Chapter 6

PERMANENT DISPOSAL WORKS

The ten year operation of the disposal plant as an activated sludge process afforded ample time for investigation of the proposed White’s Point tunnel and ocean outfall as well as final design and construction of these two important structures. In 1933, prior to final decision regarding the use of a tunnel to reach the Point, borings were taken along the proposed route. While the boring showed vividly the heterogeneous composition of the Palos Verdes pile, they disclosed nothing which would lead to the abandonment of the idea of tunneling or the route selected. The rock floor of the ocean outfall site was drilled where rock was disclosed and wash borings were taken in the sand bottom beyond the rock. All physical factors seemed to be most appropriate for the construction desired. There was little experience to guide one in the design of the ocean outfall, particularly since it was to be built directly in a busy ship roadstead. District engineers, pipe manufacturers, and metallurgists put together their best ideas and adjusted them to those of experienced marine contractors which resulted in a pretty useful and sound structure. The tunnel presented no unusual features.

Certain design criteria appeared essential to the safety, security, and appropriate operation of the White’s Point tunnel and the ocean outfall. The tunnel would obviously need be lined with reinforced concrete. To protect the lining from destruction by
oxidized hydrogen sulfide gas, the tunnel would be required to flow full at all times, regardless of the quantity of sewage flow or the position of the tide. Thus, the invert of the 8-foot nominal diameter lining was established at minus twelve feet U.S.G.S. datum which, with a salt water density equivalent of 2.5 feet over the ocean outlet, would meet this requirement. Grade of the tunnel was level from the plant to the sea. Entrained air escape vents were built into the structure near the inlet end to permit release of air entrained by entrance turbulence.
MANHOLE ENTRANCE ON OCEAN OUTFALL—Cast iron manhole frame was welded to the concrete pipe reinforcing prior to pouring concrete. Manholes placed at 500 foot intervals. Covers were clamped in place. Note wedges for tightening clamps.

The ocean pipes were designed of reinforced concrete; they were 60 inches in diameter and of 7-inch shell thickness. Alternate pipe sections were joined together with universal metal ball-and-socket joints, completed topside. The couples were joined under water with a short moderately flexible joint. Joining rings were made of Meehinite cast iron, to which it was possible to weld securely the pipe reinforcing steel and which otherwise had the corrosion resistance properties of gray cast iron. Cast iron manholes were built into the pipe at 500-foot intervals throughout its length, and the outlet end of the pipe was equipped with a three-jet, cast iron diffusion structure designed to encourage mixing with sea water and discourage spread of the sewage field at the ocean surface.

The outfall was double-barreled past the breaker line. A trench was blasted through the rock and both pipe completely embedded in concrete therein. Past the breaker line, the east pipe was directed easterly for its short remaining distance and closed with a timbered bulkhead which could be readily removed when it became necessary to extend the line. As a safety measure, the east
OUTLET STRUCTURE FOR FIRST OCEAN OUTFALL.—Breaking the flow of effluent into three jets promoted more rapid mixing with sea water, greater dispersion and, consequently, faster breakdown of the field of contamination.

trench was carried 150 feet farther seaward to obviate blasting close to the west line in place. The west line continued seaward in trench through rock, gradually emerging to the ocean floor. From about 2000 feet offshore and at 50± foot depth of water, pipe was laid directly on the ocean floor and continued in this manner to the end. The diffuser structure was elevated slightly above the floor to prevent aspirator action of the emerging jets of sewage effluent and ocean currents from causing under-cutting of the pipe. Each pipe was crossed with a 60-inch cast iron gate valve at the tunnel outlet.

The job was completed by the Merritt, Chapman, Scott Company for a bid price of $528,000. Subsequent experience with the line in operation indicated necessity for placing gravel alongside the pipe where it was laid on the ocean floor on sand to prevent scour occasioned by ocean currents. This work was done by District forces about 3± years after the line was placed in service.

It cannot be said that this ocean outfall was entirely successful. Of the structural materials, the iron showed marked electro-
GATE VALVES—TUNNEL TO OCEAN OUTFALL.—Sixty-inch diameter gate valves were placed at the shore ends of the two ocean submarine pipes at White’s Point. They have been in frequent use in revision and extension of the lines.

Ilytic effect within twenty years and at the rate of destruction noted at that time, would have been destroyed in some fifty years unless protected. Corrosion of the pipe end rings, where embedded in the pipe concrete, was sufficient to fracture the concrete at some of the joints, as was particularly noted when obsolete ammunition was detonated along side the pipe by military personnel who were fishing with explosives in the area. Concrete in the pipe walls was unaffected by salt water as was evidenced by cores taken from the
shell after twenty years of immersion. Concrete embedment appeared unaffected by use of sea water in mixing concrete for this purpose.

After investigation of the proposed Palos Verdes tunnel route including test borings of the entire line, the engineering staff concluded upon a horseshoe section, reinforced concrete lined, tunnel section, 8-foot nominal diameter. The proposals for construction were presented to bidders in three schedules, No. 1 (south) 9,072'; No. 2 (middle) 14,050'; No. 3 (north) 9,102'. The division into three schedules was dictated by soil conditions and location. Schedule 1, the ocean end, would quite obviously be excavated from the outlet portal, Schedule 2, the center stretch, would probably be excavated and completed using a shaft for access; Schedule 3, at the upper end, would be attacked from the inlet end or portal. In addition, Schedules 1 and 2 would probably be largely in rock and most likely wet, while Schedule 3 was indicated by borings as being sand and dry. Contract was awarded to Shoemaker and Gordon for Sections 1 and 2 and to United Concrete Pipe Company for No. 3.
The United job proceeded with promptness and dispatch. No water was encountered. The excavation method employed was crown spilling over 4-inch or 5-inch "I" beam ribs and side lagging where necessary. The maximum day's excavation was almost exactly 100 feet. The average was considerably less. Excavation equipment was excellent for the ground encountered. A small power shovel operated in the heading, loading directly into a belt which discharged onto an endless belt supported on a frame. The frame, slightly longer than a train of muck cars, was mounted on trucks which ran on rails with a gauge wider than the muck cars. The frame-supported belt discharged into muck cars which were spotted under the discharge end as excavation progressed. Men on the job were given incentive pay and the job, both excavation and lining, proceeded well. Nearly all of the men employed on this job by the contractor were of Slavic ethnic origin, as were the contractors themselves. In compliance with rules of P.W.A., all were from the District area.
CONSTRUCTION OF WHITE'S POINT TUNNEL.—The north schedule of the White's Point tunnel passed through sand. It was dry and, for the most part, stood well in the heading. Timbering was held in place with four and five inch 1 beams. The crown was held with spilling (later cut back) and side lagging.

The middle and south sections were attacked, respectively, from an access shaft and the outlet portal. The ground encountered was variable and, for a considerable part, moderately wet. The bore traversed a wide variety of sedimentary rocks, folded and distorted to the extent that little valid prediction could be made as to what would be encountered in the next 50 feet. A great deal of trouble was experienced with squeezing ground. Excavated to required section, the perimeter of the hole would gradually contract until it would be necessary to re-excavate to pass equipment into the heading. The squeezing continued in certain areas to a
HEAVING GROUND IN TUNNEL CONSTRUCTION — In particularly heavy and squeezing ground in the White’s Point tunnel construction, heavy bracing was required. Steel ribs were difficult to obtain at all times; hence, some tunnel support with timber.

degree that required re-excavation twice before placing concrete lining. It appeared that the ground contracted into the hole about like the lens opening of a camera closes and, as it did so, gradually built up its own resistance to further movement. When the ordinary tunnel bracing would support against further movement, the job was considered safe for permanent lining. Asphaltum was encountered in certain areas and at times flowed slowly into the hole, clogging drain pipes and ditches. The tunnel, being uniformly without slope, relied on pumping throughout for dewatering.

A near disaster occurred in the center section of the tunnel when, after the north end had been completed, drainage water began to accumulate around the upper end of the finished job. Shoefner and Gordon installed a bulkhead at the upper end of the finished line to protect their work, but continued rain raised the level of the ponded water to the extent that the bulkhead failed and the middle and north section were flooded. Fortunately, all men working in the tunnel at the time got safely out at the shaft. Damage to the uncompleted work was quite serious and the fin-
WHITE'S POINT TUNNEL CONSTRUCTION — Pressures underground forced the wall and floor into the excavated hole. Shown here, in background, is earlier excavation which had same end area as newly re-excavated part in foreground. Section was re-excavated until it ceased movement, then lined with reinforced concrete.

ished section was filled with a couple of feet of mud and sand. No lives were lost.

As might be expected, the tunnel crossed many faults in the tortuous mass which comprises the Palos Verdes Hills. Only one of
POSSIBLE FAULT CRACK IN TUNNEL CONCRETE—Shortly after the White's Point tunnel lining was placed, and before the structure was in operation, a crack developed at Station 257 + 19.6. The crack was continuously observed and explored until operation began. Again examined when the tunnel was emptied in 1955, no further movement had occurred.

the faults showed any signs of activity during construction. At Station 257 + 19' near the contact of the sandy material and the rock, a transverse crack developed shortly after that section was lined. It was carefully observed while the tunnel was still open. During this interval, it showed no further movement. Seventeen years later when the tunnel was dewatered, it was again observed still showing no further movement. Quakes since 1937 have ap-
apparently had no effect upon the structure.

Early in 1937, after completion of Schedule 3 of the tunnel, a contract was let for the remaining short section connecting the completed schedule with the treatment plant and for the entrance works. This section had been delayed, pending completion of Schedule 3, in order to allow for ample construction room at the north portal. The delay had a further advantage in that there was no interference with operation at Bixby until the entire outfall works were ready to go. The connection was completed without much difficulty or inconvenience to the plant or the contractor. Use of the works was delayed a few days pending some negotiations regarding payment for extras and delays. Federal W.P.A. labor was supplied to assist in making the minor modifications in the plant structures to accommodate them to primary sedimentation opera-
FINAL INSPECTION OF PALOS VERDES TUNNEL.—The White's Point tunnel was placed in operation in October, 1927. Final inspection prior to use was made by (l. to r.) Hugh Gordon, District Counsel; A. K. Warren, Chief Engineer; A M Rawn, Asst. Chief Engineer; an unknown man; Floyd Shoemaker, tunnel contractor; an unknown man; and Charles T. Leeds, Consulting Engineer, Los Angeles.