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HYDROGEOLOGIC ASPECTS OF UNDERGROUND EFFLUENT DISPOSAL AT WAIMANALO

by

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It has been proposed that underground discharge of effluent from a sewage treatment plant planned at Waimanalo be substituted for discharge through a long and expensive ocean outfall. As a contribution to the determination of feasibility of underground discharge of treatment plant effluent at Waimanalo, and in accordance with an agreement reached at a meeting at the Division of Water and Land Development on 16 December, the Water Resources Research Center arranged a conference on the hydrologeologic aspects involved. The conference was held Thursday afternoon 10 February, 1966, at the University of Hawaii. In attendance were the following:

Agatin T. Abbott	U.H.	Dan A. Davis	USGS
W. M. Adams	"	Augustine S. Furumoto	U.H
Stephen Bowles	BWS	Dan Lum	DOWALD
Mel Caskey	U.H.	Gordon A. Macdonald	U.H.
D. C. Cox	U.H.	Akio Ogata	USGS
Robert Dale	USGS	Leonard A. Palmer	U.H.

This memorandum report is based mainly but not entirely on the discussion at the conference. A draft was distributed among attendees for criticism, but responsibility for opinions expressed here remains with the writer, not with other attendees or the organizations they represent.

In summary this memorandum includes discussions of the geology of the Waimanalo area and of the hydrology of the area. It is concluded herein that the proposal for underground effluent disposal seems reasonable and if successful would be much cheaper than the designed ocean disposal. A sequence of hydrogeologic exploration, pilot testing and ultimate development is recommended. In consideration of the magnitude and difficulty of the investigations required and the present commitment of manpower, the employment of at least one addition full-time professional hydrogeologist is recommended.

Geology

The bedrock in the vicinity of Waimanalo is basalt lavas of the Koolau volcanic series. In the pali back of the valley there are a few dikes, but the geologic evidence from the ridges to the northwest as well as the hydraulic behavior of a few old drilled wells in the valley which penetrate to bedrock suggest strongly that beneath the valley the lava is more intensively intruded with dikes, and the caldera complex back of Kaulua may extend as far as Waimanalo.

The buried bedrock valley of Waimanalo is poorly defined in its upper portion, far mauka of the proposed sewage treatment plant, by wells penetrating to bedrock and by one of two seismic refraction lines, which show the contact in excess of 350 feet below sea level. Another seismic refraction line shows no bedrock to at least a few hundred feet below sea level. The surface of the bedrock has been carved by both fluvial and marine erosion, to a base level that may be 1800 feet below present sea level.

Within the valley and along the shore there are an undoubtedly complex series of coastal-plain sediments including coral, beach and dune and rock, lagoon muds and marks, and stream deposited alluvium. Marine deposits may be expected to predominate makai, fluvial deposits mauka, just as at the surface. However details in the surface geology cannot be expected to persist in depth.

The specific capacity of two shallow abandoned fire wells in Bellows Field strongly suggests that these penetrate through the surface sand to a coral aquifer. The lateral extent and thickness of this coral are not known It is probable that, in depth, there are other coral layers. However, deep drilling at Ewa in a similar coastal-plain has disclosed that the ratio of coral to lagoon sediments there decreases with depth.

Hydrology

It seems probable that the ratio of underground ground to surface runoff from the Waimanalo area is, in general, much lower than is usual in Hawaiian terrains. The dikes and other possible structures restricting the transmissibility of the bedrock certainly impede the seaward discharge of groundwater in the bedrock. The terrestrial sediments have, in general, both relatively low surface infiltration capacities and low horizontal transmissibilities. Only in the makai areas surfaced with sand and coral is the infiltration and underground discharge expected to be high.

Heads in the bedrock exceed 29 feet msl in the wells closest to the coast and increase greatly inland.

At Bellows field there are a number of shallow drilled wells in the sediments originally drilled for fire protection. Of these the two south-eastern-most are of special interest. These heads measured in them are reported to be $2\frac{1}{2}$ to 3 feet msl but the reliability of the datum is questionable. A head drop between them of about 0.6 ft. in 900 ft. is more reliably measured. No logs are available, but the tide response of these wells indicates very high transmissibilities, suggesting strongly that the wells pass through the surface sand into coral beneath. A shallow seismic survey provides some information on what might be either the top of the coral or the water-table. Tests indicated about 8 ft. buildup in the inland well with about 600 gpm recharge, but there was no detected interference noted in the seaward well, and the recovery was practically instantaneous, suggesting the buildup was mainly due to friction losses in the well casing and perforations. A dye test has not detected flow between the wells nor even movement out of the inland well.

Effluent injection potentialities

It seems probable that the estimated 1/2 to 2 mgd sewage effluent from the planned treatment plant could be discharged underground through a few wells if the wells penetrate one or more coral beds. The most suitable coral beds: a) might prove to be the shallowest ones in the vicinity of the treatment plant; b) might be deeper coral beds in this vicinity if it proved desirable to attempt confinement of the effluent beneath an aquiclude; or c) might be coral beds elsewhere within reasonable reach of a pipeline if the conditions found at the plant site were not satisfactory or were clearly not as satisfactory as elsewhere. The major potential problem is plugging. Coral beds seem to offer potentially great advantages in this respect over other aquifer materials in which injection schemes have been tried elsewhere. Various methods offer promise for the reduction or removal of the effects of plugging. However, only pilot experimentation can determine with certainty the amount of trouble that would be experienced, or the nature and success of possible remedies.

The low effluent discharge initially expected appears to afford an ideal chance for pilot experimentation, and the suggestion of an effluent pond as an emergency disposal means seems sound.

It seems probable that a means for underground disposal of the effluent can be developed that is far less costly than the designed ocean disposal.

Recommendations for investigation

In general the studies to be recommended below represent the minimum hydrogeologic studies considered necessary to investigate the feasibility of the proposed underground discharge of effluent from the treatment plant

at Waimanalo. It may be expected that the necessity of some additional hydrogeologic studies will become apparent as results are gained from the initial studies. The desirability of other additional hydrogeologic studies may become apparent from considerations of the sanitation aspects of the problem. It may well prove advantageous to extend the essential studies with research of a more fundamental nature. However the studies outlined here are directly contributory to the practical problem and must be supported as inherent parts of the sewage effluent disposal plan.

In brief, it is considered in outlining these studies that the overall plan will consist of the following stages.

1. Hydrogeologic exploration in the vicinity of the proposed sewage treatment plant to determine possible sites for the underground discharge of the effluent.

2. Construction and testing of initial effluent disposal wells and monitoring test holes.

3. Construction of the sewer system, sewage treatment plant, and effluent pond.

4. Pilot investigation of the hydraulic and sanitary effects of underground effluent disposal.

5. Construction of final effluent disposal system.

6. Monitoring and analysis of effects as effluent injection continues and as load increases.

There appears to be no reason why stage 3 could not be begun at any time, but stage 2 must await the completion of stage 1 and the remaining stages must follow in sequence.

The stage 1 exploration must involve, at the very least, 4 test holes core drilled and hydraulically tested in each aquifer penetrated. It is recommended that one of these holes be located at the proposed sewage disposal plant site, one makai of this site, and the other two at distances of between 1000 and 2000 feet northeast and southwest from the site at approximately equal distances from the shore. Quite probably at least two more holes will prove to be essential, tentatively on the line perpendicular to the shore through the site, one mauka and a second makai. Depths cannot be determined with certainly in advance, but it is recommended that the hole at the plant site be carried to at least 500 feet below sea level, and it is considered that the minimum drilling program will involve at least 1800 feet of drilling. The drilling method and diameter used must be capable of producing cores in the sediments, and the diameter must be such as to permit some simple hydraulic testing.

A good leveling survey must connect all wells and test holes drilled in the first and later stages. This survey must also be connected with a temporary tide station which should early be installed on the Waimanalo shore.

Some provision should be made for extension of the drilling results by geophysical exploration methods. Although neither seismic nor resistivity methods have yet been proved practical means of exploring in Hawaiian terrains of the sort at Waimanalo, investigations already undertaken or now underway seem likely to indicate that one or both will have applicability to the Waimanalo problem.

It is considered that at least wo injection wells must be provided in stage 2, as well as a considerable number of monitoring test holes (at least 6). Sizes of these wells and holes cannot be determined until the stage 1 investigation is complete. These wells and test holes should either be cored or electric logged, and the holes in stage 1 should be electric logged to permit logging correlation with the stage 2 wells and holes.

The hydraulic testing program using the injection wells and all test holes should involve, first, an investigation of the characteristics of the aquifers penetrated and the natural hydrologic conditions, and second, an investigation of the hydraulic effects of pure water discharge.

The studies should include measurements of vertical and horizontal hydraulic gradients, porosity, permeability and transmissibility determination of aquifers, attempts to determine velocities and directions of flow by tracers, location of areas of discharge into the ocean, and determination of salinities and other geochemical conditions.

Considering the construction times involved it appears probable that all purely hydraulic tests could be completed and pilot testing with sewage plant effluent begun as soon as the sewage plant is completed.

Recommendation on manpower

Considering the magnitude and difficulty of the hydrogeological investigations, and the present extent of commitments by existing hydrogeologic personnel in all agencies in Hawaii, federal, state, and local, it seems essential that the existing hydrogeological manpower in the community be expanded by at least the equivalent of one full-time professional for the period of the investigations. The special qualifications desirable are a broad knowledge of ground-water geology and hydrology, special competence in pollution aspects of ground-water and ground-water hydraulics, and experience with Hawaiian ground-water conditions.

The likelihood of finding the combination of these qualifications in a single individual is recognized. Probably the best that can be done is to provide for as much as possible of the combination of qualifications required through the full-time services of one individual, and for the supply of the remaining qualifications by part-time services of other individuals.

Doak C. Cox
Director

cc: Conference participants
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