:

Construction of the trackwork and its foundations at the 'cut-in' locations would also be especially difficult. Construction and replacement of in-service railroad track is not uncommon, and the conventional method is easily facilitated where the trackage is on the surface. In such cases, a section of track such as a complete turnout is prefabricated as a unit together with all its crossties, and installed as a 'panel' to replace a segment of pre-existing track. The use of panels facilitates quick replacement of track so that service interruptions can be minimized. However, in this case of the underground BART tunnels, the conventional methodology is inadequate due to two major limitations:



CROSS SECTION AT SOUTH TUNNEL MERGES

FIGURE 11

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FIG-11.DWG

FOR STUDY PURPOSES ONLY

FIGURE 11

- The space available within the tunnels is so constrained that only small track components could be handled and maneuvered into place. It would not be feasible to install a complete # 15 turnout as required for Alternative 'B' in one piece, at one time.
- The foundation configuration and the fixation hardware needed to support a turnout is much different than provided by the existing track slab. Yet it is impossible to completely and immediately modify the existing slab without disrupting the rails and causing long service interruptions.

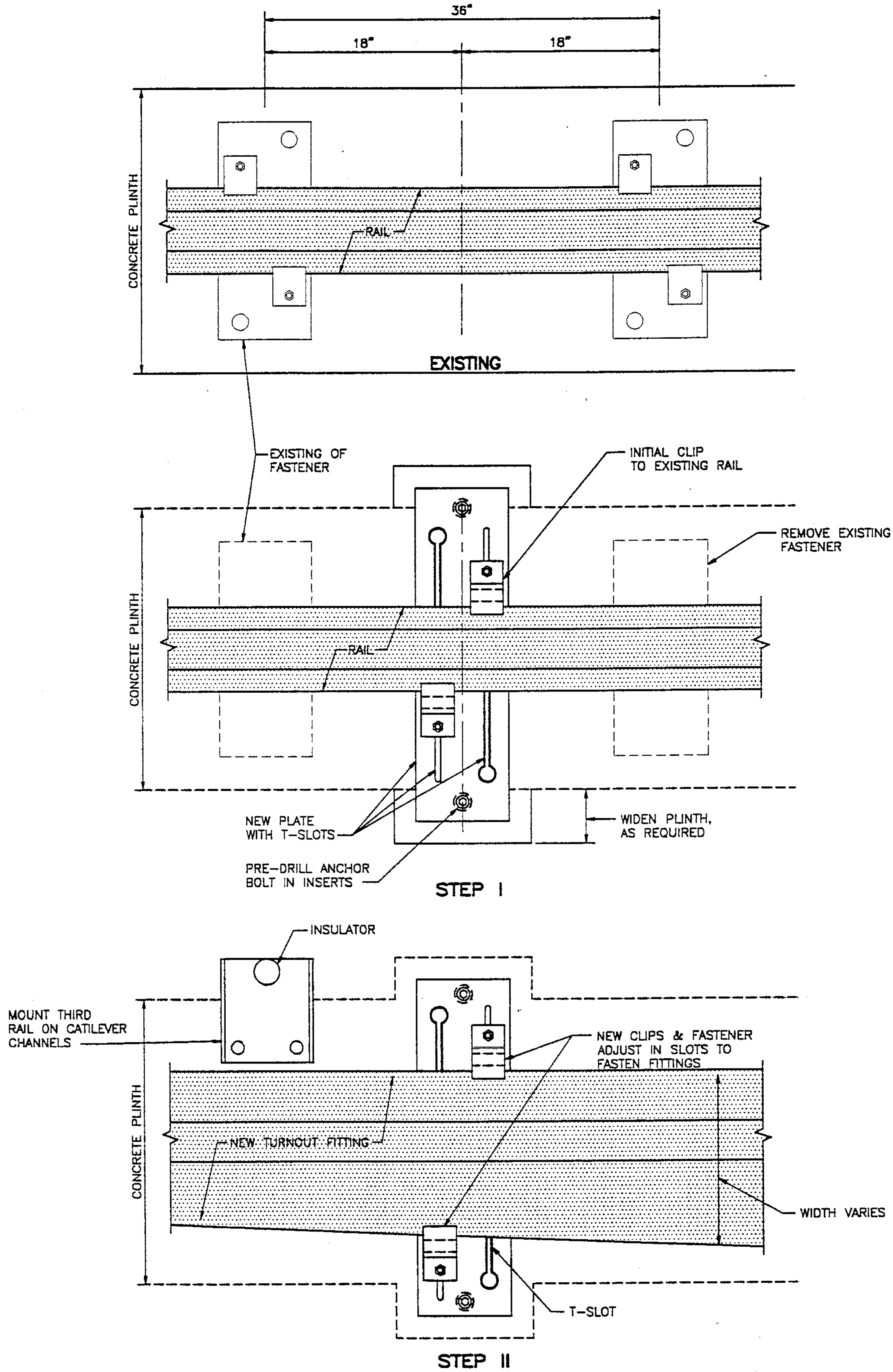
Therefore, replacement of an entire turnout as a single panel would be infeasible. Instead, construction of the new trackwork would have to be advanced piece-by-piece during the available short-time service interruption windows.

There appears to be three possible means to modify the trackwork and these are described below. This work would be preceded by removal of the adjacent concrete walkways and raceways and by electrical isolation of the track construction zone by installation of insulated rail joints. The continuous electric power third rail would be replaced by a discontinuous power rail with gaps; these being defined as the longest permitted under BART standards. (These shortened third rail segments would be supported on jigs so as to be easily and repetitively disassembled, manipulated and replaced during subsequent trackwork activities.) Trackwork modifications could be accomplished by these methods, working from the side of the track where the new tunnel excavation had been previously completed:

1. Modify Track Slab Fixation: This would be the preferred approach. The existing rail fasteners which support the rails are located on three-foot centers. These are supported by (second pour) concrete plinths about 32 inches wide, which are raised about six inches above the (first pour) concrete trackway slab. The existing direct fixation (DF) rail fasteners include plates that are about eight inches lengthwise by 14 inches crosswise with respect to the rails, and about two inches thick. Two bolts hold each fastener to the concrete plinth and two more bolts, which extend upward, affix the rail to the plates with rail clips.

   The existing fasteners are not designed to accommodate the special fittings of the new turnout. New longer-slotted rail fasteners would be needed to affix and support the switchpoint, the frog and the guardrails of the new turnouts. Also, additional fasteners would be needed to support the two additional rails (curved stock rail and curved closure rail) of the new turnouts.

   Between each pair of adjacent fasteners along each rail, there is a void about two inches high between the rail and the concrete plinth. It would be possible to insert new rail fasteners into these voids between the existing rail fasteners as shown in Figure 12-A. To accomplish this, these voids might need to be chipped away slightly to increase their depth. The concrete plinths would also need to be augmented as needed to broaden them. Next, anchor bolt inserts would be drilled and installed in the widened plinth at each location for the new fasteners. The bolt inserts would be drilled on each side of the existing rails, but placed further away from the rails than the existing rows of fastener bolts.



USE OF T–SLOT RAIL FASTENERS

FIGURE 12-A

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FIG–12a.DWG

The new fasteners would consist of 'T-slot' plates slipped under the existing rails at the positions of the new switches and frogs, and bolted onto the plinths using the previously prepared bolt hole inserts. The long T-slot in each plate could then accommodate a variety of rail and hardware widths by inserting the upper fixation bolts and sliding them laterally as needed. Initially, the T-slot fasteners would be adjusted to support the existing rails. Then the pre-existing DF fasteners would be removed and the T-slot fasteners quickly readjusted for the new rail fittings.

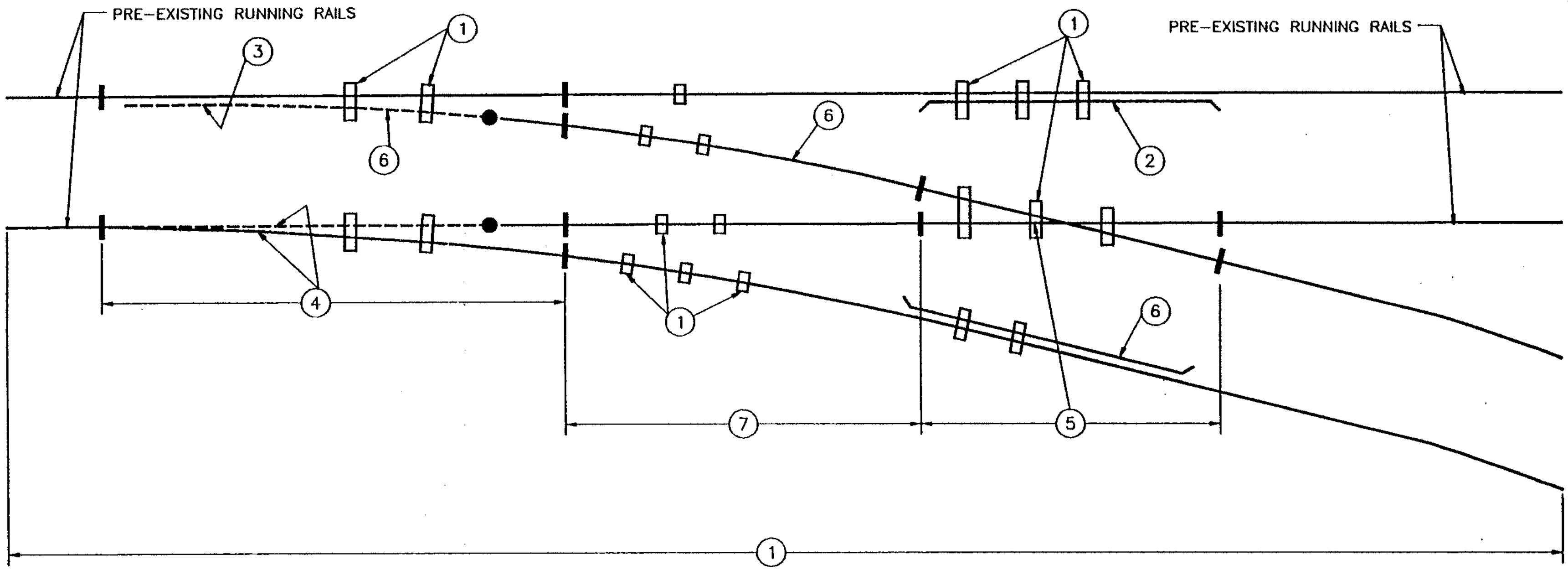
During the above-described tasks, the existing running rails would remain in place undisturbed so that only short evening/night time/weekend service interruption windows would be sufficient to advance the initial preparatory work. When all the fixation hardware had been pre-prepared in this way, segments of rail would then be cut out, one at a time, and replaced with the new fittings for the switch and the frog. The general approach to this is shown in Figure 12-B. At each time that this change-out of the major turnout components is done, a longer service interruption window, such as an entire weekend, would be required during which BART trains would be subject to single-track operations. This would probably occur a total of about 30 times during the project. During each single-tracking schedule window, work would proceed concurrently at all the new turnouts on the out-of-service track.

2. Use of 'Boot-Ties': In the segment of each turnout between the switch and the frog, there are four rails – two straight rails and two curved rails. The curved stock rail and the curved closure rail would be new additions, and in these segments the two curved rails could be placed on 'boot-ties' as alternate means of support.

   Boot-ties, as shown in Figure 12-C, are essentially small (about 12 inches wide by 10 inches thick by 30 inches long) prefabricated concrete pedestals designed to support each rail. Each boot-tie includes a resilient base pad, and the bottom half of the tie is also encapsulated in a rubber 'boot'. The boot-ties could be used in some locations in lieu of full modification of the base plinths needed for the insertion of T-slot plates. However, the boot-ties cannot be used at the switch and frog locations because of the non-standard fixation details needed there.

3. Conventional Switch Ties: This option is considered in Figure 12-D. The existing rail fasteners, which support the rails, are located on three-foot centers. By cutting and chipping away voids between the rail fasteners down into the plinths and the track slab, spaces would be created beneath the rails sufficient to accommodate new switch ties. Ties of six-inch by eight-inch dimensions would be inserted one-by-one from the side of the track where the new tunnel excavation had been previously completed. However, a major disadvantage of this approach is the greater depth needed in cutting out the base slab.

   Two new switch ties could be placed in the void between each adjacent pair of rail fasteners. Each pair of ties would consist of a Crosstie 'A' and a Crosstie 'B' as labeled in the Figure. Crossties 'A' would initially be shimmed up to support the two rails and would be affixed to them with new rail fasteners. Crossties 'B' would be left loose.



1. INSTALL NEW RAIL FASTENERS (OR TIES) ALONG TURNOUT (SEE FIGURES 12-A, 12-C AND 12-D).
2. INSTALL MAIN LINE GUARD RAIL.
3. GRIND RUNNING RAIL TO RECEIVE NEW SWITCH POINT, OR INSTALL NEW RAIL FITTING AS IN (4).
4. CUT OUT RUNNING RAIL AND INSTALL NEW STOCK RAIL WITH SWITCHPOINT.
5. CUT OUT RUNNING RAIL AND INSTALL FROG.
6. INSTALL CURVED CLOSURE RAIL, SECOND SWITCHPOINT AND GUARD RAIL AND ALL OTHER COMPONENTS.
7. POSSIBLE USE OF "BOOT-TIES".

FIGURE 12-B

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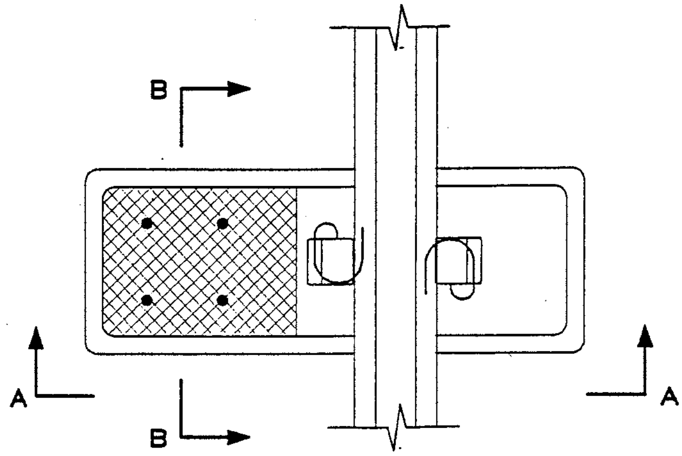
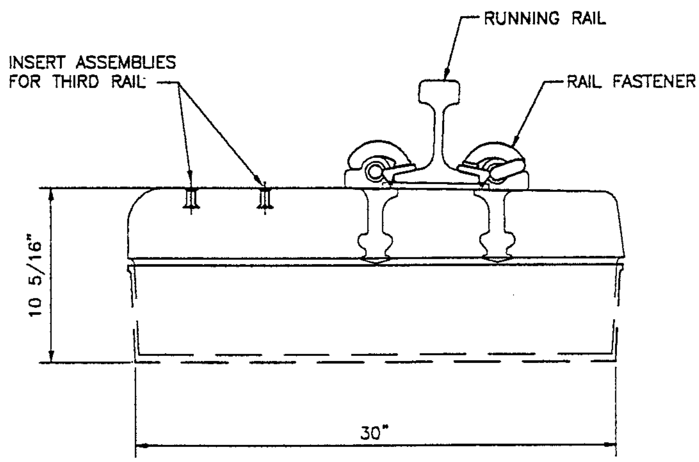
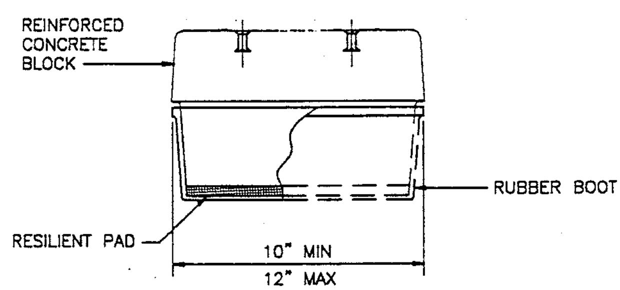
FIGURE 12-B

FIG-12b.DWG





SECTION A–A



SECTION B–B

BOOT–TIE

FIGURE 12-C

30TH & MISSION BART INFILL STATION STUDY
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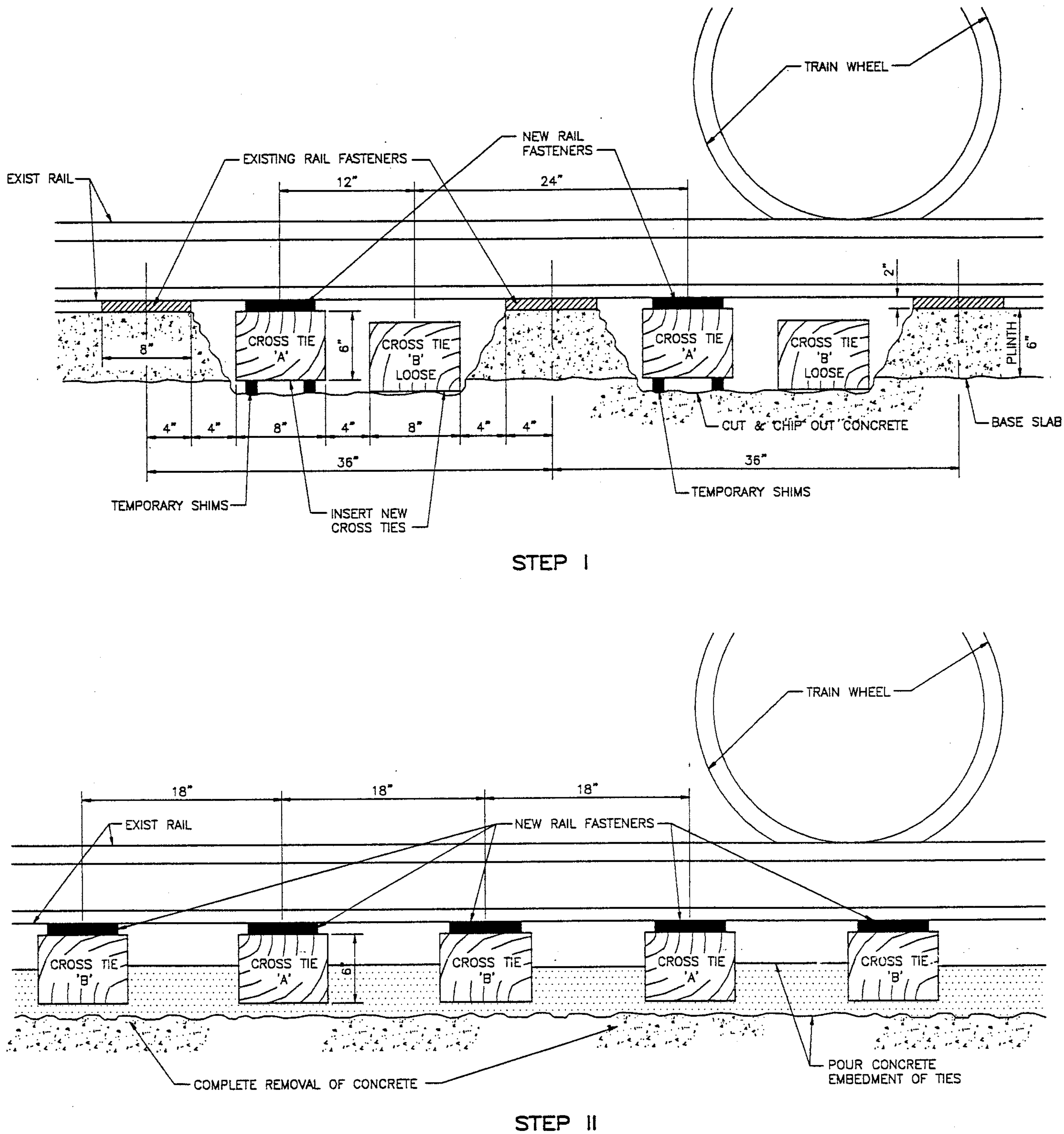
FIG–12c.DWG



LONGITUDINAL SECTIONS ALONG RAIL
SCALE: 2"=1'-0"

CONVENTIONAL SWITCH TIES

FIGURE 12-D

30TH & MISSION BART INFILL STATION STUDY
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Fig-12d.Dwg

With the rails now supported on Crossties 'A' at 36-inch spacing, the pre-existing rail fasteners would be removed and the remainder of the plinths jackhammered out to extend the voids beneath the rails and make them continuous. At this time, the loose Crossties 'B' would be shifted and respaced along the track. Then these ties would also be shimmed up and fastened to the rails. A new tie spacing of about 18-inches would thus result to support the new turnout.

With the new ties in place, a bed of concrete would be poured around and beneath them to affix them to the base slab. Installation of the remainder of the new components of each turnout would then proceed piece-by-piece as expeditiously as possible during the subsequent construction time windows.

Either timber or concrete ties could be utilized, however, timber ties have the virtue of lighter weight and can also be easily field drilled where needed to affix and adjust fasteners.

All of the above-described options have been utilized before in BART construction. The T-slot fittings and boot-ties were used in the SFO Extension project. Both timber and concrete switch ties have been widely used on BART and are conventional. Appendix 'H' includes some sample engineering details excerpted from contract drawings of similar BART installations.

With any of these methods, all of the proper tie plates and fasteners to support each turnout would have been installed during a preparatory phase during several evening/night time service-interruption windows which would involve single-track operations. Next, the main line guardrail would be installed on its pre-positioned fastener plates as shown in Figure 12-B.

Completion of the trackwork would require weekend-long service interruptions also involving single-track operations. A short segment of the running rail would be cut out to be replaced with the turnout frog. The pre-existing running rail might remain in place as the tangent stock rail, and it could be ground along the rail head as needed to receive the proper fit of the new switchpoint. Or, more likely, a completely new switch fitting could be cut into the rail. A segment of the opposite running rail would have to be cut out and replaced with the curved stock rail and the second switchpoint. The remainder of the straight running rail could remain in place as the tangent closure rail.

Finally, the curved closure rail, the permanent third rail and all the other turnout fittings, guardrail, rods, braces and hardware would be installed. The entire process would thus consist of piece-by-piece operations, each being performed during a train service shutdown. Although this process would be tedious and time-consuming, the same tasks could proceed concurrently on several turnouts at once.

For Alternative 'A', there is no requirement for a turnout, but instead the replacement of the existing tangent track segment with a curved track. Although the track hardware would be less complex than a turnout, the length would be greater because the new curve would need to be of greater radius to support the operations of higher speed main line train movements. However, certain of the above techniques, especially the use of boot-ties, could be utilized to construct the curved track while retaining the tangent rails in continuous service. The curved track, unlike the turnout alternative, may require some superelevation. This could be achieved after its initial installation by incremental insertion of shims, or raising the boot-ties, to readjust the outer rail upward.

Surface Traffic Detouring and MUNI Routes:

During almost all of the construction period, vehicular traffic, including all MUNI bus routes, could be maintained on the surface of Mission Street on a temporary deck. However, during initial construction of the temporary deck, and again during its removal, traffic would have to be restricted to only two lanes, one in each direction as shown in Figures 9-A, 9-B, 9-C and 9-F. The time during which these detour constraints would be imposed would be less than the full duration of the excavation work but would nevertheless be a significant interruption for each of the two occurrences. On-street parking would have to be prohibited during the entire course of construction in order to free up room for construction vehicles.

During the detour periods some traffic would need to be rerouted to alternative streets. Potential detour routes include the immediate parallel streets, and San Jose Avenue/Guerrero Street might be so utilized. Traffic rerouting to move distant routes, such as Dolores Street, and preferably to Alemany Boulevard/U.S. 101 and to Third Street could be encouraged by signing and adequate publicity. Detour traffic should be discouraged from entering the Bernal Heights area do to the very narrow width of the streets there.

City of San Francisco policy usually promotes public transportation, and during the two-lane detour periods it would be possible to favor the MUNI bus traffic along Mission. All MUNI bus routes, including the electric trolley buses, could be kept operating over the temporarily decked street at almost all stages of construction. To facilitate adequate street capacity for buses, peak hour auto traffic could be limited through the construction site during the two lane detour periods.

Even though two-lane detours would be needed, there are mitigations available to facilitate traffic flow through the work zones. These might include:

- Redirection of through traffic away from the site by signing and publicity
- Provision of full-width (12 or 14-foot wide) detour lanes
- Prohibition of left turns and parking
- Provision of right turn pockets at intersections
- State-of-the-art (optical) traffic signal detection and control during construction
- Relocation of temporary bus stops away from the two-lane detour segments
- Pedestrian fencing to discourage jaywalking
- Improved traffic law enforcement

With these measures, the traffic capacity through the two-lane zones might be kept adequate for all traffic.

The MUNI electric trolley buses can be kept in operation almost continuously. The trolley wires and special work (switches) can be shifted from one side of the street to the other while being supported on temporary poles as shown in the Figure 9 series. The wires can be cantilevered from one side of the street so that cross-street span wires will not interfere with construction. At each change-over, the subsequent wire rerouting would be constructed in advance, and then 'cut-in' at the extremities of the rerouting.

Between wire junctions, the wires are straight tangent runs and each succeeding layout can be constructed parallel to the preceding one without conflict. However, at the wire junctions at the Mission/30th Street and the Mission/Cortland intersections the construction would be more complex due to conflicts between preceding and succeeding wire layouts.

At each stage of wire work at these junctions, the succeeding wire layout would be constructed above the pre-existing wires, which would be kept in continuous service. The trolley bus poles, which press upward onto the wires, would thus be unimpeded while the work proceeds. This method is called 'over-building' and proceeds until the new over-built wires are ready to be 'cut-in'. (This resembles in principle—but on a smaller scale—the BART track 'cut-in' described above). The cut-in of the new trolley wires and cut-down of the old wires can be accomplished overnight or on a Sunday and it would only be at such brief times that electric trolley service would be interrupted. Diesel buses could easily be substituted at such times.

However, construction of overhead wires would entail some traffic lane closures due to use of the street by line trucks. Other interruptions to street traffic would occur during utility relocation. This typically is less time-consuming than the main detour stages but nevertheless is frequently perceived as quite disruptive. Usually this involves occasional lane closures for various periods, installation of temporary steel plates in the pavement and the like.

Property Access and Driveways: During the time that the temporary decking is being constructed and removed, and during the entire duration of its use, property access would be maintained. For pedestrians, temporary sidewalks would be constructed and supported on the construction shoring as needed, or as separate fabrications, or as portions retained from the pre-existent sidewalks where they abut buildings. Adequate pedestrian access to each building would be assured using temporary—usually wooden—structures. These would be configured to permit full handicapped access.

Where vehicular driveways exist, these would be maintained in place and/or replaced with substitute access points. Emergency access must be maintained throughout, and the requirements for this would be subject to approval by the emergency services departments of the City.

Completion of Construction: Once construction of the new tunnels, tracks, and BART system work was completed, the new tracks would be 'cut-in' to the existing BART line and train traffic rerouted to the new alignment as shown above in Figure 9-E. Portions of the pre-existing tunnels would then be removed and the station platform and mezzanine completed as indicated in Figure 9-F.

When the station box structure is completed, it would be covered with earth and the surface streets rebuilt to the newly designed layout. At that time, street traffic detouring and lane reduction would again be required prior to final completion. The sequencing of this would as shown in Figures 9-F and 9-G.

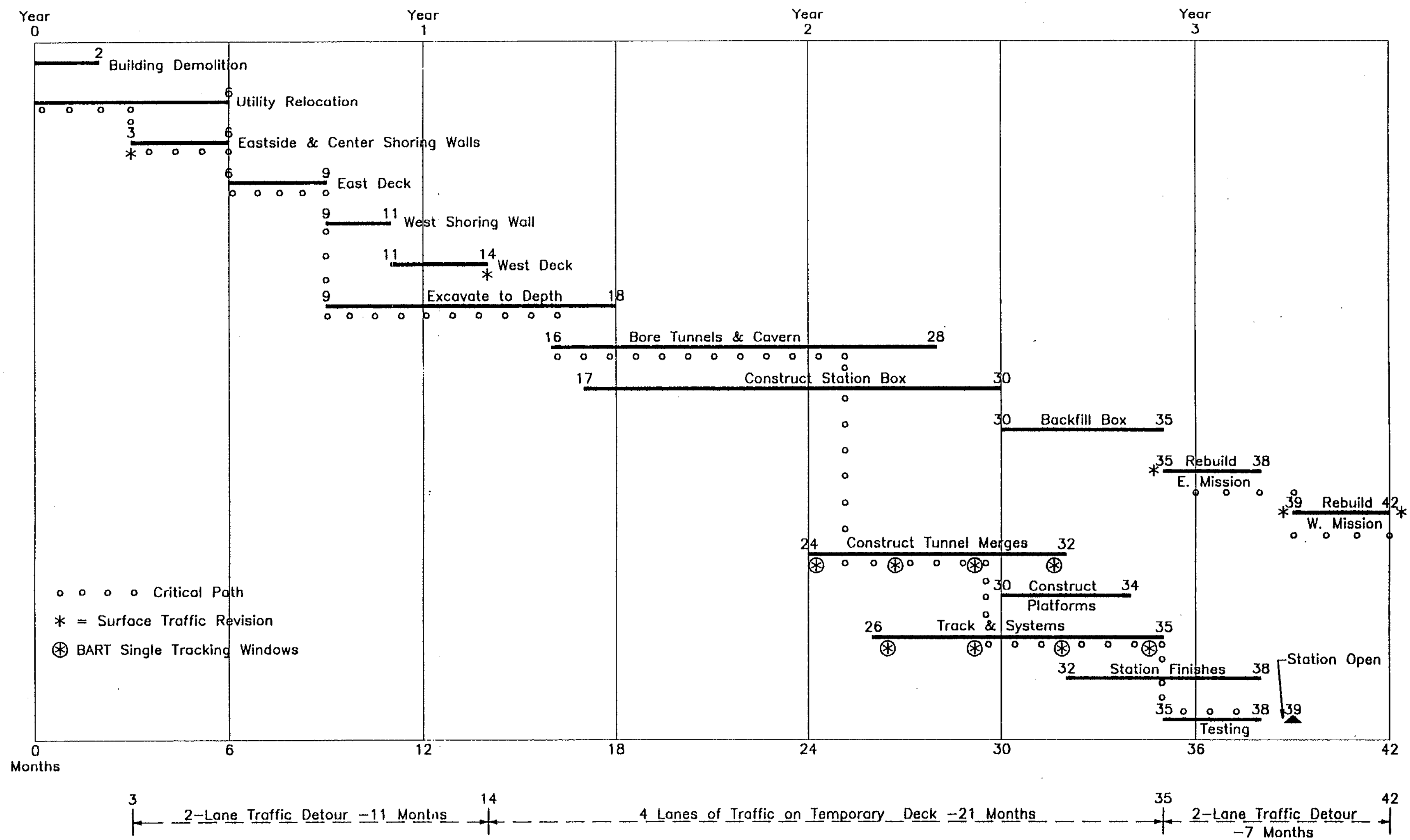
Alternatives: The basic construction staging and impacts of Alternatives 'A' and 'B' would generally be similar. However, there would be some differences. For example, the double crossover of Alternative 'A' as shown would need to be constructed adjacent to, and beneath in-service trackage, and this would multiply service interruptions during construction. The station platforms of Alternative 'B' would be constructed entirely in one stage at the same time as the new tunnels. This differs from Alternative 'A' where the platform construction would be in two stages as shown in the Figure 9 series. At the merge locations, turnouts would need to be constructed for Alternative 'B' instead of the simple track curves of Alternative 'A'. This increased length dimension of the Alternative 'A' curved-track geometry would increase the time and interruption of BART operations during construction.

Construction Schedule:

Figure 13 is a bar chart that illustrates the approximate time durations of the various aspects of the project. The general sequencing would be similar for 'A' and 'B'. The total time requirement from inception of construction to completion would be about three and a half years. This does not include the time needed to complete the engineering and prepare the contract plans or to administer the contract tender.

The main time elements of the work include these:

- Building demolition
- Utility relocation
- Drilling of east-side/center soil mix station walls
- Drilling of west side soil mix station walls
- Construct west side station decking
- Construct east side station decking
- Complete station excavation to full depth
- Bore tunnels and excavate south cavern
- Construct station box structure
- Demolish existing tunnels at station (Alternative 'A')



CONSTRUCTION SCHEDULE

FIGURE 13

30TH & MISSION BART INFILL STATION STUDY
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FIGURE 13

Fig-13.Dwg

- Backfill station box structure
- Rebuild/restore east side of Mission Street
- Rebuild/restore west side of Mission Street
- Construct tunnel south merge structures
- Complete station platforms and internal walls
- Install trackwork and BART electrical and utility systems
- Install station escalators and elevators and complete station finishes and furnishings
- Perform testing of station systems

Many of the above tasks can be implemented concurrently or are partially concurrent with each other.

The time during which the street traffic lane reductions would be imposed would be much less than the 42-months total construction time, lasting about 11 months at the onset and seven months at the conclusion.

High-Risk Construction Issues:

This project involves many unusual and difficult operations that entail risk. The meaning of risk is that there is a reasonable probability that unforeseen problems may arise or that foreseen problems might become more problematic than originally expected. Such factors include the possibility and increased potential for hazard during underground construction in constrained areas, and for construction near an operating rail system. Potential risk factors might include the following:

- Encountering undocumented underground obstructions
- Increased vulnerability to seismic events
- Possibility of groundwater intrusion and flooding
- Groundwater uplift and 'floating' upward of underground structures
- Need for additional soil improvement treatments along tunnels
- Damage to adjoining properties and/or properties above the tunnel excavations
- Need for special building underpinning
- Unforeseen subsidence and/or need for settlement monitoring and control
- Unforeseen noise and vibration mitigation
- Worker accidents
- Potential for accidents involving moving trains and their passengers

- Likelihood of repeated and/or severe service disruptions due to scheduling errors, failure to clear tracks, construction mishaps, etc.
- Consequential damages arising out of the above

To address these potential problems, all construction operations must be undertaken with utmost caution, with the most conservative safety measures fully enforced. In addition, costly special insurance policies might be warranted.

7. MAINTENANCE OF BART SERVICE DURING CONSTRUCTION

Service Reduction Windows During Construction

Track Availability for Construction: The present BART service schedule at the site operates passenger-carrying ('revenue') train service from 4:00 am until 1:30 am, five week days a week. Start-up on Saturdays is 5:30 am and 7:30 am on Sundays. Thus there is only a two and a half hour window most nights when revenue trains are not in running. However, during these intermissions, BART must still run occasional trains and equipment.

For example, during the night some BART trains are moved from place to place on the system to remove disabled trains from wayside sidings on their way to the repair shops. Also, trains may be moved from line terminal to terminal to 'balance' the correct number of vehicles and redeploy them for morning service start-up. The tracks are also used for routine and for unscheduled maintenance and to move maintenance equipment from place to place. Thus there is a constant demand for track usage even during the nighttime revenue service shutdowns.

When the tracks are removed from service for construction activities, it is necessary to shut off the electric traction power and also to deactivate the automatic train control facilities along the tracks. To assure safety, certain procedures must be followed and this requires a certain amount of time. Likewise at the conclusion of the construction activities, when the track is to be placed back into service, the safety procedures and tests needed are time-consuming.

Accordingly, useful construction windows cannot always be provided during regular nighttime service suspension. Instead, construction on the tracks must involve reductions in revenue train service. The opportunities for such service suspensions are those times when diminution of train service would inconvenience the fewest patrons. Such times are when trains run on longer headways and carry fewer passengers. This happens after 9:00 pm on weekdays and also on weekends, especially on Sundays.

It would be possible to provide seven-hour construction schedule windows between the hours of 9:00 pm and 4:00 am on each weeknight and also longer windows, from 9:00 pm Friday nights until 4:00 am Monday mornings. However, these construction opportunities would also be limited by the need for BART to use the tracks for purposes other than revenue service, as described previously. Also, there are certain times of the year and periods when special events would preclude any reductions in service.

Therefore, the available time for construction activities at the site is very limited.

Single Tracking:

It is not considered practical to completely shut down BART service even during the limited windows. Although it is possible in theory to set up substitute bus service ('bus-bridges'), there are serious deficiencies to that approach as will be described below. Therefore the option of single-tracking is the only remaining possibility. With single-tracking, one of the two BART tracks is shut down for construction while trains from both directions take turns using the remaining track. This is feasible only during the times when fewer trains are running, as in the late evening and weekends. It nevertheless would impose considerable delay and inconvenience on patrons.

A single-tracking segment is defined by the location of existing crossover tracks. For the 30th Street Station site, the nearest crossovers are north of 24th Street Station and south of Balboa Park Station. Therefore, trains from north and south would take turns using one track between these points, running on one of the tracks through the Balboa Park, Glen Park and 24th Street Stations.

On Sundays, there are only two BART lines in service, each on a 20-minute headway (See Table in Section on Existing Conditions.) However, it is not feasible to operate all of the trains of both of these two lines over the single-track. Single-track operations entail train slow-down throughout the crossovers, waiting time and manual train control instead of computer automatic control. Single-track operations would be on 20-minute headways through the 24th Street to Balboa Park segment. Therefore, one of the two lines would have to be turned back at each end of this segment using the same crossover track locations.

Passengers on the turnback trains would have to be deboarded at 16th Street and Daly City Stations and wait for the following train. The wait time for these patrons until the next train would be 10 minutes.

It might be possible to supplement the single-track service with a bus-bridge or possibly with augmented parallel MUNI and/or Caltrain service. However, these are not sufficient to completely replace BART service. Substitute bus service was considered and described as follows:

'Bus-Bridge' Substitute Service Option

Substitute bus service during construction could take the form of a bus-bridge between BART 24th Street Station and San Francisco International Airport (SFO) and Millbrae/Caltrain. For this option, BART train service would be terminated at 24th Street Station. Service beyond that station (all the way to Millbrae and SFO) would be handled by the bus-bridge. This would be a difficult and costly operation because of the large number of buses involved and the volume of passengers having their travel times significantly increased (possibly an hour or longer from 24th Street to Millbrae).

The substitute service would start at 9:00 pm and continue until about 1:30 or 2:00 am for evening service suspensions. In order that morning service not be affected, the tracks would need to be returned to train use no later than 4:00 am weekdays, 5:30 am Saturdays and 7:30 am Sundays.

There are major disadvantages to this concept. Passengers from SFO or Millbrae/Caltrain might normally depart those BART stations on a last train at 11:50 pm. Such patrons could then get to their destinations anywhere on the BART system. If a bus-bridge were used, the last bus would need to leave by about 10:30 pm or 11:00 pm in order to deliver passengers to 24th Street Station so as to catch the last trains to the Eastbay.

Thus there would be a great deficiency serving any passengers getting off work at 11:00 pm at SFO, and normally taking BART to get to Dublin/Pleasanton. These patrons would not be able to make the needed connections in time. The project would impose a heavy inconvenience on such passengers who may use the BART system between 11:00 pm and 12:00 am.

The bus bridge operation also would become more inconvenient for a greater number of customers on Friday and Saturday evenings when there is on average more late night patronage of the system.

8. OPERATIONS QUALITATIVE REVIEW

This is a initial qualitative analysis of the operational and capacity impacts of building an infill station at 30th Street. In addition, assessment of the delays to real-time train operations are more fully and accurately addressed in the simulation analysis described in the following Section..

As described above, the present study has narrowed various station alternatives to two, and these options are shown diagrammatically in Figure 14. There also continue to be slight variations possible for each alternative, such as the positioning of crossovers, etc.

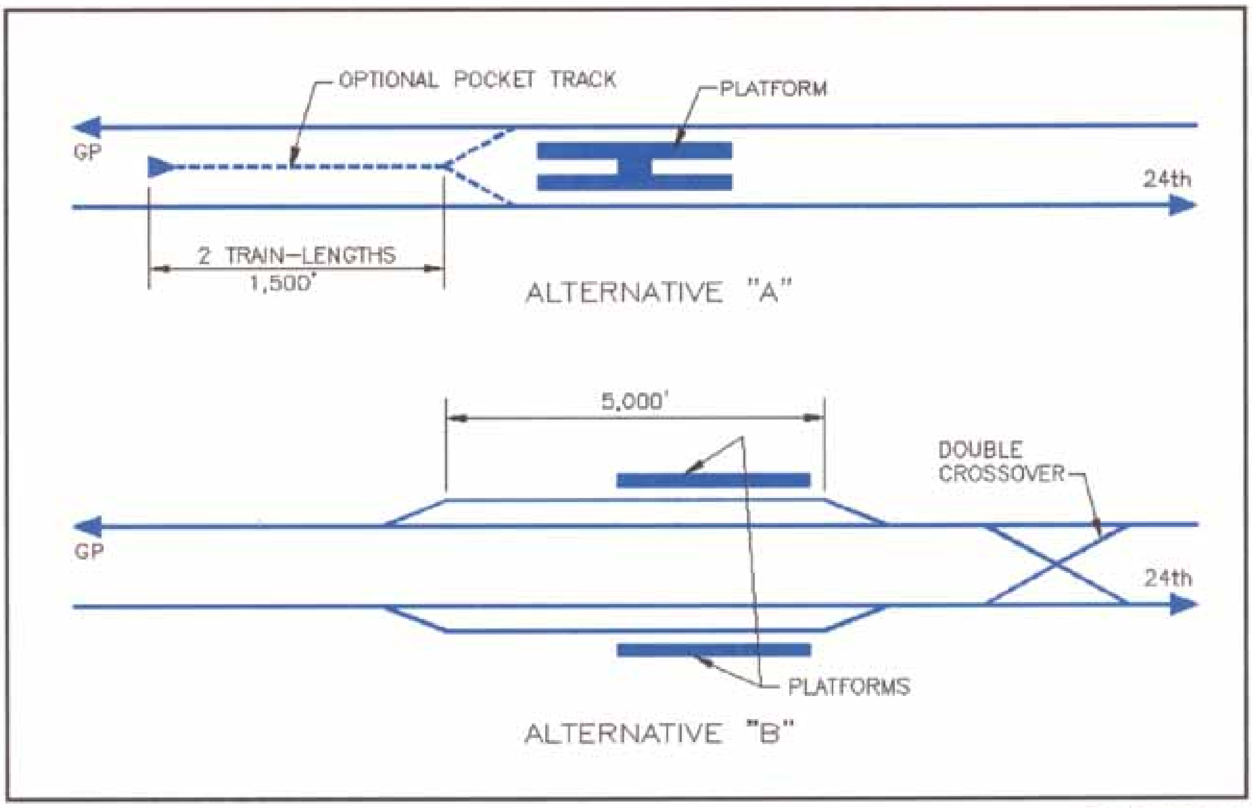


FIGURE 14

Alternative 'A': Two new tracks and platforms, with an option for a center pocket/tail track south of the proposed 30th Street Station. **This is an on-line station.**

Alternative 'B': Two new tracks and outboard platforms, located away from of the main line tracks, with a new crossover between the existing main tracks north of the proposed 30th Street Station. **This is an off-line station.**

Operating Assumptions

The BART staff has outlined the following potential operational assumptions as a basis for capacity analysis:

- A 12-minute base headway with two peak period rush trains (Pittsburg/Bay Point-Millbrae).
- Minimum two-minute headway during the peak hour on the main line.
- Optimize train sequencing
- Any scheduled short turnbacks at 30th Street Station would be by Fremont-to-30th Street trains. (The Fremont Line is also being considered for extension to San Jose/Santa Clara).
- Train sequencing and headways would be the same for both am and pm peak hours, in the peak direction.
- Full moving block automatic train control (AATC) operation on the main line.
- Alternatives must be capable of supporting through-train operations in both directions.

The following are the benefits and drawbacks of each Alternative:

Alternative 'A' – Benefits

- The basic scheme has no switching, thus there is no additional delay created by merging revenue trains.
- See below for benefits of turnback option.

Alternative 'A' – Drawbacks

- This scheme requires all trains to stop at 30th Street and so lengthens end-to-end runtimes for all routes. This might require additional revenue vehicles (a complete additional train for some routes) to maintain headways.
- All trains stopping at 30th Street would have to stop on a main line track, thus seriously reducing line capacity in both directions.

Alternative 'B' – Benefits

- Permits 'skip-stop' ('express') operation past 30th Street. Through 'express' trains would operate on mainline tracks while 'local' trains would diverge onto the side tracks to stop at the station platforms.
- Compared to Alternative 'A', this scheme provides a four-track segment with crossovers and off-line storage capability. This has improved potential for delay mitigation.

Alternative 'B' – Drawbacks

- With 'skip-stop' operation, there is a potential for very long station dwell during the peak period for those trains that serve the new 30th Street Station. During the peak hour, trains on the main line could run at minimum two-minute headway or less with AATC. Trains that stop at the platforms (probably the Richmond, Fremont and Dublin/Pleasanton Lines) may be held/delayed up to 12 minutes to wait for a gap in the bypass track schedule. (These trains could even be held until after the peak period, when train density is reduced significantly, to allow catch-ups in the schedule.) Thus in this example, only the Pittsburg trains, which bypass the station, would be exempt from excessive new delays.

  (There might be an exception to this if BART Central Control could direct occasional trains out-of-sequence by allowing the delayed stopped trains to 'force' a merge back onto the main line before the next scheduled bypass train arrives at the merge point. But this scenario might delay following through trains on the main line.)

- With very close headways and the potential train interactions that will be a result of a new AATC system, any delays or 'off-set' in timing for diverted trains to merge back onto main line, may result in reduced capacity. Delays or 'off-set' in timing for merging diverted trains onto the main line at 30th Street would also particularly reduce line capacity in the pm peak direction. This would occur for either 'skip-stop' or all trains stop at 30th Street, and delayed trains or running trains out of sequence from 30th Street to the north, would also unfavorably impact schedule adherence and on-time performance for all trains.

  The first late train of any delayed route arriving in downtown San Francisco would experience longer dwell time as more passengers accumulate on the platforms. Longer dwells will in turn exacerbate the delay and reduce train throughout at those critical downtown stations (Montgomery and Embarcadero), which control overall line capacity.

Alternative 'A' includes a turnback pocket track as an extra-cost Option. Alternative 'B' does not include a special turnback track, but would permit use of the two center bypass tracks for turnback as an operational option. If the center track were to be used for turnback/storage function, it could not be simultaneously available as a bypass/express track. There are also two types of turnback use – One for reversing revenue trains, and a second for storage and reversing of disabled trains. The following are the general benefits and drawbacks of turnback train operations:

Alternatives A' and 'B' Turnback Track – Benefits

- Operational flexibility by allowing revenue trains to turn back at 30th Street, out of the way of main line traffic. Potentially useful for future San Jose trains.
- Depending on the schedule, there may be the ability to reduce the need for rolling stock by saving a train on some routes, with short turnback of revenue trains at 30th Street instead of at Daly City or further south; OR:
- Capability to temporarily store disabled trains on the center track(s), out of the way of mainline traffic, facilitating delay recovery as well as reducing the impact of train mechanical failures.
- The tail track option of Alternative 'A' is on a flat grade, which improves safety and facility.

Alternatives 'A' and 'B' Turnback Track – Drawbacks

- Operational complexity requires merging of trains leaving the pocket track into the main line.
- For revenue turnback, trains would require three separate dwells: One for alighting passengers, a second on the turnback track to 'change ends', and a third for boarding passengers after the short-turn is completed. Changing ends would require train operators to walk through the train, from beginning to end, to 'key-in' and 'key-out'. This additional time could result in a missed schedule slot. (An alternative is to have two train operators, one at each end. But this would increase labor requirements and cost.)
- The three possible uses of the center tracks of Alternative 'B' – (express trains, revenue train turnback and disabled train storage) are mutually exclusive at the same time, yet they are all needed most at peak periods. It would be possible to augment the track layout to permit simultaneous uses, but only at additional cost.
- The 3.21 per cent grade of the center tracks in Alternative 'B' is disadvantageous for their most effective use for train turnback and storage. It is desirable for safety that these types of tracks be on flat grade. If not, special safety features might be needed at extra cost.
- Construction of the Alternative 'B' double crossover tacks on the existing mainline would disrupt train operations and require additional use of single-tracking and/or substitute bus service.

9. TRAIN OPERATIONS SIMULATION ANALYSIS

An analysis of train operations with and without a 30th Street Station was conducted by BART staff. A computer simulation was utilized based on certain operations assumptions which are listed below. The objective was to define train headways as the major index of system capacity and train 'thruput.'

Comparative alternative simulations were run for the existing line without the new station at 30th Street as well as with the new station. Also, there were alternative simulations run for train control based on the pre-existing train detection by track circuits (TC) so as to compare it with the new Advanced Automatic Train Control (AATC) system. Track circuits, which detect trains by electric current flow through the rails, are a traditional railway technology but have been a limiting factor in BART line capacity. The AATC improvements, which at completion for the entire BART system, will represents a total $100 million investment, is a new technology especially developed and implemented to improve BART system capacity, especially the train capacity of the Transbay Tube.

Advanced Automatic Train Control (AATC)

The BART system already handles 90 million passenger journeys a year, and in the mid-1990s projections for traffic growth suggested that BART urgently needed to increase line capacity. Critical points on the network are the Oakland Wye junction and the Transbay Tube. Building new lines under the Bay would cost many billions of dollars, and the search for a more cost effective alternative to permit shorter headways on the existing system pointed to improving the control exercised upon every train on the network.

Therefore, BART and its contractors begin developing AATC in 1994. The new AATC system will cut headways and shorten end-to-end journey times, improving the ability to recover after delays and allow BART to run its existing service with one fewer trainset. Also, with fewer brake-to-power transitions, energy consumption will be reduced.

Operating Issues and Concerns:

- Reliability and travel times from station area to Downtown, Peninsula and Eastbay
- Travel time would increase between stations south and north of 30th Street
- New station would affect operating capacity on BART lines and rider capacity on trains, especially morning peak northbound trains

The backbone of AATC is a robust radio network providing data communication and radio-ranging determination of train location. The AATC system communicates vital location data using a radio network rather than inductive wire loops, or track circuits, both of which are more traditional methods of train detection.

(The above description was partially excerpted from *Railway Gazette International,* as reproduced in Appendix I)

The following are the assumptions used in conducting the headway simulation of the present study:

Track Circuit (TC) System Simulation Assumptions

- All 10-car trains
- Maximum train speed of 70 miles per hour (BART designation of 'PL2')
- Station dwell times of 30 seconds
- Simulations did not include turnback times at end of line
- Spacing between trains of 700 feet minimum (as per Sequenced Occupancy Release System enabled - SORS is a safety system that assures a minimum distance between trains)
- All existing track speed limits enforced
- Station Target Velocity of 36 miles per hour. (Station Target Velocity is the top speed at which the front of the train first may enter a station. Under track circuit control this is 36 miles per hour, that being the closest track circuit speed code available.)

Advanced Automatic Train Control (AATC) System Simulation Assumptions

- All 10-car trains
- Maximum train speed of 70 miles per hour (BART designation of 'PL2')
- Station dwell times of 30 seconds
- Simulation did not include turnback times at end of line
- Minimum spacing between trains of 700 feet not enforced
- Speed limit defined by maximum track design speed (about 80 mph)
- Station Target Velocity of 43 miles per hour. (Station Target Velocity is the top speed at which the front of the train may first enter a station. Since AATC can send any speed code in one mph increments, it can more closely match the optimum station-stop target speed, than has been possible with track circuits.)

Simulation Results

This simulation analysis addresses only the Alternative 'A' basic on-line station for which all trains would have to stop. The operational affects of the Alternative 'B' off-line station would presumably be less pronounced because not all trains would stop at 30th Street. However, its overall analysis would be much more complex. The operational scenarios of Alternative 'B', and their advantages and disadvantages have been described qualitatively in the previous Section.

The results of the simulation are included in the tables below as train headways in seconds at various stations along the line. Each of the train control alternatives is shown with respect to the following operating scenarios, or *'crush'* definitions:

'Uniterfered Crush': This criterion is utilized for analysis of scheduled train service. This is the minimum scheduled headway resulting when all following trains run end-to-end as though there were no other trains on the track (i.e. - as fast as the lead train). Resulting train headways are as follows:

	UNINTERFERED CRUSH HEADWAYS	
	Track Circuit (TC) Control	**AATC**
EXISTING SYSTEM:		
Westbound/Southbound Track	130.5 sec @ Daly City	**128.0 sec @ Daly City**
Eastbound/Northbound Track	142.5 sec @ Balboa Park	**123.0 sec @ Balboa Park**
WITH 30TH ST. STATION:		
Westbound/Southbound Track	130.5 sec @ Daly City	**129.5 sec @ Daly City**
Eastbound/Northbound Track	191.0 sec @ 30th Street	**171.5 sec @ 30th Street**

Accordingly, there are increases in headways projected for the San Francisco BART line with the introduction of a 30th Street Station. An increase in headways means that passengers must wait longer for trains; therefore this is a degradation in service. The results for AATC are the significant values as this is the control system that is now being placed into service. The table illustrates that the AATC system enables reduction in headways from the pre-existing TC system. The results also show that the more significant headway increases are for the eastbound/ northbound track

Comparing the 123.0 vs 171.5-second values in the above table indicates that the eastbound/northbound headway increase would be 48.5 seconds, or a degradation of about 39 percent.

'Recovery Crush': This criterion is utilized to define headways needed to recover from service interruptions or delays. Under this criterion, two trains are dispatched 60 seconds apart. The lead train is held at each station platform until the following train is forced to come to a complete stop behind it. The Recovery Crush Headway is measured as the longest time between train departures from amongst all the stations in the simulated segment. The resulting headways are as follows:

	RECOVERY CRUSH HEADWAYS	
	Track Circuit (TC) Control	**AATC**
EXISTING SYSTEM:		
Westbound/Southbound Track	116.0 sec @ Embarcadero	**87.5 sec @ Daly City**
Eastbound/Northbound Track	110.5 sec @ 24th Street	**83.0 sec @ Daly City**
WITH 30TH ST. STATION:		
Westbound/Southbound Track	116.0 sec @ Embarcadero	**87.5 sec @ Daly City**
Eastbound/Northbound Track	143.5 sec @ 30th Street	**124.0 sec @ 30th Street**

The above table shows that there is an even more pronounced improvement from TC to the new AATC control. However, the most significant finding is that there is a substantial degradation of about 49 per cent in headways from 83.0 to 124.0 seconds eastbound/northbound with introduction of a 30th Street Station. However, no degradation is indicated westbound/ southbound.

<u>*'Steady State Crush'*</u>*:* This is a theoretical index also used to analyze train headways. For this index, thirty trains are dispatched 60 seconds apart. The Steady State Crush headway is the average time between departures at the last simulated station for the last three trains in the simulation.

	STEADY STATE CRUSH HEADWAYS	
	Track Circuit (TC) Control	**AATC**
EXISTING SYSTEM:		
Westbound/Southbound Track	111.5 sec	**89.5 sec**
Eastbound/Northbound Track	114.5 sec	**87.0 sec**
WITH 30TH ST. STATION:		
Westbound/Southbound Track	113.0 sec	**90.0 sec**
Eastbound/Northbound Track	147.0 sec	**125.0 sec**

Again, there is a decrease in headways with AATC, but an increase in headways with a 30th Street Station.

<u>*Run Times*</u>*:* These are calculated for the travel time between Embarcadero Station to Daly City.

	RUN TIMES	
	Track Circuit (TC) Control	**AATC**
EXISTING SYSTEM:		
Westbound/Southbound Track	25 min 25.0 sec	**23 min 40.5 sec**
Eastbound/Northbound Track	25 min 62.5 sec	**24 min 34.0 sec**
WITH 30TH ST. STATION:		
Westbound/Southbound Track	26 min 33.5 sec	**24 min 36.0 sec**
Eastbound/Northbound Track	27 min 3.5 sec	**25 min 32.5 sec**

For the existing system without the new station, the AATC System reduces run times in all cases, with a one-minute, 28.5 second improvement on the eastbound/northbound track. However, with the 30th Street Station added, the run times are increased in both directions, up to 58.5 seconds on the eastbound/northbound track.

In addition to the above quantitative headway simulation, BART staff previously undertook a separate study based on estimating existing available excess line capacity and the potential impacts resulting from a 30th Street Station. That analysis is described in the following section.

Conclusions Regarding the Simulated Operations Analysis

The simulation analysis was conducted in terms of train headways, which are the time intervals between trains as indicated at various station locations along the San Francisco line. The capacity of a line is inversely proportional to train headways. That is, as the time between trains increases, the number of trains and hence line capacity decreases, and service is therefore degraded.

Line capacity can be also increased by adding cars to each train or adding passenger capacity (i.e. removing seats and increasing standee space) in each car. However, BART trains already operate at the maximum length of 10 cars through the Transbay Tube during peak periods. Removing seats from the trains would not likely be regarded as a popular or easily implemented policy.

There would clearly be a degradation of BART line-haul service if a 30th Street Station were implemented. The most important impact on AATC capacity with the 30th Street Station is on the eastbound/northbound track (from Daly City/Colma to the Eastbay). To a large degree, this is caused by the downgrade of the track in the area of the new station, which increases the stopping distance of the trains going toward downtown.

Similarly with regard to headway, the 30th Street Station would have the major impact in the eastbound/northbound direction, as it becomes the 'worst' station on the line in terms of its affect on train headways. However, westbound/southbound trains (from Eastbay to Daly City/Colma) are virtually unaffected by the 30th Street Station. This is because in that direction, there are other stations on the line with more detrimental effects on headways than the proposed 30th Street Station. With regard to run times, 30th Street Station impacts the system unfavorably, but about equally in both directions.

In summary, the simulation shows that the magnitude of the degradation would be a major setback to the improvement in line capacity achieved by implementation of the new AATC system. However, there are various ways to interpret this potential change:

The most optimistic conclusion would be that the AATC system will make possible the addition of a 30th Street Station without a degradation of BART line capacity below that which existed previously with the track circuit train detection system. Under this interpretation, however, part of the cost of AATC on the San Francisco line should be assigned to the 30th Street Station in comparing the project costs to its benefits.

A more pessimistic interpretation of the simulation findings is that the addition of a 30th Street Station would set back BART operations to a condition similar to that which prevailed before AATC. If conditions were considered unsatisfactory then, a return to a similar condition in the future might be regarded as even more unsatisfactory.

As described in previous Sections, the Alternative 'B' off-line station might permit some mitigation of the elongated headways calculated for through-trains by the simulation, but at the price of lesser service to the 30th Street Station itself.

While the projected increases in travel times of slightly less than a minute may seem minor, any increase in rail system travel time is potentially very significant. When train run time is increased, a larger number of trains is required in order to support a given passenger capacity. For an increase of the indicated magnitude of the simulation an approximate increase of one train set of 10-cars would be needed. The equivalent capital costs, based upon $3 million per rail car, would thus be about $30 million. In addition, there would also be increased maintenance costs for the extra cars, more repair shop space needed, etc. None of these costs have been included in the preliminary cost estimate conclusions of this report.

10. SYSTEM CAPACITY

Line Capacity Factors

A line capacity analysis was conducted to assess the impacts on Transbay capacity of adding an infill station. The analysis focused on estimating the available line capacity sufficient to meet Transbay demand during am and pm peak hour, peak direction as this is the period which rolling stock and resources are taxed to the maximum.

The analysis approached the problem by determining the magnitude of excess capacity, if any, of the Transbay line. It was then assumed that any such excess capacity would be available to serve the needed extra service demand of a new 30th Street Station. A further assumption of the analysis is that all available trains would be dispatched to support the peak demand.

AM Peak Hour

The results reveal that there is sufficient am peak hour westbound line capacity to accommodate new riders from downtown San Francisco to points west and south. Since the majority of passengers deboard as one of the four downtown stations, westbound trains would not be crowded after leaving downtown. However, lacking any ridership estimates of westbound Transbay traffic due to a 30th Street Station, it is difficult to analyze if new trips of significant numbers might be generated that would impact westbound Transbay capacity.

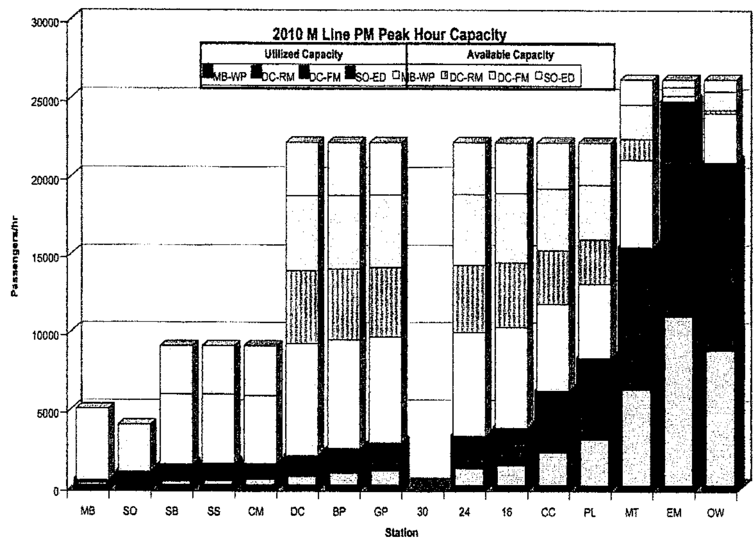
It should be noted that am peak hour Transbay capacity is estimated to reach headway limits at around FY2012, with 28 trains per hour in the peak direction. Judging by the number of trips generated at 24th and Glen Park Stations (only 478 am peak hour trips from the Eastbay in FY2010), it is postulated that new ridership generated by a 30th Street Station from the Eastbay is likely to be small.

The am peak hour eastbound trains carrying passengers from southern points to downtown San Francisco may experience capacity constraints between 24th Street and 16th Street Stations. Some lines may be more crowded than others. Since all four routes utilize the main line in the eastbound direction, proper load management can effectively spread demand amongst these lines. Furthermore, since high-load eastbound trips are relatively short (only a few stations to downtown), passengers might be willing to tolerate more crowded trains in that short segment than for a longer trip all the way to the Eastbay.

PM Peak Hour

Variability in headway as a result of extended dwells and close station distance spacing (especially as occurs in downtown San Francisco) has been found to significantly reduce line throughput in the pm peak hour. The results shown in the bar diagrams 15-A and 15-B indicate that there is approximately 1,380 available Transbay trip capacity for FY2010 and FY2020.

FIGURE 15-A
FY2010

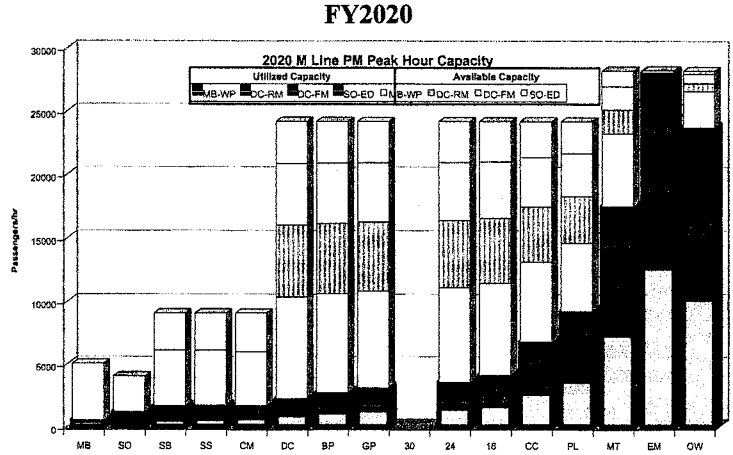


Available pm peak hour transbay capacity (passengers/hr):

Year	FY2010	FY2020	
		Unconstrained	Constrained
Available Capacity	1,382	2,138	125

Although Figure 15-B shows significant eastbound capacity for FY2020 that is available west of the major downtown stations, this capacity is needed to satisfy Transbay demand and, therefore, should be reserved to meet the greatest demand at the *maximum load point station,* which is Embarcadero. Thus, eastbound Transbay traffic generated by the 30th Street Station, while assumed to be low, would have detrimental impact on line capacity to the Eastbay, if it were to exceed the available Transbay capacity.

FIGURE 15-B
FY2020



Line capacity was also estimated for FY2020. The unconstrained analysis assumed that the train control system will be sufficient to handle the required train density to meet rising demand. It also was assumed that service levels would not be reduced significantly from current levels, thus maintaining a similar level of service. The constrained scenario assumes a maximum train throughput of 28 trains per hour, which is the maximum throughput possible with the implementation of AATC. This includes an acceptable operating margin to account for delay recovery.

The results indicated that there were approximately 2,140 and 125 available pm peak hour Transbay capacity (passengers per hour) for the unconstrained and the constrained scenarios, respectively for FY 2020 (see Figure 15A). Since rising ridership would require BART to increase service, the service planning model also showed that by FY2020, the unconstrained scenario would require BART to acquire approximately 70 new cars to operate the service plan, with 49 new cars needed for the constrained scenario.

Figure 12-B presents the constrained scenario for FY2020. It shows that eastbound pm peak hour Transbay capacity demand is at its maximum at Embarcadero Station. Any additional trips generated by a 30th Street Station, or any other infill station on the line will be a detriment to that line capacity.

Summary of Findings on Operations

1. Alternative 'B' offers superior operational flexibility and means to recover from delay. It is preferred to all the other alternatives studied, especially for the critical eastbound pm peak.

2. Alternative 'A' is not as operationally beneficial as Alternative 'B' but nevertheless appears to be minimally acceptable from the operations standpoint, subject to further more detailed analysis.

3. With either of the two Alternatives, there will probably be sufficient am peak hour capacity in the westbound direction to satisfy demand.

4. A 30th Street Station (with either Alternative) may contribute to limited capacity constraints at 24th and 16th Street Stations in the am peak hour, eastbound direction. However, since the trips are short and better load management across the lines may mitigate these effects, this is not now considered a serious impact.

5. New eastbound traffic generated at a 30th Street Station would limit the critical pm peak hour eastbound Transbay capacity by FY2020.

6. A detailed assessment of the impacts of delays to real-time operations can be determined only after detailed line simulations of the proposed Alternatives are undertaken.

7. The provision of turnback capabilities would be beneficial, however, similar capabilities might be provided elsewhere at lower cost.

11. RIDERSHIP

Station Patronage

The only available projections of station patronage were developed in a brief study which was prepared by the San Francisco County Transportation Authority in 1998. However, that study as excerpted below lacked detailed origin/destination input data, and was based only upon demographics.

Comparative Demographics

The population within a one-quarter mile radius of 30th and Mission Street is nearly 20,000. This is equivalent to a density of about 40 persons per acre. By comparison, the population within a one-half mile radius of the BART 24th Street Station is about 35,000, with a density of 65 persons per acre. Therefore the density at 30th Street is about three-fifths that of 24th Street.

Zero-vehicle households constitute 11.7 percent of the population near the 24th Street Station, but only 8.5 percent of the population near the proposed 30th Street Station. The poverty rate is similarly higher for 24th Street compared to the 30th Street location. Those who live near 24th Street Station undertake about 25.5 percent of their trips by transit, while those near the proposed 30th Street Station make only 18.5 percent of their trips by transit. The residents of 24th Street make 53 percent of their trips to downtown San Francisco by transit, while 30th Street residents make 48 percent of their trips to downtown by transit.

Current Ridership Levels

Current ridership at the 24th Street BART Station is 9,500 weekday exits. This is one of the highest ridership stations – on the order of Berkeley, 12th Street Downtown Oakland, and Balboa Park (which has parking and better transit service) Stations. The ridership at the Glen Park Station is 6,300 weekday exits.

BART Ridership Factors for Proposed 30th Street Station

- It should be noted that ridership numbers are difficult to estimate accurately without specific origin/destination numbers.
- Using demographic information only, from the areas around the 24th and 30th Street Stations, ridership levels of the proposed 30th Street Station would probably be no higher than 60 percent of the level of the 24th Street Station. This ranges up to a maximum of 5,700 expected riders. However, it is likely that this number would actually be lower because the residents around the 24th Street Station are more likely to be of lower income levels (and therefore more transit dependent) than those near the proposed 30th Street Station. Because of this, the numbers might be only two-thirds to three-quarters of the 5,700 patronage at 24th Street, or on the order of 3,800 to 4,300 riders. The ridership numbers might be further diminished because of the proximity of the 24th Street Station. On the other hand, patronage

might be subject to increase because the 14-Mission, 24-Divisadero, and J-Church MUNI lines could function as feeder routes to the proposed station.

- The 24th Street BART Station ridership might also be subject to decrease because some patrons who currently ride the 14-Mission or 67-Bernal Heights buses would disembark at 30th Street instead of 24th Street. The number of patrons who access the 24th Street Station by foot would probably also decline, as some would find the new 30th Street Station more convenient.
- Glen Park BART Station ridership might decline somewhat, but probably not to the extent as at 24th Street. This is because 30th Street is closer to 24th Street than to Glen Park, and there is hilly topography, which impedes pedestrian travel between Glen Park and 30th Street.
- Ridership could also possibly attract current automobile users who do not use MUNI to transfer to BART, and also possibly residents of new dwellings development that might be spurred by the new BART station. Thus it is possible that the percentage of persons in this area who commute to downtown by transit would increase by up to 10 percent with a mode split similar to the 24th Street area. This could mean that up to 500 riders of the proposed station just to the downtown area, would be new BART riders.

Based on all the above factors taken together, a value of 3,700 to 5,000 riders might be expected to use a 30th Mission Street Station.

Anticipated New Factors

The above 1998 ridership projections by the San Francisco County Transportation Authority did not anticipate the opening of the BART extension south of Colma and did not include riders using BART to reach San Francisco International Airport, or Millbrae and the Caltrain connection to points along the Peninsula and to Silicon Valley.

In addition, land use changes since that time and as proposed for the future by the City of San Francisco also need to be assessed to estimate the full ridership potential of the new station with any degree of accuracy.

Ridership Considerations:

- 1998 San Francisco County Transportation Authority ridership projection: 3,800 – 5,700
- Caltrain connection at Millbrae could add many new riders to BART
- Riders expected to be diverted to BART from Mission MUNI lines
- Station could attract new riders to other MUNI connecting lines

Currently, the San Francisco Planning Department and various neighborhood groups are planning to revisit zoning, land use and housing changes in the immediate vicinity of 30th and Mission. At the same time, relevant changes are also being proposed for key MUNI transit corridors that link to the 30th and Mission site, particularly along the eastern Bayshore and within the vicinity of Bernal Heights. The outcome of these efforts would be essential in establishing the full magnitude of ridership and benefits that this station could attract, generate and create.

12. INTERMODAL CONSIDERATIONS

BART/MUNI Transfer

The transfer potential between BART and MUNI at a new 30th Street Station would generally be the same for any of the described alternative BART stations and track layouts. Transfer of passengers would be via escalator or elevator to the surface street, where MUNI bus routes load at on-street stops. The service impact of a new BART station would generally occur in one of four ways relating to the existing MUNI routes:

1.a. Those MUNI routes that run approximately parallel to the BART line, and that already serve other existing BART stations, would be expected to lose a very small amount of patronage to BART. These routes include the 14-Mission, 14L-Mission Limited, 26-Valencia, 49-Van Ness/Mission and J-Church light rail. The presence of a BART station at 30th Street would encourage BART passengers with origins or destinations near there, and who presently transfer to any of the above MUNI routes, to consider a transfer to MUNI at 30th Street instead of their present transfer station. Or some of these passengers may be able to completely substitute a BART-only trip instead of their present MUNI/BART combined trip. In either of these cases, the MUNI ridership would be reduced, but probably by only a very small volume. It would be expected that, given the opportunity, passengers with an option would choose to use BART, (assuming equal fare cost) because it is faster than MUNI.

b. It is also possible, however, that the above MUNI parallel routes might regain an even slighter patronage due to the improved BART access at 30th Street. This would be due to the improved SFO Airport and Caltran connections. Thus the parallel MUNI routes would be acting in this role as collector/distributors for BART access. However, the net affect on the parallel MUNI routes can still be expected to be small.

2. For a crosstown MUNI route such as the 24-Divisadero, which presently does not serve any BART station and does not generally parallel BART, it would be expected that related transfer ridership would increase on both MUNI and BART. This is because the opportunity and convenience of transfer would increase the overall performance of transit and therefore draw new riders. Indeed, a transfer between BART and the 24-Divisadero would be the greatest single intermodal improvement of the proposed project. This is due to the large service area of the 24 Line, which extends all the way from the Marina District to Hunter's Point. However, the Hunter's Point connection would be the most significant because all the other northerly neighborhoods along the 24 Line already have more direct MUNI routes to existing BART stations.

3. For a local shuttle route such as the 67-Bernal Heights line, which already serves another BART station at 24th Street, it would be unlikely that a new 30th Street Station would have great impact on ridership. There would be a slight improvement in travel time for transferring passengers using the new station, for whom the bus journey would be shortened.

For those patrons who would be able to substitute BART instead of MUNI for all or part of their journey, comfort, reliability and speed would be improved and crowding conditions reduced.

Parking

The objectives of this project do not include provision of BART station parking. This is in keeping with present BART and City of San Francisco policy, as BART parking in any other San Francisco is limited to a small number of spaces at Glen Park Station. Parking impacts of a new station would be limited to that resulting from surface street modifications needed to construct the new station. These would include possible elimination of some on-street and off-street parking during construction.

But in addition, there is also the potential to improve or increase neighborhood parking as a component of, or a byproduct of the station project. Such improvements could range from merely widening of the existing narrow on-street parking lanes, up to a major increase in parking supply by construction of one or more additional neighborhood off-street parking lots. Such new lots could utilize any surface right-of-way that might be obtained for the project and that became surplus at its completion.

Conversely, if the objective is to strictly limit right-of-way obtained for the station project there may be no excess right-of-way, and it might be necessary to reduce the present parking slightly in order to obtain space for the station entrances or for MUNI bus stops. For example, the large Safeway parking lot on the west side of Mission Street may be encroached upon by construction and also might be considered as the location for future station entrances. Likewise, the Pizza Hut property on the east side of Mission Street, including its parking lot, could be considered as the location of a major station entrance incorporated into a joint development.

Handicapped Access

With respect to ADA and handicapped patron transfer to MUNI at a new 30th Street BART Station, it is expected that few special facilities would be needed on the surface of Mission Street. The gradient of Mission Street at the proposed station location is approximately three per cent, which is well within the five per cent maximum slope required by ADA for pathways and ramps.

Transfer to the nearest ADA-accessible MUNI Metro J-Line stop at San Jose Avenue is approximately 1,400 feet from the proposed 30th Street Station location, and this appears impractical for a direct transfer or connecting pathway arrangement. This transit connection might be regarded as a redundant route option, because BART-to-J-Line transfer is available at other existing BART stations. However, the transfers at Glen Park and Balboa Park Stations are circuitous and not handicapped-friendly due to grade changes or length. The transfer at Civic Center Station is distant from the proposed station site. Thus the J-line transfer at a new 30th Street Station could be a net improvement to connect and integrate BART and MUNI Metro, especially for the handicapped.

Station entrances located along Mission Street and/or on cross streets may be placed in newly constructed sidewalk bulb-outs to avoid blockage of the existing sidewalks. Taxis serving the station could use MUNI bus stops adjacent to the proposed station entrances in a similar fashion as at the 16th and 24th Street Stations.

A possible design refinement would offset the station position toward the west to preserve the east property line, but this would sacrifice more of the property frontage along the west side of Mission Street. Consequentially, post-project redevelopment of these west-side properties at the station site might provide additional area for more off-street space for new bus/taxi pullouts.