General Guidelines for Hydrogeological Investigations

Excavations for gravel pits or man-made lakes may have an impact on the local hydrologic conditions, primarily by diverting water or impacting water quality. It is necessary, before permits are issued, to determine pre-excavation hydrologic conditions at the proposed site and to assess whether adverse environmental impacts could occur. In order to document these conditions or assess possible impacts, it is necessary for the permit applicant to complete a hydrogeologic investigation prior to beginning any on-site excavations or issuance of a permit by the LWMD. There are different levels of investigation required that are dependent upon site features such as: location in a watershed, proximity of existing surface-water bodies, site hydrology, local geology, and local land use. Some of these features are readily discernible; others, such as geology, are not. The following is a suggested sequence of work that may be followed by a permit applicant in investigating conditions at their site.

1) **Site and Project Description**

a) Prepare a map showing the regional setting. At a minimum, the map should cover an area with a one-mile radius measured in all directions from the center of the property. If the size of the project is large, it may be appropriate to increase the geographic area covered by this map. The site location map must show the following features in a clean, legible manner:
- proposed limits of excavation
- scale and north arrow
- section lines and numbers
- township and range numbers
- township name
- location of all existing lakes, streams, drainage ditches, and apparent wetlands within the geographic area covered by this map
- boundaries for the property where the proposed excavation will occur

b) Prepare a detailed site map that covers an area that extends at least 1000 feet beyond the property boundaries of the permit applicant. This map should show:
- scale and north arrow
- property boundaries
- boundaries and owner names for all adjoining land parcels
- location of all existing lakes, streams, drainage ditches, and apparent wetlands on-site and within 1000 feet of the property boundaries
- delineated wetlands expected to be impacted by excavation
- location of proposed excavation extent
- land surface elevations for the property shown by appropriately selected contour intervals
- water surface elevation for all existing lakes, streams, drainage ditches, and wetlands located on-site and within 1000 feet of the property boundaries

c) Describe the existing site conditions and the proposed project

2) **Field Investigations**

a) Test borings must be drilled to determine the subsurface geology. There should be a minimum of five test borings: four located outside the perimeter of the proposed excavation and one boring in the center of the proposed excavation. These borings must de drilled at least 10 feet deeper than the proposed depth of the excavation. The borings should be completed as temporary observation wells. The locations of these borings must be clearly shown and labeled on the site topographic map. Descriptive logs for each boring should be prepared by a qualified professional using the Unified Soil Classification System (USCS) to describe the subsurface soil and sediment. The boring logs must contain the following:

- boring name
- land surface elevation
- depth of boring
- description of different sediments encountered to the bottom of the boring
- construction details for the temporary observation wells
- top of casing elevation
- depth to water
- elevation of water in well

b) Install monitoring wells near the site perimeter outside the proposed area of excavation. If more than one aquifer is encountered in the test borings, separate wells should be screened in each aquifer to determine the vertical head gradient. Include monitoring well construction logs in the report appendix.

c) Water levels in the monitoring wells and all nearby wetlands, streams, and lakes should be measured and related to a common site datum. Present all water level measurements and elevations on a map and in the report table.

d) Residential wells within a one-mile radius of the site should be inventoried and located on the map (item 1d above). Include all well logs in the report appendix.

3) **Data Analysis**

a) Prepare a contour map of the water table elevations, including water-level measurements from nearby wetlands, streams, and lakes. Show the site boundaries.

b) Prepare a map showing the location of investigation cross-sections.

c) Prepare multiple cross-sections passing through the proposed excavation and all areas of concern (wetlands, streams, lakes, residential wells, etc.) to a distance of approximately 1 mile beyond the site boundaries. On these cross-sections, show the following:

- Vertical and horizontal scale
- Existing land surface elevations
- Boundaries and depth of the proposed excavation
- Well locations and logs used to prepare the cross-sections
- Thickness and extent of the subsurface geologic strata

- Location and depth of all residential wells, wetlands, streams, and lakes falling on the cross-section

d) Conduct an analysis of the impact of excavation de-watering, if appropriate, on nearby surface water and groundwater resources. This may be any appropriate method of analysis, which would include either analytical or numerical modeling methods. It would be up to the consultant to justify the selection of the analysis methodology. An analytical model or superposition numerical model would be the most appropriate methods since we want to assess the change in water levels, not simulate the hydrologic cycle for an entire watershed.

e) Conduct an analysis of the impact of the excavation on nearby surface water, including wetlands and groundwater resources. Discuss the difference between the existing and post-construction conditions. In the existing condition, water falls on the ground, some runs off, some is lost by evaporation from soils or transpiration from plants, and the rest infiltrates to the underlying aquifer. After construction, the water falls on the excavation water surface. There is no surface runoff and no transpiration from plants, only evaporation from an open body of water. The rest infiltrates to the underlying aquifer, if vertical gradients are downward. The consultant should make an assessment of the net change in water loss in the area of the excavation. If there is a net increase in water loss, this rate should be used as a stress on the aquifer, analogous to a pumping well. A simple well hydraulics or analytical model could be used to approximate the water-level decline at various distances from the excavation center; numerical modeling is not required.

f) If multiple aquifers are encountered during test drilling activities, and the proposed bottom of the excavation will completely penetrate an intervening confining layer, the analysis becomes more complicated. An examination of groundwater level data from the monitoring well clusters will determine whether there will be a negative impact on either aquifer. If water levels in the deeper aquifer are lower than the upper aquifer (as in a groundwater recharge area), breaching the confining layers will create a conduit through which groundwater from the upper aquifer will drain into the lower aquifer. There will be a permanent lowering of the water table in the vicinity of the excavation, potentially draining nearby wetlands or ponds, or lowering water levels in nearby residential wells. If water levels are higher in the lower aquifer, the opposite will happen, water levels in the upper aquifer will rise, while those in the lower aquifer decline. The degree and extent of decline in either case will depend upon the hydraulic properties of the aquifers and the rates of groundwater recharge and lateral groundwater inflow from surrounding areas. An analysis of this type of problem would require a numerical model.

g) Prepare maps and cross-sections showing the extent of the impact (e.g. water-level decline); do not simply map the water table elevations.

h) Show all supporting documentation for sources of data, data analysis calculations, model input data sets, and model output. Do not fill report appendices with arrays of numbers from numerical model input and output data sets. Provide numerical model data sets in digital format.

4) **Investigation report**

The data in this report document pre-excavation site conditions and should be made a part of the permit application file. The report should be provided to the LWMD for review prior to issuing a permit. This report will contain the following elements:

- an introduction describing present land use and the relationship of the site to surrounding properties. Use either the site location or a topographic map, whichever is more appropriate.
- a discussion of the proposed excavation activities and schedule, along with the intended future use of site. Use a topographic map showing proposed extent of excavation, and different phases of excavation, if applicable.
- a presentation of measured water levels as a contour map of the water table that also shows the groundwater flow directions
- a discussion of groundwater and surface-water movement through the area. Use either the site location or a topographic map, whichever is more appropriate
- a presentation of the results of test boring work as cross-sections through the proposed excavation showing land surface elevation, surface water features (if applicable), the proposed extent of excavation, and the subsurface soils and sediments encountered in the test borings.
- a conclusion discussing the expected impact to the hydrologic characteristics of the local area

5) **Additional work**

It may be necessary to require additional work at the site. Items to look for are, but not limited to, the following:

- <u>Surface-water diversions</u> – There may be existing surface-water bodies or wetlands located on-site or very near the proposed excavation. With this situation, there is the potential for water to be diverted toward the excavation and away from the existing surface-water bodies or wetlands. Additional investigations may be needed to demonstrate that no diversion of surface water will take place. It may be necessary for modify the design to insure that a topographic divide exists between the excavation and the surrounding surface-water bodies.

- <u>Groundwater diversions</u> - There may be instances where multiple aquifers are encountered by the test borings. If this is the case, it is necessary to have temporary wells screened in each aquifer expected to be penetrated by the excavation. It is necessary to measure hydraulic head (water level elevation) in each well to determine whether there are vertical differences in head between aquifers. If there are vertical head differences, groundwater will move into the excavation from aquifers having higher head, possibly draining this aquifer. As an example, if there is a perched aquifer with a connected wetland and an underlying aquifer with a lower head, groundwater will drain from the perched aquifer and wetland to the underlying aquifer by way of the excavation. Water levels in this aquifer and wetland may lower as a result. If there is an underlying aquifer with a higher head, groundwater will flow from this aquifer to the excavation. This may result in a lowering of heads in this aquifer. If there are flowing wells screened in this aquifer or springs associated with this aquifer, heads may be lowered sufficiently to stop the flow of water from the well or spring.

- Water quality impacts – It may be possible to impact the quality of existing surface-water bodies if the chemical quality of water in the excavation changes as a result of land use practices around the excavation. For this to occur, there must be a surface water connection or significant groundwater connection to the surface-water body. The risk to surface-water quality may be reduced by adopting land use practices which don't impair the water quality in the excavation and reducing, or eliminating, any surface-water connection to nearby surface-water bodies.