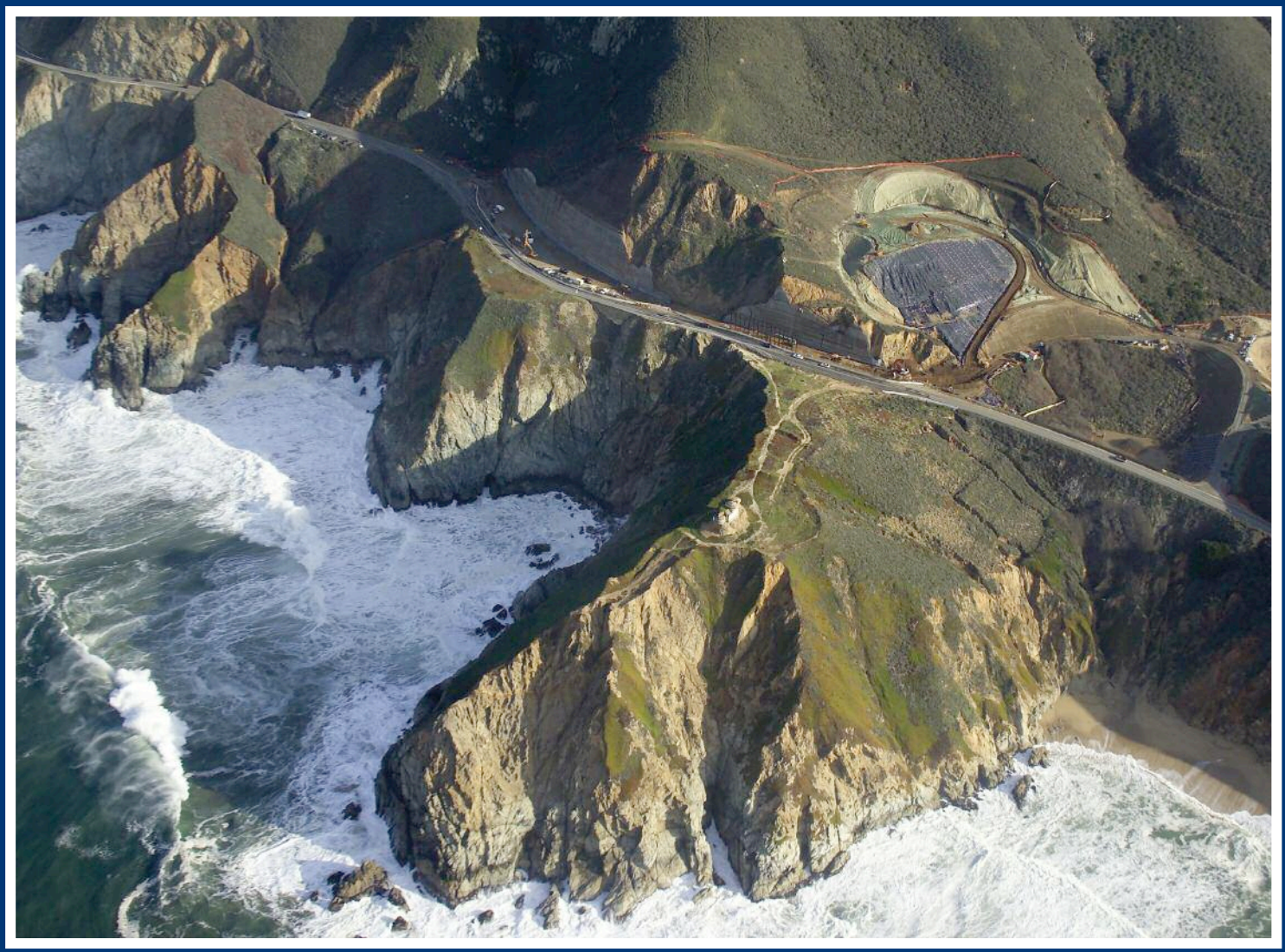
MARCH 2010

tunnels & tunneling NORTH AMERICA



ITA • AITES 2010

World Tunnel Congress and 36th General Assembly

Vancouver, Canada May 14 – 20, 2010

The ITA-AITES 2010 World Tunnel Congress and 36th General Assembly will be held at the new Vancouver Convention Centre which is located along Burrard Inlet in the Coal Harbour area of downtown Vancouver, Canada, May 14 to 20, 2010.

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Sponsored by the Tunnelling Association of Canada (TAC)

A 2-day ITACET tunnel training course will be offered on Friday May 14, 2010 and Saturday May 15, 2010, at the Vancouver Convention Centre. It is organized by ITACET Foundation and coordinated by Garry Stevenson. Numerous tunnelling related subjects and case histories will be offered and presented by industry-distinguished professionals. A certificate of participation will be provided for accreditation of any professional organizations.

Accommodation Deadline: April 1, 2010

A limited number of rooms have been reserved on behalf of participants in several hotels located in downtown Vancouver and in the vicinity of the Vancouver Convention Centre. You are reminded to reserve your accommodation early. May is a very busy time in Vancouver and it is strongly recommended to make hotel reservations as soon as possible.

Visit the Congress website for details, to register and to make your hotel reservation **www.wtc2010.org**

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Organized by the Tunnelling Association of Canada (TAC) and the National Research Council Canada (NRC) on behalf of the International Tunnelling and Underground Space Association (ITA-AITES)

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Front cover

The tectonic collision at the edge of the pacific that is still forming the Rocky Mountains in the US also gives California it wild and preciptous coastline, particularly south of San Francisco and onwards to Monterey and then Los Angeles, the high hills and ridges of a tumbled landscape plunge in steep slopes to the long rollers of the ocean.

The very landscape is also a problem at times for engineers and traffic controllers. The state highway is vulnerable to rock falls from slopes above of up to 70 degrees as weather and sea erosion dislodge material. Particularly difficult is a location known as the Devil's Slide south of the city of Pacifica. A small town, Montara lies to the south.

The Devil's Slide name refers to a rocky peninsula and also a short 180m stretch of the highway, though the project will by-pass roughly 5km of the existing road (p8).

Sustainable jobs

One reason often given for investing in infrastructure is to create jobs. While all in the tunneling industry are in favor of that, construction jobs are, by their very nature, temporary. The world is littered with 'white elephants' created to boost flagging economies or, maybe, to add to the aggrandizement of a totalitarian government or leader. Together with corruption, such projects can give construction a bad name.

However, this is not the whole story. Where investment is carefully planned, and spent at a reasonable price, then far more then construction jobs can be created. This issue of T&T North America highlights some projects where a large number of permanent jobs are expected to be created as a result of the tunneling project rather than in it.

In addition, if carefully managed, improved efficiency, especially in transport, can create more jobs by freeing wealth makers from the congestion of overcrowded freeways etc. Sustainability is not just a matter of conservation, it can also mean long-term benefits from development.

Some projects, and this is not as often recognized as it should be, provide environmental benefits as well as indirect jobs, such as through tourism facility improvements as with the Devil's Slide by-pass tunnel.

The tunnel replacement for the Alaska Way viaduct in Seattle not only replaces and unsustainable transport route that is no longer a real asset for the City, but it will permanently improve the famous waterfront for residents and visitors alike, which associated facilities developments and job opportunities. Also in Seattle, the University Link metro line should also create indirect jobs. Senator Murray, chair of the Senate Transportation Appropriation Committee, has pointed out, "I can't think of a better time to be kicking off a project that's going to create thousands of jobs in the Puget Sound."

Now while politicians are also keen on emphasizing jobs that can be created by their projects, the tunneling industry is sometimes uncharacteristically bashful is publicizing the wider benefits of its work rather than just stating why it can be good to put facilities underground. When competing for even more reduced government funding this is self-defeating.

The US Department of Commerce model not only predicted 2900 direct construction jobs, it estimates that the economic stimulus created by the project will create around 22 800 direct and indirect jobs. This could be considered a nearly 8-fold return on investment

Not only will University Link improve access between highly populated areas and zones of employment, it will be a valuable alternative to driving the very congested Interstate 5 highway – itself a statement in sustainability.

There are many demands on government funds, especially in hard times, but with the creation of the American Recovery and Reinvestment Act, President Obama recognized the importance of investing in infrastructure. There may be many protestors (usually misguided in the case of tunneling) against individual infrastructure projects, including 'NIMBYs', 'greens', and political opportunists. But, if there is a real need, surely investing in real jobs and benefiting communities through long-term infrastructure project investment is one of the best ways of spending limited funds in a sustainable way.

Alive & kicking!

We don't want to bore you with that much-used Mark Twain quotation, but let's just say T&T North America is alive and kicking with its new and expanding team.

We will continue to serve the North American tunneling industries and, like all good tunnellers, do not give up at the first sign of difficulty, real or imagined. Not only will we continue to work for the industry in North America, but also, with the unrivalled international audited circulation of Tunnels & Tunnelling International, we will continue to portray the best of North American companies to the rest of the world.

This author alone has had the pleasure of reporting on tunneling activities in California, Illinois, Massachusetts, New York, Ontario, and Washington (DC and State) and expects to visit many more provinces and states to report on what is going on in tunneling.

But if only seeing is believing for you, then come along and see us at both the ITA World Tunnel Congress in Vancouver on May 14-20 and the North American Tunneling Conference in Portland, Oregon, on June 20-23. We will be there.

Give us the truth and we will do the same for you! ■

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Tuesday 28th September 2010

The ICE, One Great George Street,
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Tunnels & Tunnelling Conference 2010

in partnership with the

British Tunnelling Society

Tunnels and Tunnelling International **and the** ***British Tunnelling Society*** **are proud to announce their second jointly organised conference, following the overwhelming success of last years event.**

This one-day event will feature presentations from both the UK, and the international tunnelling communities with an unbridled focus on 'technical' content.

After years of attending such events, and in a time when picking the right conference for you is vital, we know we can provide content that a tunnelling attendee will actually want from a day's lectures. We will be avoiding the less specific 'brochure' type programmes and marketing style presentations, focussing instead on topics that will benefit you as an engineer.

We will also be encouraging open and frank discussion between presenters and delegates on subjects close to the heart of the tunnelling industry.

Jon Young
Editor, Tunnels and Tunnelling

Watch this space for further announcements but make **September 28th** a date at the ICE

For more information please contact:

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San Francisco's Central Subway

Ground was broken in February on San Francisco's Central Subway.

The US$-1.6bn. 2.7km-long tunnel will form part of a new commuter line running north to south from Caltrain station to Chinatown on the Muni Metro light rail system. The tunnel will be excavated using a TBM. Tunnelling is scheduled to begin in 2012.

The line was originally expected to be operational by 2016 but this date has now been pushed back to the end of 2018.

The Department of Transportation donated US$ 948M towards the project. The rest of the funding will be made up of state and local dollars.

The groundbreaking ceremony took place beneath an Interstate 80 overpass, the location where the subterranean portion of the railway will begin.

San Francisco Mayor Gavin Newsom told reporters at the ceremony that the subway will reduce surface street congestion, will unite cultural centers and create over 40 000 jobs.

The client San Francisco Municipal Transportation Agency estimates that 76 000 people will use the subway daily by 2030. ■

Davenport's West Side Diversion Tunnel

Davenport's west side sewer diversion tunnel in Iowa will get financial aid, it was announced in February.

The state of Iowa will spend US$ 9.5M on the US$ 56M project as part of the I-JOBS bonding initiative.

"With these funds, we are helping these communities meet their immediate infrastructure needs, all while laying the groundwork for future economic growth," Iowa Governor Chet Culver said in a statement.

The tunnel will divert flows from the Jersey Ridge Tunnel, increasing northwest Davenport's sewer capacity and mitigating existing sanitary overload problems. Existing flows often exceed capacity of the Jersey Ridge Tunnel resulting in sewer backups and overflows.

The project will be completed in three phases. Phase One, to replace ageing sewers and improve sanitary sewer capacity, began last October with an expected completion date of September 2011.

Phase Two will begin near the completion of Phase One and will construct the actual diversion tunnel. It is expected to take 24 months to complete.

Phase Three will begin about the time Phase Two is completed and will connect the mainline trunk sanitary sewers to the West Side Diversion tunnel diverting sanitary sewer flow from the Jersey Ridge tunnel. It will take about 12 months to complete. ■

Brightwater move by client

The client in the Brightwater sewerage scheme in greater Seattle will use an emergency powers procedure to replace the contractor on a stretch of bore with the other joint venture on the project. The reason is continued delays to TBM excavation on part of the scheme.

King County will seek to end the Vinci, Parsons and Frontier-Kemper (VPFK) JV's work on the other half of its 21 100ft (6.4 km) long westbound BT-3 bore but leave it to complete the remainder of the eastbound, 11 500ft (3.5 km) long BT-2 drive in the Central section of the sewer.

The plan, which will bypass the usual procurement system, will see another JV – Jay Dee, Coluccio and Taisei (JCT) – undertake the completion work on the BT-3 tunnel. It is working on the West section of the sewer project with its 15.4ft (4.7m) diameter Lovat EPBM driving east towards the Central section.

However, the move needs to be approved by King County Council.

A spokesman for King County said that in deciding to elect for the switch in contractor it does not know the extent of the costs associated with the delays and repairs, or responsibility for extra costs. "Both issues will be subject to negotiation with the companies involved," he said.

Both JVs have experienced challenges with the geology on the project but the VPFK JV had to halt both its TBMs last May due to wear at the rear of the outer rim of the cutterheads. Both drives are using 16.7ft (5.1m) diameter Herrenknecht slurry machines, and the repair work faced the challenge of working at depths of approximately 300 ft (91m) with pressures up to 5.5 bar.

First repair work took place on the BT-2 shield ('Helene') with pressures lowered significantly in sandy gravels by dewatering using five screened wells and two monitoring wells. However, despite the benefit of clayey soils on its drive, the BT-3 machine ('Rainier') has had greater surface access problems due to the more built-up areas below which the alignment passes.

In the third quarter of last year it was anticipated that the BT-2 drive would resume by October but this did not happen until last month, said the client. The BT-3 drive was to have been restarted before the end of 2009 but has yet to happen, and this is the drive that King County wants switched over to the JCT JV to complete.

King County said that VPFK JV had estimated that a further US$ 98M was needed to repair the TBM in the BT-3 tunnel and complete the remaining 10 500ft (3.2 km) of excavation. With the sewage treatment works on schedule to open in late 2011, the client added that the tunnelling plans at present would result in the project not completing until the end of 2013. ■

Palisades funding and award questioned

The funding and priorities of the New Jersey Transit and its Mass Transit Tunnel construction scheme were bought into question by members of the public at an open session of a Special Board of Directors meeting in January.

Following the award of the 1.6km-long Manhattan Tunnel US $583M contract to the Barnard-Judlau jv (see *T&TI* World News January p11), the design-build contract for the Palisades Tunnel has just been awarded to a joint venture of Schiavone, Skanska and Shea. The contract is valued at US $258.75M with 5 per cent contingencies.

Authority to award the contract was sought and given at the special meeting, and it seems to be this that was concentrating the minds of some attendees. The meeting also approved revised contract conditions for tunnel construction management and services. One was for THE CM Consortium (a jv of Tishman Construction Corp, Parson Transportation Group and Arup for construction management services for the Palisades Tunnels at US$15.8M plus 5 per cent contingencies (total contract now US$ 87 990 000), and for THE Partnership (jv of Parsons Brinckerhoff, STV Inc and AECOM) for construction assistance design services at a cost of US$ 3 726 690 plus contingencies (total authorization now US$ 234 338 958).

The Palisades Tunnels will run a mile (1.6 km) from Tonnelle Avenue in North Bergen to Hoboken Shaft in northwest Hoboken. The contract work includes open-cut work from Tonnelle to the west face of the Palisades Mountains, a large-diameter shaft at Hoboken and about 10 000 ft (3 km) of hard-rock tunnelling requiring a TBM for two bores.

There were claims at the meeting that remaining sections of the project were not properly funded. Joseph Clift, member of the Regional Rail Working Group, questioned rushing into approval of the Palisades Tunnel in view of tough fiscal conditions, and noted that he did not see the bids listed on the NJ Transit web-site.

David Alan of the Lacakwanna Coalition said he was shocked by the Board pledge of a quarter of a million dollars to the construction of the Palisades Tunnel at a time when the same management plans to cut service. He said that there would be significant cuts in the Hoboken train service, but received no response to his enquiries. He was surprised to attend a special board meeting, but said he should not have been due to the agenda. He commented that, with the Corzine (State Governor Jon Corzine – defeated in a 2009 election) administration leaving office, the Board would have no further opportunity to pledge hundreds of millions of scarce dollars to huge corporations. He asked for the money to be redirected to build an alignment for a new tunnel to the existing Penn Station, so saving the state the cost of building 'the useless deep cavern terminal' (the new underground extension to Penn Station in Manhattan).

Seattle Alaskan Way details

Following the announcement of a shortlist of design-build proposer groups for the Washington State SR99 bored tunnel project in Seattle (T&TI World News January p7), proposers were due to receive a draft Request for Proposal (RFP) as T&TNA went to press.

Formal proposals must be submitted by the fall with detailed plans for the groups' completion of the tunnel design, constructing a TBM and constructing the tunnel including carriageway, services and controls, ventilation buildings and portal connections. The soft-ground TBM will need to be one of the largest in the world.

The shortlisted proposers are: Seattle Tunnel Group – jv of S A Healy Co, FCC Construccion, Parsons Transportation Group and Halcrow Inc; AWV Joint Venture – Kiewit Pacific, Bilfinger Berger Ingenieurbau, AECOM; VTS Joint Venture with Arup – VTS comprises Vinci Construction Grand Projets, Traylor Bros and Skanska USA; and Seattle Tunnel Partners (STP) – jv of Dragados USA and HNTB Corp.

The contract value is estimated at US$1.96 bn compared to a reported US$ 10.5-11.5 bn estimated for a cut-and-cover tunnel in 2002, but the bored tunnel is now recommended by local authorities including the WSDOT, City of Seattle, King County and Port of Seattle. The whole program current estimate is US$ 3.11bn including associated projects.

The project features a 9100-ft (2.77-km) bored tunnel, plus associated road links and other transport improvements, to replace the waterfront portion of the Alaska Way Viaduct and seawall.

In the outline plans there is an internal double-deck structure within an inner diameter of 52 ft (15.8m) plus smaller passages for emergency egress, maintenance and ventilation. The two 12 ft-wide (3.66m) lanes on each deck will have one 2-ft (0.61-m) shoulder and one 6-8-ft (1.83-2.44-m) shoulder. There will be 16 ft (4.88m) of vertical clearance. The actual tunnel length will depend on proposed relocation of the portals following consultations.

Major construction is planned to commence next New Year for the bored tunnel to open to traffic in fall 2015.

The Seattle Alaskan Way corridor where the work is to take place

Devil's Slide diversion drive

A bypass tunnel on the scenic California coast is well advanced to avoid the Devil's Slide landslide area on the famous scenic Highway One route, reports Adrian Greeman

The tectonic collision at the edge of the Pacific that is still forming the Rocky Mountains in the US also gives California its wild and precipitous coastline; particularly south of San Francisco and onwards to Monterey and then Los Angeles, the high hills and ridges of a tumbled landscape plunge in steep slopes to the long rollers of the ocean.

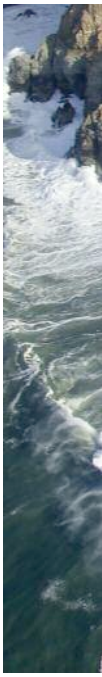
The area is highly scenic, and a major attraction for tourists and travelers, particularly along the famous highway, Route One, which carries traffic on a snaking line 100m up around the spurs of the coastline. There erosion has left major outcrops and promontories. The road has featured in various Hollywood films, a famous cola advert and numerous travelogues. Water sports and the natural environment of the area, much of it protected, are additional draws to the scene.

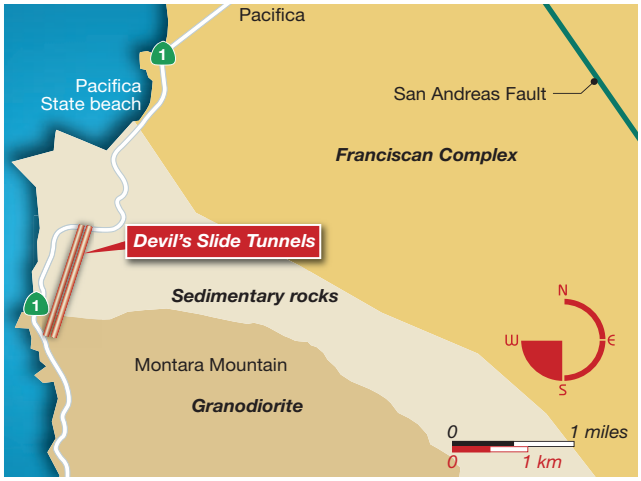
The very landscape is also a problem at times for engineers and traffic controllers. The state highway is vulnerable to rock falls from slopes above of up to 70 degrees as weather and sea erosion dislodge material. Particularly difficult is a location known as the Devil's Slide south of the city of Pacifica. A small town, Montara lies to the south.

The Devil's Slide name refers to a rocky peninsula and also a short 180m stretch of the highway, though the project will by-pass roughly 5km of the existing road. Ever since it was built in the mid-1930s this section has been subject to cracking and slippage, which have caused major problems.

"About every ten years or so there is a major failure and cracking which means the road must be closed," says California Department of Transportation (CALTRANS) principle design engineer Skip Sowko. He is project leader for the Devil's Slide tunnel now underway, leading a team of some forty or so Caltrans staff on the project. "It is a consequence of toe erosion at the bottom of the slopes; the whole mountainside is slowly moving," he explains, reporting that it has a factor of safety less than one.

The closures can last several months as they did in 1995 and again a couple of years ago and this has severe community and





Above: Permanent lining installation in progress viewed from the Ceresola reinforcement gantry end (Photo: John Huseby, Caltrans Photographic Dept)
Right: Simplified geological map of the Devil's Slide area

economic impact, especially as the local businesses concentrate heavily on tourism and leisure. There are few other routes in this largely state park area and so shutdown can be critical, and no more so than in a time of "credit crunch".

Sowko says he is not aware of any fatalities from the rockslides but no one wants accidents. The slides also mean routine maintenance on the section is more expensive.

Bypass schemes, including an inland route promoted by Caltrans, have been under consideration since the 1970s. Initially the state highway agency ruled out a tunnel option, even though there had been a small railway tunnel on the route earlier. That was closed in Prohibition times to prevent alcohol smuggling.

The proposed new tunnel route included a 1250m-long, dual-bore tunnel with a bridge at the northern end, 300m long to leap a final valley. Road approaches of 460m and 305m at the ends complete the link. These have some high retaining walls with a good area of soil nailed structure.

According to Sowko the tunnel was too expensive according to an assessment in the 1980s, but the inland over ground route was controversial because of environmental and ecological considerations. It drew considerable opposition, especially as it had climbing lanes making it wider than the usual single lane each way allowed for in the area. An injunction in 1987, from an environmental lawsuit, suspended work on the project.

"In the 1990s we had another look and the tunneling option was more attractive because of advances in technology," Sanko says. "Relative to the increased environmental impact and land costs of the alternative it was also looking better."

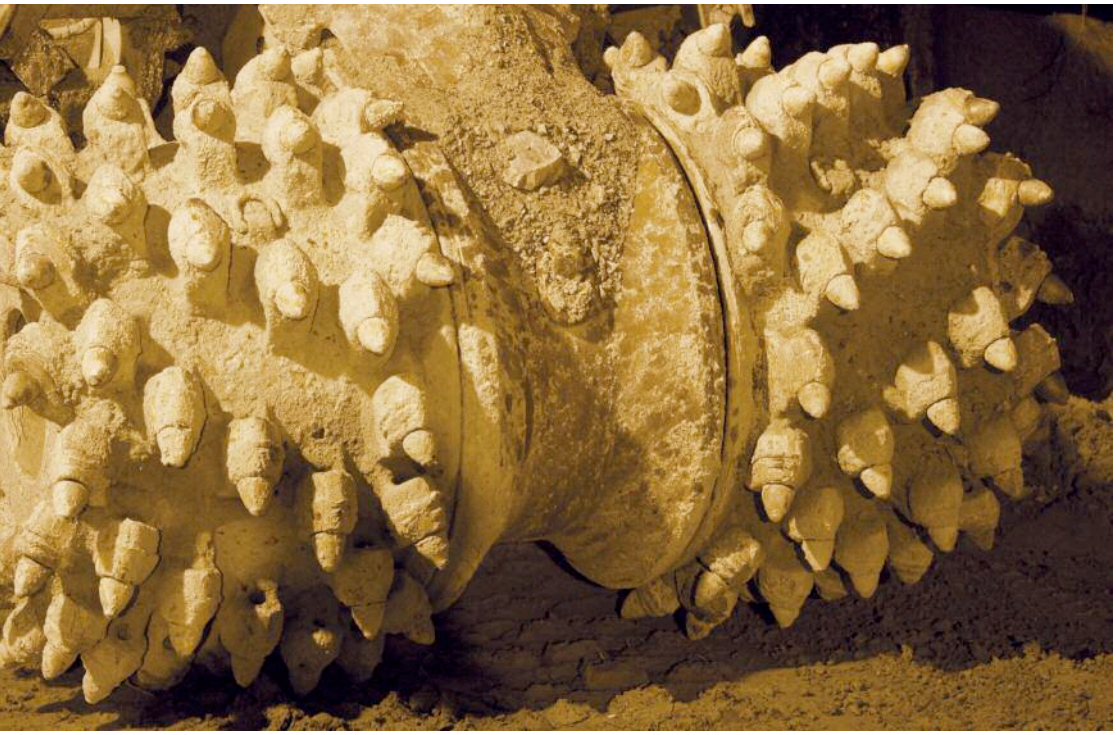
The main technological advances perhaps were the increased use of and familiarity with NATM (New Austrian Tunnelling Method) methods in the US. This was looking like the best way to construct the tunnels, which were not really long enough at 4000 feet (1231m) to justify a TBM. The route also passes through a complex mix of ground.

Geology of the region is fairly young and heavily disturbed by the tectonic activity of the region. The tunnel site lays between the well-known San Andreas Fault system, 8km to the east on the San Francisco peninsula, and another, the Seal Cove fault, just 3km out to sea.

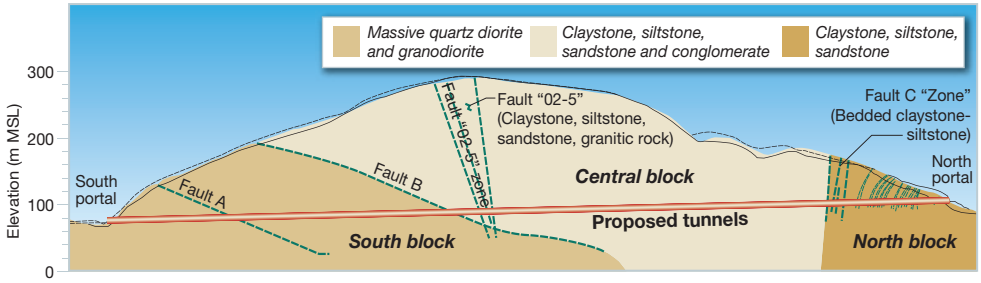
There are two main geological layers encountered; a lower, layer of Mesozoic granodiorites predominantly, and an upper Tertiary layer of marine sedimentary rocks. On the tunnel alignment the harder rock is found in the southern half of the route, in the Montara mountains, and a mixture of claystones, siltstones, sandstones and conglomerates in the next third. This is under part of the adjacent San Pedro mountains. The remainder making up a block on the northern end is strata of the Shamrock Ranch area, also with claystone, siltstone and sandstone. The geology is typical of formations found west of the San Andreas in the Salinian Block.

The effect of the rock types is to create a variable ground "which the flexibility of NATM is well suited to getting through" says Sowko. "We have a whole slew of different rocks and you can find a mixture even in the same face. Being able to modify support metre by metre is important."

The tunnel section of the project comprises two single-lane tubes taking each direction of traffic north and south. Each has a horseshoe profile of inner dimensions 9m (29.5ft) wide and 6.8m (22.3ft) high, which gives room for a single lane of traffic of 12ft (3.6m), sidewalks or pedestrian walkways either side of 4ft (1.2m), and shoulder areas of 8ft on one side and 2ft on the other (2.5m and 0.6m).



Left top: **Roadheader cutterhead (Photo: John Huseby, Caltrans Photography Dept)**
Left bottom: **Aerial view of Interstate 1 at Devil's Slide showing the unstable slopes that are being avoided by the new tunnel (Photo: Bill Hall – Caltrans District 4)**



Above: Longitudinal section through tunnel alignment showing main geological features. The varying surface profile are over the two centerlines of the bores.
Left : The Ceresola travelling formwork before delivery to the site (Photo: Ceresola)

The twin bores are set 18m (59ft) apart with one slightly longer than the other at 4100ft (1250m) and 4150ft (1265m). Cross connections are being made at 390ft (120m) centers, which will be the core of the safety provision, allowing an unaffected tunnel to serve as the emergency and escape route for any incident in the other bore. The ten cross-passages are big enough for pedestrian escape and there is one larger in the centre of the tunnel that can allow maintenance vehicles through, although it is not big enough for large vehicles.

The project was designed and reviewed by Caltrans and consultants, and the plans and specification were completed in early 2006. Kiewit Pacific Company won a competitive tender process in November 2006 that had attracted far more interest than expected with 14 bidders. Kiewit's lowest bid was slightly over estimates at US$ 272M but promising a shortened 1500-day time schedule.

Other contracts were let for the bridge and approach works and some smaller environmental mitigation works.

Mobilizing and preparation work was quite extensive, but tunneling began in fall 2007 with ground breaking at the south portal. Both tunnels are being driven towards the north to emerge at the southern abutment of the concrete bridges, two parallel balanced cantilever concrete arches, which were recently completed. "We were allowed no falsework in the valley for those" says Sowko.

Kiewit is using a mixture of drill-and-blast and roadheader excavation for the tunnel, with some conventional excavator digging when the face is soft enough. Blasting is only needed for the harder igneous rock and some of the sandstone, with most done by two 120-t Alpine roadheaders "which is the most cost-effective way," says Sowko. The ATM 105 machines were purchased new for the work at just over US$ 3M each.

Face advances are made in quite short rounds of 3.3-3.9ft (1.0-1.2m), with two headings - a top and a bench.

The NATM design has five categories of support with the usual shotcrete, rockbolting, spiles, grouted steel pipes and lattice girders used as required, with increasing thicknesses of shotcrete and more steel reinforcement/support for poorer ground.

"The three 'heaviest' categories also involve tunnel invert excavation and installation of a shotcrete invert arch, with concrete backfilling to road level" says Sowko. The lighter categories simply excavate to good rock for the road level.

Caltrans and its consultant HNTB, using borehole survey data produced and analyzed by geotechnical consultant EMI, designed support categories.

"On site the support is the contractor's call though if it was judged too light we would intervene," says Sowko. "Their engineers and ours meet every morning to discuss what is needed and it has gone very well with a good consensus."

Mucking removal is with Caterpillar 730 articulated trucks loaded at the face with roadheader conveyor. Cleaning up from the face is done with a small Cat mini-excavator. Cat equipment also comprises most of the support fleet, including a D9 bulldozer, assorted loaders and for running materials up and down the tunnel, Cat skid-steer loaders.

Drill-and-blast sections use a Tamrock twin-boom rig and mucking out with Cat loaders. The relatively large tunnel profile allows conventional construction equipment to be used.

The tunnels are fairly dry. Though there is some water, it is mainly dealt with by the lead tunnel heading, which effectively acts to dewater the following faces.

"It is not much at all;" says Sowko "perhaps 150 gallons per minute (9-10 liter/s) was the largest inflow though 50 gallons is more like it."

Spoil disposal is in a dump close to the site; this was carefully selected explains Caltrans spokesman Bob Haus "to allow landscaping and contouring." The area is a concavity in the mountainside, which will end up convex, and is being blended into the local landscape. Some 900,000 yd^3 (700,000m^3) of rock will go in eventually.

So far work has gone reasonably well and the rock has only needed more of the lighter support categories than expected, although Sowko says the final 25 per cent or so currently remaining is likely to be the most difficult and demand more heavy support.

Progress has been a little slower than scheduled, which is particularly tight, and one of the winning criteria for the bid. It is nothing exceptional, says Sowko, and he says the contractor has taken some measures to accelerate, including 24/7 working.

There have been a few changes to the contract value which is currently US$ 300M, "but there is nothing outstanding and we are close to budget" says Sowko. "There is the usual range of potential claims," he says. But he adds that relations with the contractor are good and the product "is of good quality so far." The tunnels should be holing through in the fall this year.

Following excavation there will be installation of an in situ lining of 14 inches (350mm) of concrete over a fleece and watertight membrane, using Ceresola formwork. Ceresola also supplied Kiewit Pacific with a gantry for erection of the steel support elements. The tunnel will be drained at the sides.

An unusual element is a texturing of the concrete lining near the portals. The portal itself projects slightly from the mountain face in a horseshoe similar to the tunnel barrel and with a cut back slope matching the mountainside.

The outside and inside concrete faces are textured using polymer form liners which as far as possible match the rock texture of the hillsides around the portals, to make an architectural blend.

Landscaping is important all round for the tunnel and the control building area on the south side. It therefore comprises a sunken basin with the building half buried to keep its profile low. The building is part of the tunnel contract.

The tunnel electrical and mechanical fittings include the now standard modern CCTV and road loop surveillance, with linear heat detectors for fire. Doors and switches are monitored telemetrically at the control center, which can display messages remotely with variable message signs at intervals.

"The monitoring is also replicated at the regional control centre," says Sowko.

Traffic should be running on the new route line in 2011, with roughly the same 2000 vehicles/h average as on the existing highway itself.

Meanwhile the work also includes further landscaping, tidying up and external drainage. The conversion of the old section of highway into a country walk and hiking path is also part of the job once the traffic has been diverted. ■

Wetting Washington

Water company engineers in Washington have moved away from traditional cut-and-cover techniques for water main installation, instead opting to tunnel through hard rock

Contractors working for the Washington Suburban Sanitary Commission (WSSC) on the bi-county water main project have had a challenging couple of weeks. The worst snow fall in over 100 years hit the region in early February with more than 24 in. (60cm) recorded in a single event. So severe were the conditions that airports were closed, and the roads were so icy that snow ploughs were not allowed to be used.

"It has impacted on us in the last week but I don't anticipate many weather delays once mining starts," says Tim Winn, project manager for the Renda Southland contracting joint venture.

The bi-county water main is named after the two areas served by the WSSC; Montgomery and Prince George's County. The area has over 1.8 million customers, spread over 1000 sq miles (2600 km^2) making WSSC the 8th largest water and wastewater company in the US. "We knew that we would need this water main or some portions of our

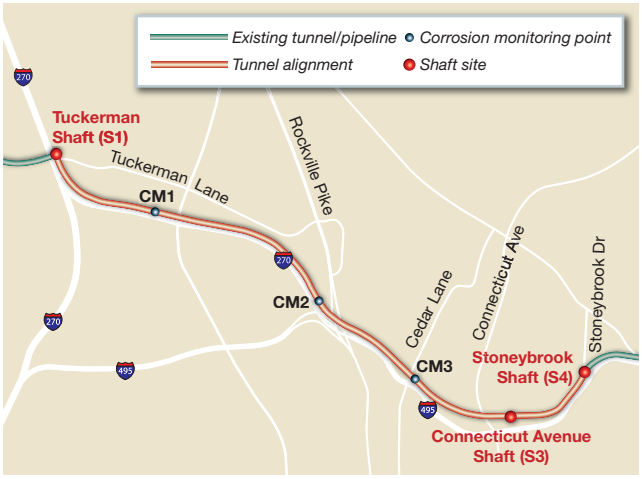
Above: **The main working shaft is 75 per cent complete and will be 160ft (48.8m) deep.**

service might experience low water pressure under very specific conditions in the future," explains WSSC project manager for design John Mitchell.

Plans to install a new larger main and boost supply capacity have been in progress for over 30 years. "The project went into a number of planning studies. It was originally envisaged in the 1970s but we continued to postpone construction until we have reached this point of need," says Mitchell.

Once WSSC had decided on the route of the new main they were then left with two options; either to use the traditional water main construction technique of cut and cover, or go for a tunnelled option. "We chose the tunnel because over time tunnel technology has improved and bought the cost closer [to cut-and-cover] and also this particular alternative minimizes disruption to WSSC customers and is more environmentally friendly," says Mitchell.

Building the new main involves construction of an 84 in. (213 mm) diameter steel water pipe, running for 5.3 miles (8.5 km), that will boost water supplies to the catchment area by up to 100 million gallons/day. Site preparation began in August 2009 and the team is aiming for completion in August 2013. Three contractors are working together on the US$ 113M project; pipeline specialist Oscar Render Contracting from Roanoke, Texas; tunnel specialist Southland Contracting from Fort Worth, Texas and pipeline and tunnelling contractor SAK Construction from



Above: Tunnel route map (Courtesy Ron Williams/WSSC)
Left: Working space is tight around the working shafts but Conneticut Avenue has six acres for contractors.

St Louis, Missouri.

Despite the bad weather the team is working hard to keep to the relatively tight construction programme, which sees the 3m diameter Robbins-main beam TBM arriving on site in early March. "Assembly will take three weeks to a month so boring will begin in April," says Winn.

Boring is set to start from the Connecticut Avenue shaft and head east for 4100 ft (1250m) before returning to the main shaft and heading west for most of the bore, which is 21 000 ft (6400m).

"Our main working shaft is about 75 per cent complete. We have also begun the first receiving shaft which is about a third of the way complete," says WSSC project manager for construction Steve Pinault.

The main working shaft situated at Conneticut Avenue will be 35 ft (10.6m) in diameter and extend down to 160 ft (48.8m) below ground level. The site was previously used by the Maryland State Highway Administration for construction work on the nearby I-495 and so an area of six acres had previously been cleared, providing WSSC's contractors with working space.

The receiving shaft, called the Stoneybrook shaft will be 110 ft (33m) deep with a 20 ft (6m) diameter, and a final retrieval shaft – the Tuckerman shaft - sits at the end of the bore. "We are excavating with drill-and-blast for the tail and starter tunnel to install the TBM and we will begin mining towards the Stoneybrook shaft from Connecticut Avenue. We hope to average approximately 80 ft (24.4m) per day," says Winn.

To use drill-and-blast in a suburban area, WSSC has had to work hard with the local community to inform them as to the impact of the works. Any residents within 1000 ft of the blast site were offered pre-blast surveys of the property. Peak particle velocities are to be limited to below 1 in./s for any surrounding structures, and blasting hours are 7am to 7pm. Consultant McKown Associates has been appointed to advise the contractor on blasting.

Ground conditions along the route of the main are classed as good to very good and at the depth of 200ft there are just two types of rock formation present: "There are two types of rock. Syskesville formation of metamorphic gneiss and schist, and then the Georgetown intrusive suite of metamorphized quartz, tonelite schist and amphibolite," explains Mitchell.

The rock analysis was performed using 21 borings taken along the formation and data from three previous boreholes were also used. "We also reviewed existing information from a previous WSSC tunnel and metro construction in the area," says Mitchell. It was the location of the hard rock that dictated the depth of the tunnel. "We wanted to construct deep enough that we stay in solid rock the whole time and avoid mixed face conditions," says Mitchell.

Rock bolts will support the tunnel and a series of ribs will be installed in areas of poor ground. "These are to be confirmed on site," says Winn.

The bore itself is scheduled to take 14- 15 months and a major concern for the site team is the small diameter versus the length. "To move enough air into the face and remove the muck in an efficient manner is going to be pretty difficult as we get into the longer portion of the project, further away from the access shaft," says Pinault "To manage this we are going to use a continuous ventilation pipe, which is to be rolled on site. We also have reversible fans and back up systems."

Muck removal will be a straightforward cart locomotive system with the material being used as fill locally. If contractors achieve the planned 80 ft/day (24.4 m/day) there will be 233 yd^3/day (178 m^3/day) of muck to remove and with swell this could increase to 350 yd^3/day (268 m^3/day). "Our peak truck volume is up to 480 yd^3/day just to be conservative," says Mitchell.

More challenging for the team is the pipe installation which follows on after the bore. Each steel section is 160 ft (50m) long and must be welded to the preceding pipe before the team grout the surrounding area. "The biggest risk section is the tunnelling but once this is complete there is the phase where the steel pipe is inserted and that is a significant amount of work," says Pinault.

However according to WSSC the biggest challenge has been in communicating the project to the local community and getting its support. "The trickiest thing was the community outreach and getting 'buy in'," says Mitchell. "Two of our working shafts are located within the property of Maryland National Park and Planning Commission, so we needed permits from agencies for work within the park and that took a lot of coordination and planning to obtain."

In addition due to the urban setting work areas at the shafts are generally small, particularly at the receiving shaft, Stoneybrook where space is constrained by a wetland, a major road, a national park and private property.

"We are making the most out of every inch of space. The road and wetland come together at that point, and the property owner adjacent did not want us to take any space from them. Everything we could get we got from the park," says Mitchell.

The proximity of the working shafts to private properties means that the team are being extra careful to keep the neighbours happy. "We are within a few hundred feet of residents so we are trying to be good neighbours. We are in close quarters for quite some time so that is my biggest concern," says Winn.

Despite the space constraints, proximity of neighbours and terrible weather, the team remain upbeat about meeting their construction timetable. Over the next few weeks the TBM will arrive at the site from another project in St Louis and assembly is expected to take three weeks. At the same time the team continues to excavate the shafts and prepare for the drill-and-blast of the tail and starter tunnels. By the summer of 2011 boring will be complete and construction of the steel water main can begin. By 2013 residents of Prince George's County and Montgomery will benefit from increased water supply. ■

Probing the 710 freeway gap

Tunnel options are being evaluated following extensive site investigation for the 'missing link' section of California's 710 freeway reports Patrick Reynolds

With completion of the draft geotechnical study into five possible routes to including a tunnel option for the 4.5-mile (7.2-km) 'missing link' of the SR 710, in the freeway network north of Los Angeles, consultations are underway to brief the public on what's been learned to date and to debate the alternatives.

The feedback is being pulled together for the final report, due for completion shortly, following which a decision will be made on how to proceed, says California Department of Transportation (Caltrans), which is working with Los Angeles County Metropolitan Transportation Authority (Metro) on the studies.

Traffic congestion is the main driver for completion of network. At the moment the existing 710, or Long Beach Freeway runs north and just stops. Vehicles are diverted onto two stub roads which exist to tie-in the missing section of 710, and so bypass the 4.5-mile (7.2-km) long gap that has remained a problem for almost half a century as various concepts have been proposed, evaluated and deferred.

The problem with the previous project proposals – all surface roads – was that each failed to meet regional mobility needs and also satisfy both community and environmental concerns. No-one was happy about plans for a road to plough through their neighbourhoods, no matter how carefully and sensitively it would be engineered. But the traffic problem remains, and grows worse every year.

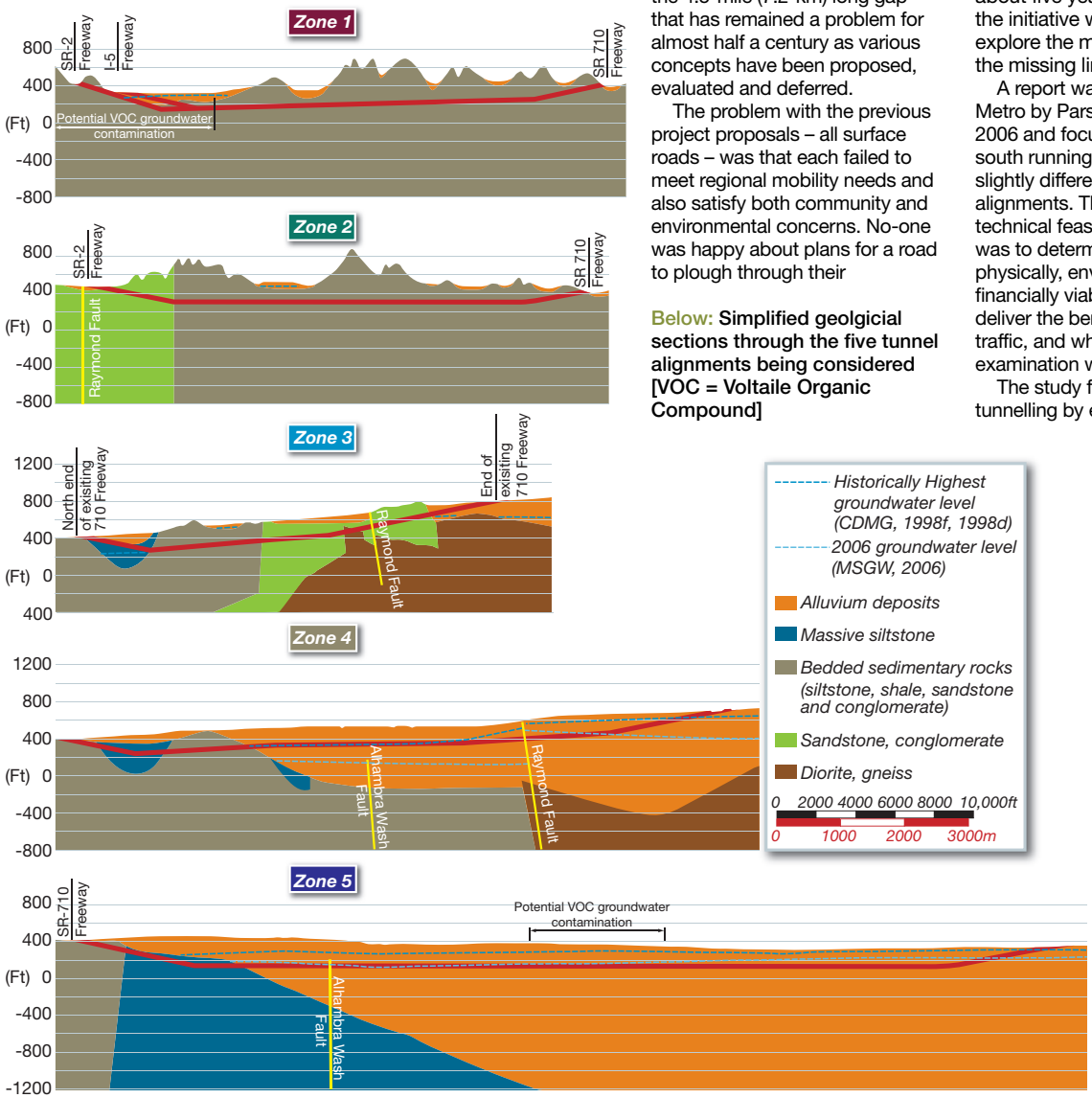
Tunnel Studies

The Southern California Association of Governments (SCAG) has had the problem listed in its regional transport plans for the last 20 years. Then, about five years ago, Metro took the initiative with Caltrans to explore the merits of completing the missing link underground.

A report was produced for Metro by Parsons Brinckerhoff in 2006 and focused on the north-south running corridor which held slightly different horizontal tunnel alignments. The key aim of the technical feasibility assessment was to determine if a tunnel was physically, environmentally and financially viable, and could deliver the benefits sought for traffic, and whether more detailed examination was recommended.

The study focused on deep tunnelling by either TBM or

Geological section and tunnel alignment within:



Below: Simplified geolgicial sections through the five tunnel alignments being considered [VOC = Voltaile Organic Compound]

sequential excavation method (SEM) for most of the route of the twin-tube project. Each bore would hold four lanes, and in the study the TBM-driven outside diameters were estimated at 48ft-57ft (14.6m-17.4m). SEM drives would be mined to widths of 60ft-72ft (18.3m-22m). Major ventilation structures would be required to be excavated along the route.

The report concluded that the scheme was both physically and environmentally feasible, and placed the estimated cost at USD 2.3bn-3.6bn (2006 prices). It was estimated that the construction period, from mobilization of project resources to opening of the new tunnel to traffic, could be about nine years for the TBM build methods and 11 years for sequential excavation alternatives.

The most recent push to explore the tunnel option began in mid-2008 when Metro and Caltrans launched a programme to examine five potential routes that fan out from the southern stub road, including the north-running corridor from Los Angeles towards the Foothill Freeway (Interstate-210), in Pasadena, this time called the Zone 3 option.

The approach to the alternatives has been 'route neutral', they said, but add that as well as relief of traffic congestion a secondary benefit is to improve air quality.

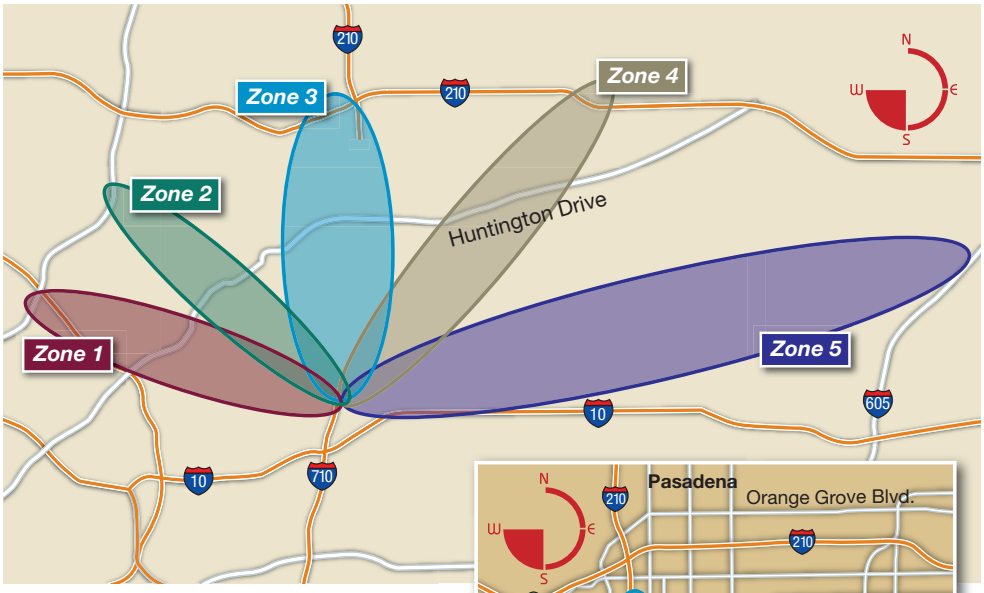
Site Investigation

With five corridors being examined – Zones 1-5 (see sections) – the SR 710 Tunnel technical study covers a large area and has involved significant site investigation work, though no significant environmental assessments. The study area encompassed the cities of Alhambra, Glendale, La Canada-Flintridge, Los Angeles, Monterey Park, San Marino, South Pasadena and Pasadena.

The site investigation work was undertaken by Caltrans' geotechnical services unit in conjunction with a jv of consultants comprising CH2M Hill, Earth Mechanics, Jacobs Associates and ILF.

The range of field works included mainly borehole sampling and tests, and geophysical surveys, for the route of a hypothetical tunnel of 50 ft (15.2m) width and an invert level that runs approximately 200 ft (61m) below the surface, though there is consideration of tunnel excavation taking place at depths of more than 250 ft (76.2m).

The aim of the analyses was to determine geotechnical factors – strata, groundwater and seismicity – that would affect tunnel design and construction, and also means of comparing the data.



Above: **Horizontal alignments of the five tunnel optiuons under consideration**
Right: **Map of general alignment of the corridor requiring the connection between Interstate highways**

Field Exploration

Along the corridor studied previously, in the 2005 study, and named Zone 3 this time, both igneous and sedimentary formations had been found but volcanic rock was unexpectedly found in one borehole, at a shallower depth than expected for a tunnel. The geological structures had bedrock units folded into a series of synclines and anticlines, plus there were a few major faults. There was only limited information on deep groundwater.

In the latest site investigation, carried out in the first half of 2009 with analyses in the following months, the work was carried out again in Zone 3 and the four new zones. All five are set out as trapezoidal-shapes with three (Zones 1-3) having of a similar average length of approximately 5 miles (8 km). The other two are longer; one slightly and the other very much – Zone 4 is almost 7 miles (11.2 km) long on average, and Zone 5, running to the east, is approximately 10.5 miles (16.8 km) long.

To supplement previous site investigation data the team could draw upon, the latest field exploration undertook a further 25 core borings, mostly in Zones 1-3, plus 17 seismic reflection lines and 78 surface wave lines, the geophysical surveys being spread reasonably evenly over the zones.

Previous data called upon 286 borings, and in each of the zones these broke down as 74 in Zone 1, 61 in Zone 2, 40 in Zone 3, 34 in Zone 4 and 77 in Zone 5. The least amount of data was available for Zone 3, and hence the site investigation work focused more in that area. Literature reviews show that the five zones straddle five separate groundwater basins. There is no correspondence of zone limits to those of the basins.

The Zones

Zone 1

A tunnel in Zone 1 would be bored mostly through weak to moderately strong formations mainly of sandstone and thin siltstone interbeds but with some other sedimentary strata plus some marine deposits. The potential for methane gas in the sedimentary strata presents concerns. Groundwater may have some toxic contamination due to the presence of a dump (San Fernando Valley Superfund site). Alluvium might be found in the portal areas, and groundwater level within the formation is shallow. There are several inactive faults.

Findings were that the low strength and uniform nature of the formations in this zone suit TBMs, and higher progress rates would be expected, as compared to most of the other zones. Alluvium at the portal areas would require ground treatment and groundwater control. When crossing the Los Angeles River, lower cover to the tunnel could increase the potential for significant groundwater inflows, although the formations in general would not be expected to have much ingress. There is also the concern related to the presence of methane in the formations, as has been experienced with other tunnelling projects in the region. A further concern relates to whether groundwater may have some toxic contamination due to the presence of dumps, and so might present a chemical attack risk for the tunnel lining.

Zone 2

This zone would see the bore pass through similar formations to Zone 1, including shale, but

older. There is also the possibility of local volcanic intrusions. The potential for methane gas exists, like Zone 1. There is an active fault and several inactive faults. The steeper terrain is expected to mean less possibility of alluvium at the portal areas. Groundwater is shallow in the alluvial valleys.

Similar to Zone 1, there are weak sedimentary strata which are expected to be favourable for efficient TBM excavation. While there are no river or toxic groundwater concerns along this alignment, there is some potential for encountering methane and also there is an active fault to cross – the Raymond Fault. Such a difficult tunnel design has been undertaken previously, at the Hollywood Hills tunnel of the LA metro.

Zone 3

Data shows this zone to be the most geologically varied with formations ranging from weak sedimentary layers, and alluvium, to strong granitic rocks. There is less potential for methane gas. There is an active fault (Raymond), which is also a groundwater barrier. There are also several inactive faults. Groundwater depth varies significantly. As the earlier study also identified, there are folds.

The more varied geology of this zone is considered to present a greater challenge to tunnelling with lower progress rates, and even more specialised approach to driving through alluvium is suggested to be needed. While the potential for methane is less due to proportionally less sedimentary deposits, the route is like Zone 2 as it would have to content with the Raymond Fault but at a deeper location, farther from the portals.

Zone 4

Mainly alluvium (possibly with cobbles and boulders) and unconsolidated soil deposits lie in this zone, although there are some sedimentary formations, like Zone 1. The risk of methane gas is estimated to be the least of Zones 1-4. There are two active faults (Raymond, Alhambra Wash). Depth to groundwater varies a good deal, but most of the tunnel would be below groundwater level. The possibility of toxic contamination of groundwater due to a dump (San Gabriel Valley Superfund sites) is a concern.

Ground stability presents a key risk for tunnelling in this zone. This zone would be expected to see active groundwater control, closed mode drives and the slowest progress rates of the alternative excavations of Zones 1-4 as effort is made to also minimize the risk of ground movement in alluvium, and consequent surface settlement. The methane risk is viewed as the least among the Zones 1-4 alternatives. Like Zone 2, however, there is the challenge of crossing two active faults – the Raymond and the Alhambra Wash, the former being the greater risk.

Zone 5

Neighbouring Zone 4, this zone has similar formations of alluvium or unconsolidated soil deposits. Methane gas risk is similar to Zone 4, and so is much less than the other zones. There is only one active fault (Alhambra Wash) but the risk of toxic contamination of groundwater is viewed as greater due to Superfund sites (San Gabriel Valley). Like Zone 4, most of the tunnel would be below groundwater, the depth of which varies.

Being the longest zone and requiring the longest tunnel, this presents a proportionally greater challenge than for a bore in the similar geology of Zone 4, in terms of ground stability, groundwater control, close mode drives and methane risk. Potential for groundwater contamination is greater, too, due to more Superfund sites in the zone, and this increases the risk of chemical attack over a greater length of tunnel. However, there is only one active fault to be crossed, the Alhambra Wash.

Further Steps

The study concluded that from a geotechnical perspective, based on previous data and new information gathered and analyzed, tunnelling is feasible in a five of the alternative routes.

Following the public consultations and finalizing the geotechnical report, the project investigations for the twin-bore tunnel would progress to studies that will result in an Environmental Impact Report.

At that stage, in addition to environmental assessments, the analyses will also address further design matters, including risk mitigation, seismic design, fault/rupture displacement, cross passages, shafts and ventilation, constructability and, of course, a review of the cost estimates. ■

Go fourth at Caldecott

The fourth bore dig at Caldecott tunnel is set to start on site reports Patrick Reynolds

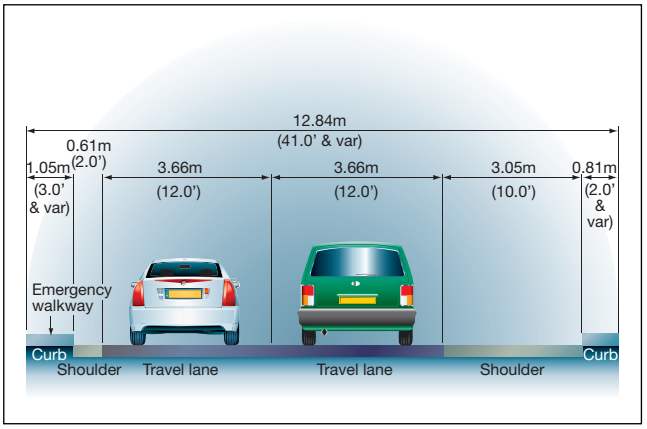
After winning the US$214.8M contract to build the fourth bore of the Caldecott Tunnel with a bid that was both cheaper and faster than the engineer's estimate, Tutor-Saliba plans to excavate the 3,389ft (1,033m) long tunnel tube through weak, sedimentary rock mostly using roadheaders.

Site clearance commenced in late January and the contractor is building a 1,000ft (305m) long by 35ft (10.6m) high sound barrier near the west portal to limit noise to neighbours from construction activities.

Tunnel excavation is to start by mid-year with faces being advanced from each end. The contractor has mostly discounted use of drill and blast as an excavation method due to proximity of the new tube to the live road tunnels it is to supplement on SR24 at San Francisco, and also the time and noise restrictions on using other methods.

Located in the Bay area of San Francisco, on the border of Alameda and Contra Costa Counties, the Caldecott Tunnel was opened in the 1930s as a twin-bore route and has been progressively expanded, first in the 1960s with a single bore addition and now the fourth tube project is underway.

The first, twin bores are both 3,619ft (1,103m) long with an emergency walkway between the tubes. The bores each carry two-lane traffic but have no shoulders. The third bore, to the north, was added in 1964 and is 3,771ft (1,150m) long with two lanes plus narrow shoulders at either side, plus walkways at each end. For future expansion, a corridor to the north was included in plans.



Left: **The cross section of the Caldecott fourth bore**

Above: **Local officials celebrate the ground breaking**

Commuter traffic to and from the Bay area is effectively throttled with the eight lanes of the SR24 reduced to six at the Caldecott Tunnel. The middle bore operates a reversible flow, usually with a twice-daily switch. The fourth bore will unblock the bottleneck by matching the number of lanes to the rest of the highway, and so help relieve traffic congestion in the non-peak direction. The new tunnel will carry westbound traffic.

Planning

Given its local importance to road network and wider strategic value to the state economy, the Caldecott Improvement Project is a partnership project between California Department of Transportation (Caltrans) and two county agencies – Contra Costa Transportation Authority (CCTA) and Alameda County Congestion Management Agency (ACCMA).

However, despite having the protected corridor and traffic congestion, the timing of the construction of the fourth bore had to be assessed with studies starting almost a decade ago, including a no-build option. In addition, though, there were further variations to a fourth bore explored, such as adding lanes on northern and southern alignments.

The option selected four years ago calls for construction of a 42ft (12.8m) wide horse-shaped tunnel holding two lanes of 12ft (3.66m) width, a 10ft (3.05m) main shoulder adjacent to the curb on the south side, and a 2ft (0.61m) minor shoulder next to an emergency walkway on the north side. The fourth bore will be linked to the third tube by seven cross passages spaced 394ft-544ft (120m-166m) apart.

Additional works include road realignments, rehabilitation, and construction of new building operations, maintenance and control with consequent relocation of systems.

The state and local agencies established their partnership in 2004, and the main consultant on the scheme is Parsons Transportation Group with other consultants including Jacobs Associates and ILF. The scheme was costed at US$230M-US$250M (2007 costs) before final design commenced and Caltrans undertook the construction procurement stage last year. The scheme is fully funded, including a federal contribution.

Construction of the new, two-lane bore is to be completed by the second quarter of 2014.

Construction

The initial plan was for contract award in the second quarter last year and work to start about August for completion by late 2013 or early 2014. However, Caltrans considered the complexity of the project merited the award being put back by 6 months.

Left: A view of construction on the first bore of the Caldecott

Tutor-Saliba submitted the lowest of four bids, which were opened in September. It proposed a construction period of 1105 days – about six months shorter than the engineer's estimate – and a price that is one-fifth below the threshold of almost US$275M. One other bid came in below the estimate, from Barnard Flatiron JV.

Geology comprises dipping marine and non-marine sedimentary formations (sandstone, shale, chert, mudstone, siltstone and conglomerate) with sections of crushed rock and the alignment crosses four fault zones. Rock strength ranges from UCS approx 1400psi-7000psi (approx 12MPa-50MPa).

Tutor-Saliba will drive the face from the east side and its subcontractor Foxfire will excavate from the west end. Using roadheaders mainly, except where drill and blast is best for possible hard rock, the faces will be advanced by sequential excavation and given the anticipated fractures, low competency of the rock then progress on each drive may be 1m-2m per day, it is expected.

The proximity of neighbours prevented drill and blast during night shifts and much of the day, and traffic flows in live tunnels also restrict the windows of opportunity. As a result, only blasting at noon would be possible. In addition, other work would have to stop. Consequently, the contract will rely on roadheaders as much as possible.

Excavation support will mainly be with shotcrete, rock bolts and ribs. Following installation of a waterproof liner a further layer of shotcrete will be placed.

The tunnel package represents just over half of the entire US$420M scheme. About 47% of the total project cost, or US$197.5M, is being met by federal stimulus funds. As of January, the Caldecott Improvement Project was among the country's largest stimulus investments.

Construction of the new, two-lane bore is to be completed by the second quarter of 2014. ■

GUANGZHOU | SACRAMENTO | DELHI

SWIFT EPB.

At 336 m in one month, a Robbins EPB is tunneling the Guangzhou Metro faster than any of the other 60 TBMs on-site. In Sacramento, a Robbins EPB has achieved a rate of 45 m in 24 hours — while installing PVC-lined concrete segments. And in Delhi, a Robbins EPB has advanced a record 202 m in one week—beating the rates of the other 14 machines on the Metro project.

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