GEOHYDROLOGY AND WATER QUALITY - BAYWOOD-LOS OSOS GROUNDWATER BASIN, SAN LUIS OBISPO COUNTY, CALIFORNIA

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ABSTRACT

The study of the Baywood-Los Osos Groundwater Basin was conducted to determine the effect that the use of septic tank-leachfields for sewage disposal was having on the groundwater quality and to determine if saltwater intrusion into the basin was an immediate problem. Historical water quality and level data combined with an extensive sampling program provided the data base for the study and the conclusions reached.

The shallow groundwater was found to be degraded by effluent from sewage leachfields. Additional development and disposal to land will only compound the existing problem. Data indicate that at this time little mixing of effluent and the deeper groundwater zone has occurred. Any increase in pumpage that could cause mixing would result in degradation of this water.

Groundwater use has not exceeded the safe yield of the basin. This was demonstrated by the nondeclining groundwater levels and the lack of saltwater intrusion in wells adjacent to the bay. There are no indications that under existing pumping conditions that saltwater intrusion will occur in the near future.

INTRODUCTION

The Baywood-Los Osos groundwater evaluation study was initiated at the request of the California Regional Water Quality Control Board, Central Coast Region, per Resolution No. 78-07. The State Water Resources Control Board was asked to provide an independent evaluation of the effect on-site sewage disposal had on water quality within the Baywood-Los Osos Groundwater Basin. The request was made because of conflicting reports by others and the disagreement over the potential threat of degradation caused by effluent from septic tank-leachfield systems percolating to the good quality groundwater. The Hydrogeologic/Geotechnical Section of the State Board conducted the study.

The specific questions asked by the Regional Board are the following:

1. How much more, if any, septic system effluent can be discharged to the Baywood-Los Osos Groundwater Basin before permanent groundwater quality degradation occurs?
2. What quantitative changes to the groundwater quality will result if septic system discharges continue to increase?
3. What is the magnitude of the potential threat of seawater intrusion into the aquifer?

4. What development "density" (gallons of septic system effluent per acre) could be permitted without measurably increasing pollutant concentration in groundwater?

The study was initiated in October 1978 and included the compilation of existing data from all sources plus collection of new data including an update of water quality, water levels, and geologic data for the Baywood-Los Osos area. Using basic data available from the Central Coast Regional Board, it was possible to calculate very crude estimates of the hydrologic characteristics of the aquifer within the Los Osos Basin.

The in-depth study of the basin was necessary in order to better evaluate both the potential for nitrate degradation of the groundwater and the potential for seawater intrusion within the groundwater basin. Without a thorough understanding of both the geologic and hydrologic parameters of the basin, neither of these two problems could be evaluated with any confidence.

GEOLOGY

Introduction

The geology of the Baywood-Los Osos Groundwater Basin has been discussed in detail in many other sources and, therefore, will not be repeated in this report. (Plates 1 and 2 represent the area geology.) Only those parameters concerning the immediate study will be discussed here. Anyone seeking additional geologic information should refer to the bibliography included in this report. Figures 1 and 2 depict the location of the study area.

Water-bearing Versus Nonwater-bearing Formations

For the purposes of this study, water-bearing formations will be those formations which provide major water for either municipal or domestic use within the Los Osos Groundwater Basin. Nonwater-bearing formations will be those which provide marginal use or constitute the nonwater-bearing rocks on the perimeter or base of the groundwater basin.

Nonwater-bearing Rocks

Franciscan Formation (JKf) - The Franciscan formation underlies most of the Los Osos Groundwater Basin. It consists of cemented siltstones, shales, and sandstones of Jurassic-Cretaceous age. Because of its essentially nonwater-bearing characteristics, the Franciscan acts as a barrier and hence is the lower boundary of the Baywood-Los Osos area.

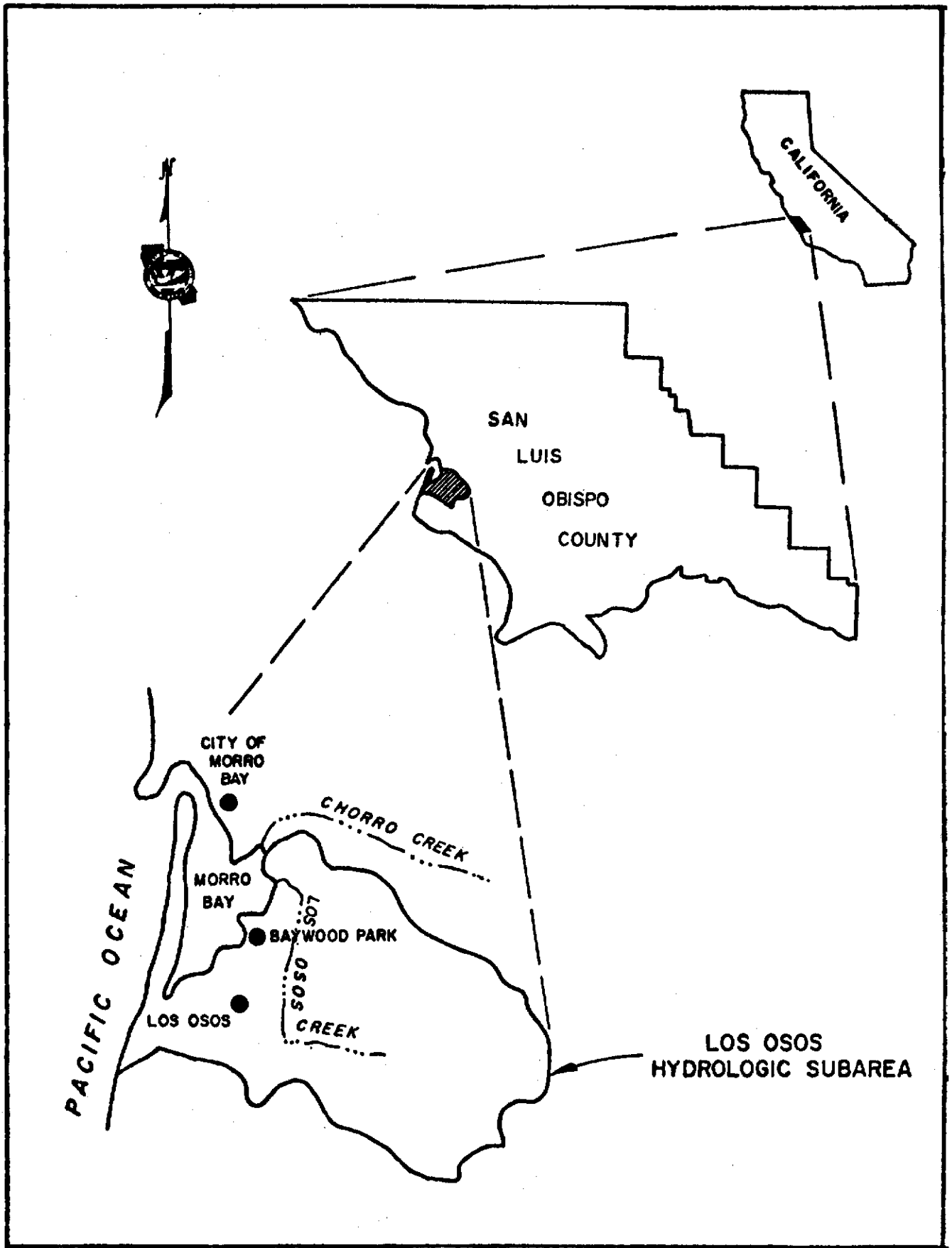


FIGURE I-LOCATION MAP

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1973

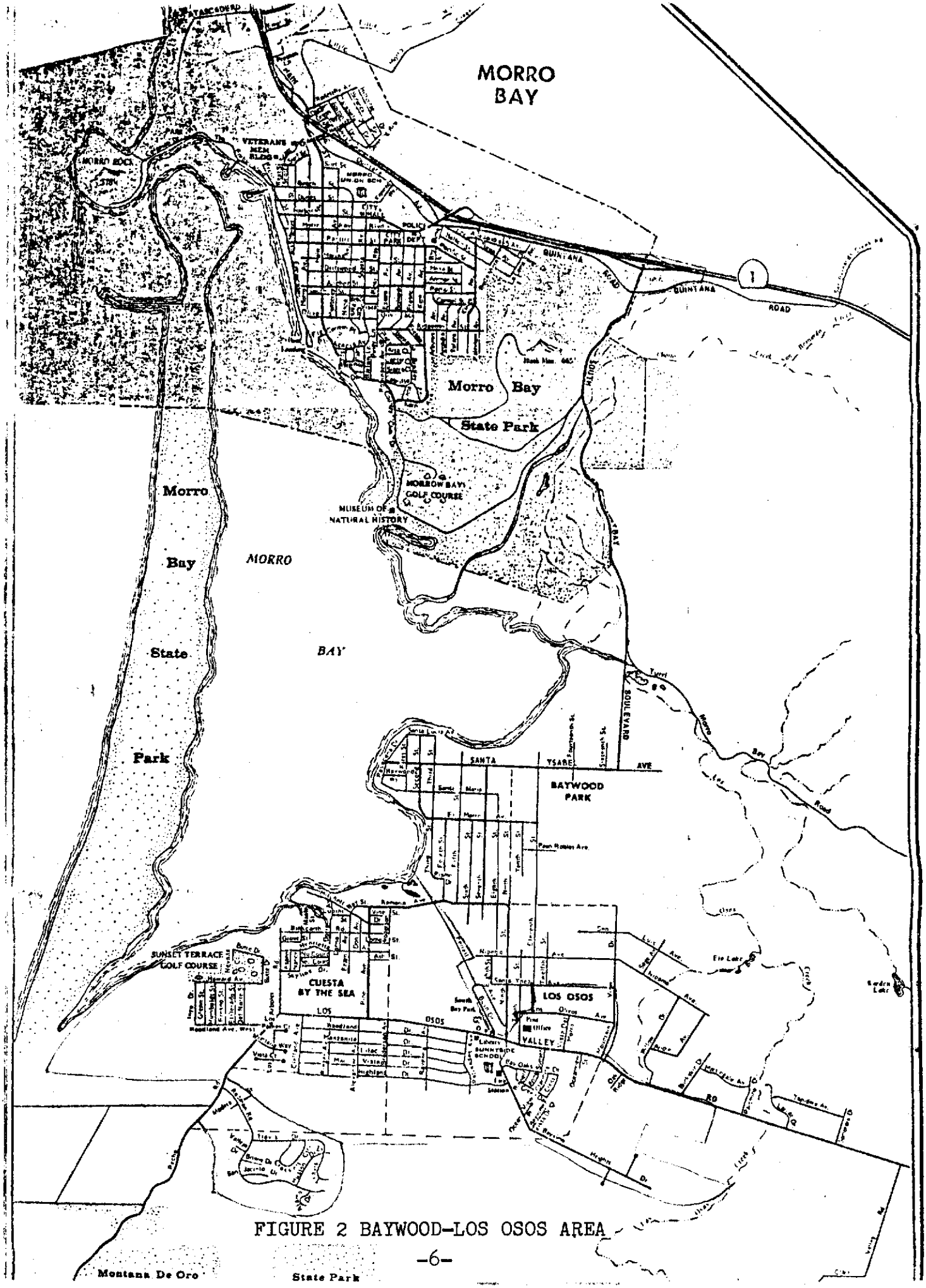


FIGURE 2 BAYWOOD-LOS OSOS AREA

Pismo Formation (Tp) - The Pismo formation also is essentially a nonwater-bearing formation underlying the Los Osos Basin on the south side of the valley west of Los Osos Creek. It consists of consolidated marine sediments. Although several wells have been completed in this formation, for purposes of this study it is considered nonwater-bearing. This formation was combined with the nonwater-bearing formation and is not shown on Plate 1. It is shown on the cross-section on Plate 2.

Water-bearing Formations

Paso Robles Formation (Qpr) - The Paso Robles formation underlies much of the Los Osos Groundwater Basin. This formation is probably the primary groundwater aquifer for the municipal water systems within the basin. The Paso Robles formation may extend to depths of as great as -600 feet relative to sea level. It is a siltstone with stringers of sands and gravels which constitute the major water-producing zones.

Until recently, the Paso Robles formation was felt to occur just in the subsurface. However, recent work done by Hall (USGS MF511, under revision) shows that the Paso Robles formation does occur along most of the perimeter of the basin and is quite extensive in the eastern portion of the Los Osos Valley.

Sand Dunes (Qs) - Sand dune deposits have been accumulating in the Los Osos Valley for millions of years. These deposits have

essentially subdued the older relief by filling in valleys and draping thin veneers over old topography hills. The sand dune deposits in some cases appear to be at least 250 feet thick pinching out on the northern and eastern edges of the valley. The sand dunes are a primary aquifer source for the shallower domestic wells and some shallow municipal water systems.

Alluvium (Qal) - The Quaternary alluvium in the Baywood-Los Osos area is found along Los Osos Creek. It consists of sands, clays, and gravels and is an aquifer where there is sufficient thickness of the alluvium present to provide for storage of groundwater. The alluvium probably does not extend to depths greater than 20 to 30 feet below existing ground surface. It therefore may be a benefit to the basin as a recharge area but not as a usable aquifer.

Structure

The exact structural geology of the Baywood-Los Osos Valley is not completely understood. Whether the present geometry of the valley is a result of faulting or deformation of older formations is unknown and not really of importance in this study. The geometry or configuration of the groundwater basin which can be determined from existing data is needed to understand the hydrology.

GEOHYDROLOGY

The Los Osos Valley appears to consist of a single saturated, unconfined, aquifer system with a few isolated confined areas. Although several different quality waters are present, these seem to be related to the materials from which the water is extracted.

The primary aquifer consists of alluvium, beach sand deposits, and the Paso Robles formation. The aquifer system is unconfined and staurated throughout the entire thickness. Although clay lenses are present in most borings, estimates of aquifer characteristics verify the unconfined nature of the basin.

Horizontal permeabilities were shown to be much higher than vertical permeabilities. This was demonstrated when the municipal water wells were continuously monitored for changes in chloride (Cl) and nitrate (NO_3) concentrations. Samples were collected three to four times daily during a four-day period while the wells tested were pumping on a continuous basis. Theoretically, if vertical and horizontal permeabilities were similar, a pumping cone of depression would have been generated which should have reached the top of the water table. In the case of the Cal Cities Pecho Road well, shallow wells across the street had measured NO_3 levels in excess of public health limits while the NO_3 levels in the municipal well were less than 5 milligrams per liter (mg/l) NO_3. If the Cal Cities well's pumping cone approached the water

table, NO_3 laden water should have been induced into the well. During the test period, the NO_3 level in the pumping well remained at the constant low level. This demonstrates that the portion of aquifer in the vicinity of the well perforations has sufficient permeability, compared to overlying material, to provide the well yield without dewatering the shallower sediments. If the shallower sediments had been dewatered, there should have been a measurable increase in the NO_3 level.

Water levels show a water surface sloping in a generally westward direction toward the bay. The freshwater becomes confined where the bay muds cap the older sand deposits as it extends out under the bay.

There is also a confined connate zone of high total dissolved solids (TDS) water underneath an alluvial fan deposited by Los Osos Creek where it enters the basin south of the intersection of Los Osos Valley Road and South Bay Boulevard. This fan may extend as far north as Santa Ynez Avenue. The significance of this alluvial fan sequence is twofold:

First, the sewage effluent and recharge appears to perch on the top of the fan and percolate laterally northward into the basin. This tends to concentrate the effluent in the perched zone. No wells were found which extract water from this perched water. Where this effluent mixes with the main aquifer, there probably

is a pronounced concentration of NO_3 in the groundwater. Better definition of the areal extent of this perched zone is necessary to determine where this effluent is going.

Second, the fan sequence tends to isolate some connate water which enters the basin from the south. Water samples collected from beneath the fan had a much higher TDS and chloride level than anticipated. The only connates detected in the basin seem to be coming out of the formations south of the groundwater basin. Recharge in the basin appears to be primarily from deep percolation of precipitation and surface inflow. The apparent quality of the subsurface inflow indicates that little recharge is derived from this source.

In the 1974 Brown and Caldwell study, Groundwater Basin Management Study, a 1972 water balance showed 4,100 acre-feet of groundwater inflow and a subsurface outflow of 2,080 acre-feet. Assuming that irrigation use has remained at the same 1,100 acre-foot level and urban consumptive use doubles from 920 to 1,840 acre-feet, there still is an excess outflow of 1,160 acre-feet for salinity control. The doubling of urban consumptive use was not measured but estimated to reflect the doubling of population between 1972 and 1979. It was also assumed that there was no change in average precipitation over the two base periods used.

Analysis of the data generated during the spring of 1979 show that saltwater intrusion is not occurring. The water table has not shown a regional decline when compared to the 1976 water data. Nor is there an indication of pumping depressions which could induce intrusion. The outflow appears to be adequate to keep saltwater out of the basin.

WATER QUALITY

Introduction

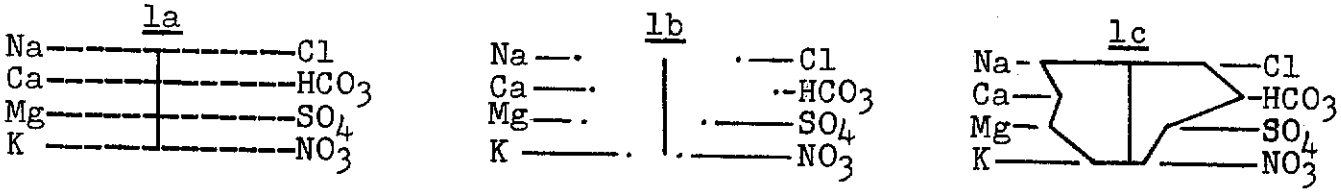
The natural quality of the groundwater in the Los Osos area is quite diverse, ranging from excellent to poor. This quality has been shown by means of Stiff diagrams of the various water analyses (Plate 4).

Stiff Diagrams

The Stiff diagram is a graphical representation of water quality. Through the use of these diagrams, general water types can be determined and anomalies easily detected.

Basically, the technique utilizes the equivalent parts per million (epm) values for the major cations and anions in a chemical water analysis. Although not restricted to these ions, sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K) are the cations used and chloride (Cl), bicarbonate (HCO_3), sulfate (SO_4), and nitrate (NO_3) are the anions.

The epm for these ions are plotted from a zero reference line (Figure 1a). These plots are then joined together to form the Stiff diagram (Figures 1b and 1c).



The best groundwater is found in the shallow alluvium and the dune sand deposits. The water has typically a low TDS, usually under 200 mg/l and is sodium chloride (NaCl) in character. The waters in these deposits come from direct precipitation and percolation. The chloride levels tend to increase closer to the coast because of the accumulation of salt sprays.

Underlying the alluvial and sand dune deposits is the Paso Robles formation, a nonmarine sequence of clays, silts, sands, and gravels. This formation appears to be saturated with production of municipal water supply quantities from the more permeable zones. The TDS up to at least 900 mg/l tends to increase with depth. This increase in TDS probably represents connate water which migrated into the formation from adjacent marine deposits. The upper portion of the formation has been partially flushed accounting for the lower TDS. The general character of the water is sodium-magnesium-bicarbonate ($Na-Mg-HCO_3$). Although being more highly mineralized than the dune sands, the water is still of good enough quality for human consumption.

Bordering the southern edge of the basin west of Los Osos Creek is the Pismo formation, a marine sequence which only provides water to a few domestic wells and one municipal well. The municipal well sample was a calcium-sodium-chloride (Ca-Na-Cl) water more highly mineralized than municipal well water samples

collected in the sands or Paso Robles formation in the basin. For the purposes of the study, this formation has been considered nonwater-bearing and is shown in the cross-sections but not on the geologic map (Plates 1 and 2).

Factors probably affecting the quality of the groundwater in the Los Osos basin are the presence of the nearby Franciscan formation and the igneous intrusive rocks related to the Morro Rock and the serpentinite intrusions. These types of rocks generally contain highly mineralized fluids which tend to degrade nearby groundwater sources.

Nitrate Degradation

Shallow groundwater quality in the Baywood-Los Osos Groundwater Basin has been severely degraded by the presence of nitrate (NO_3) (Plate 5). Water samples collected during early 1979 show an increase in the NO_3 levels compared to earlier samples throughout the area. Some samples of water from wells have NO_3 concentrations approximately double the 45 mg/l public health recommended limit.

Areally, the distribution of high NO_3 levels appears to be related to the population density. Agricultural wells in outlying areas generally had NO_3 levels below 5 mg/l, while newly constructed domestic wells adjacent to the more populated areas had much higher concentrations. This implies that the high NO_3 waters are being

generated in the populated areas and are spreading out laterally to the less dense areas. Based upon these data, it has been concluded that the NO_3 comes from the present sewage disposal method.

The degraded area is probably much larger than shown on Figure 5. Due to a lack of sampling wells in the areas served by water districts and downgradient from populated areas, the total extent of degradation cannot be determined. There does not seem to be much vertical mixing of the NO_3 laden water with the deeper groundwater. Deeper municipal wells in the basin show very low levels of NO_3, while the nearby shallower domestic wells have NO_3 considerably higher.

Hydrologically, as previously discussed, the municipal wells are not pumping enough water to induce a cone of depression to reach the degraded shallow water. Under these conditions, there is no movement of the degraded water into the wells. However, as the demand for municipal water increases, the likelihood that NO_3 levels will increase in deeper wells will increase.

Current projections (Table 1) show a doubling of the South Morro Bay area population between 1978 and the year 2000. This would result in a doubling of the NO_3 loading resulting from the use of leachfields for sewage disposal. This would also result in a doubling in the urban water demand.

If the water demand is satisfied by the use of domestic wells, the NO_3 problem in the shallow zone will become more apparent. If the water demand is met by the water districts, the amount of vertical mixing will increase resulting in higher NO_3 levels in the groundwater to a greater depth. This greater mixing will cause more of the domestic wells and probably some of the shallower municipal wells to become unusable.

SALTWATER INTRUSION

The Los Osos Basin has not been affected by saltwater intrusion. Chemical analyses of both municipal and domestic wells showed only one definitely intruded well.

Many factors have contributed to the nonintrusion of saltwater. Some of these are lack of overdraft, an apparent continuous clay cap of bay muds separating the producing aquifers from the bay, sufficient hydraulic head to keep saltwater out of the producing zones, and high horizontal compared to vertical transmissivities that have prevented large pumping cones from being generated.

Water level measurements made by San Luis Obispo County personnel in 1976 and again in 1979 indicate that the groundwater basin contains essentially the same amount of groundwater now as then. Comparison of the contour maps show there has been little change in overall water surface (Plates 6 and 7). As long as the existing water balance is not drastically altered, no significant intrusion should occur. The use of septic tank-leachfields for sewage disposal helps preserve this balance, but also ensures the maximum recycling of the basin's groundwater.

The water surface lowers to sea level at the coast. Inland the water surface is above sea level providing a positive hydraulic gradient toward the ocean. Several small pumping cones have been

generated by the larger capacity wells in the basin. None of these cones appear to be large enough or deep enough to create an intruding condition. The presence of the bay mud aquiclude and an adequate seaward hydraulic head allows the quality of the inland groundwater to be maintained. Movement of chloride ions through the bay mud probably occurs, but at present there is enough movement of the groundwater seaward to avoid a build up of chlorides. This is evidenced by the CSA No. 9 Third Street well which pumps on a continuous basis from a pumping level of approximately -50 feet below sea level. This well is no more than 30 feet from the bay, and the chloride level is no higher than most of the other wells in the basin. The lack of chlorides in the CSA No. 9 well may also be the result of sufficient seaward hydraulic head and/or the high horizontal to vertical ratio of permeabilities. As long as the hydraulic pressure in the shallow aquifer is not reduced enough to allow saltwater to migrate landward, no intrusion takes place.

If water can move horizontally into the well at a rate equivalent to the yield of the well, no cone of depression will develop which can induce the movement of saltwater into the well. This phenomenon seems to occur when the well yield is relatively low in comparison to what probably could be pumped. Also, this condition most likely is why nitrate-laden water is not induced in some of the deeper municipal wells.

Water quality analyses in the deeper wells in the basin do not contain a significantly higher concentration of chloride (Cl) than the shallower wells. For this reason, it has been assumed that a saltwater wedge has not intruded into the deep portions of the aquifer. If the wedge existed, there would be a definite potential for moving higher Cl waters vertically into the shallow pumping cones.

GROUNDWATER RESOURCES AND DEMAND

Current water level data show that the basin is not in an overdraft condition. No obvious decline in water levels was detected. Water quality data indicate saltwater intrusion is also not an immediate problem. The only serious problem is the high concentration of NO_3 found in the shallow groundwaters throughout the populated portions of the basin where wastewater is being recycled.

Groundwater resources continue to meet increased demands without adverse effects on quantity. From 1972 to 1978, the population approximately doubled without a decline in water levels or detected saltwater intrusion (Table 1). Using the Projected Water Demands (Brown and Caldwell, 1974), 1978 consumptive water use was approximately 2,000 acre-feet, or double the 1,000 acre-foot safe yield of the basin estimated in 1972.

There is a definite need to update the safe yield estimate for the basin. Such an update is beyond the scope of this study.

TABLE 1

South Morro Bay Population Projection*

July 1978	9,210
July 1979	9,970
1980	10,790
1985	13,130
1990	14,780
1995	16,320
2000	18,020

*1978 County planning estimate based on current Coastal Commission policies.

CONCLUSIONS

1. The shallow groundwater in the Los Osos basin has been and is being degraded by nitrates (NO_3).
2. The primary source of the NO_3 is effluent percolating down from individual sewage treatment leachfields.
3. The agricultural and dairy activities do not appear to contribute significant amounts of NO_3 to the groundwater.
4. The area affected by high NO_3 degradation is increasing both vertically and horizontally.
5. Additional use of leachfields for effluent disposal can only increase the magnitude of the NO_3 problem.
6. Groundwater levels appear to be at essentially the same levels as they were in the fall of 1976.
7. No indication of saltwater intrusion could be documented.

In response to the four questions in Regional Board Resolution No. 78-07, the following conclusions can be reached:

Question 1. How much more, if any, septic tank systems effluent can be discharged to the Baywood-Los Osos Groundwater Basin before permanent groundwater quality degradation occurs?

The water quality study conducted shows that degradation from nitrate has already occurred in the shallow groundwater zones under and downgradient from the populated portion of the basin.

No more sewage effluent should be discharged in those populated areas where the NO_3 levels are already in excess of the recommended public health limit of 45 mg/l. Movement of the population or transport of the wastewater within the basin would only be a temporary solution because the NO_3 levels will start increasing in the new location as soon as the disposal system or leachfields become operational.

Question 2. What quantitative changes to the groundwater quality will result if septic system discharges continue to increase?

Continued use of existing septic tank-leachfields for sewage disposal will cause the NO_3 level in the groundwater to increase underneath and downgradient from the NO_3 sources. Additional leachfields constructed in the basin will increase both the areal extent of degradation and the depth within the groundwater system to which the degradation will take place.

At present only the shallower domestic and municipal water wells have been affected by the build up of NO_3. As demand for more groundwater increases, the depth of degradation will increase because greater mixing will result from the increased pumping. Since much of the water extracted is recycled, a proportionately greater volume of the basin's groundwater will be degraded.

Question 3. What is the magnitude of the potential threat of seawater intrusion into the aquifer?

Presently, there does not appear to be any saltwater intrusion threat in the Baywood-Los Osos Groundwater Basin. Water levels measured in the fall of 1976 and the spring of 1979 indicate the basin is not in an overdraft condition (Plates 6 and 7).

Most of the extracted water appears to be returned to the groundwater basin via direct percolation on the ground or from leachfields. As long as precipitation can make up for the water lost through evapotranspiration and subsurface outflow to the ocean, there is little risk of saltwater intrusion.

Question 4. What development density (gallons of septic system effluent per acre) could be permitted without measurably increasing pollutant concentration to in-ground waters?

No quantitative answer to this question has been developed because data collected show there is little mixing of the NO_3 laden water with the better quality deeper groundwater. The sewage effluent appears to float on the surface of the water table.

Any estimate would be inconsistent with the quality data. The only way to implement a development density for the area would be to allow the surface of the groundwater to become degraded and

only utilize the deeper portions of the basin for potable water. With this approach, the water in most of the existing domestic wells and shallower municipal wells would become unfit for human consumption. This approach is inconsistent with the Porter-Cologne Water Quality Control Act.

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