



## TECHNICAL MEMORANDUM

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### City of Wimberley Bluehole Regional Park Water Budget Modeling

**Project No.:** 1732-002-01  
**Date:** September 7, 2016  
**Prepared For:** City of Wimberley  
**Prepared By:** Steve Coonan, P.E., APAI  
Jason Voight, PWS  
Matt Stahl, P.E., APAI

A water budget study was performed to calculate the frequency and distribution of stored water in the soil zone of the Bluehole Regional Park adjacent to the Wimberley Wastewater Treatment Plant to support the reclaimed water irrigation design. The study applied a simplified, one-dimensional spreadsheet model which estimates the proximity and timing of saturated soil in relation to the ground surface. The model outputs were used to evaluate the viability of irrigated grass cover and to determine the daily irrigation volume that can be applied without excess runoff. The following sections detail the assumptions, development, results, and conclusions of the water budget study.

#### Assumptions

The water budget model used to develop the site water budget is a simplified, one-dimensional model. Assumptions and limitations include:

- Geotechnical – Site-specific geotechnical data were not available at the time of this evaluation. Publicly available soil survey data were used in the model.
- Irrigation – Irrigation volume was converted to depth based on the total irrigated area. Irrigation was applied daily unless the daily precipitation volume exceeded 0.1-inch or the cumulative 3-day precipitation exceeded 1-inch.
- Grass cover – Adequate growth occurs when the lower 30-60% of a 12-inch root zone is saturated.
- Simplifications – The model was run on a unit basis, in which each irrigated acre of the study site receives contributing runoff from an adjacent, upslope acre. Water exchange rates in the confining layer (vertical hydraulic conductivity) of the soil zone are computed as deep percolation and assumed lost from the system. Due to unavailability of soil data above the confining layer, the confining layer porosity was conservatively applied throughout the soil zone depth. Therefore, water

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exchange rates (hydraulic conductivity, infiltration, etc.) within the soil zone were not considered in the model.

#### Development

##### Water Budget Components

The water budget model can be broken into two components. First, the physical component consists of the contributing watershed and the soil zone. The contributing watershed generates inflow as runoff to the soil zone. Second, the water budget component of the model accounts for changes in water volume using calculations that estimate the contribution, removal, and storage of water in the soil zone over an extended period of time. The water stored in the soil zone equals the inflow, minus the outflow, plus the storage from the previous time-step. Water is stored in the void spaces of the soil layer. To estimate storage, the soil zone is assigned the parameters of maximum allowable soil depth (soil profile in which water will be stored), and maximum allowable soil water (based on soil porosity and degree of saturation).

Inflow to the soil zone may include: precipitation, runoff from contributing watershed, and inflow from irrigation. Outflow from the soil zone may include: evapotranspiration, deep percolation (water lost below the defined soil profile), and overflow as runoff. The model only generates runoff after the soil zone becomes completely saturated.

##### Water Budget Inputs

The water budget requires inputs for precipitation, irrigation, evapotranspiration, and deep percolation. The inputs are summarized in Table 1.

**Table 1 – Model inputs**

| Model Input        | Source                     | Details  |
|--------------------|----------------------------|--|
| Precipitation      | <u>NCDC</u> <sup>1</sup>   | Daily precipitation (February 1982 to August 2016), San Marcos, TX Station ID: GHCND:USC00417983   |
| Irrigation         | Variable                   | Daily irrigation was varied to establish volume that generates excess runoff   |
| Evapotranspiration | <u>NCDC</u>                | Daily calculated Hargreaves value, from daily maximum and minimum temperature (February 1982 to August 2016), San Marcos, TX Station ID: GHCND:USC00417983 |
| Deep Percolation   | <u>SSURGO</u> <sup>2</sup> | Saturated hydraulic conductivity, ks <sub>sat</sub> range = 0.06 to 0.57 in/hr<br>Porosity range, Gruene clay = 0.40 to 0.70; Depth to restrictive layer = |

<sup>1</sup> NCDC: National Climate Data Center

<sup>2</sup> SSURGO: Soil Survey Geographic database

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|  |  | 7 inches to 16 inches; cases used in the model were a 7-inch depth and a 12-inch depth |
|--|--|--|

#### Water Budget Application

First, the site inputs (1982 to 2016) without irrigation were applied in the model to simulate and quantify the water stored in the soil zone and the runoff produced under saturated soil conditions. This established a baseline with no irrigation, for average days of runoff per year, assuming the two cases of a 7-inch and a 12-inch depth<sup>2</sup> to the most restrictive soil layer.

Second, the site inputs (1982 to 2016) with irrigation were applied in the model to determine the maximum volume of irrigation that could be applied before generating excess runoff. The irrigation volume that exceeded each baseline value for average days of runoff per year was considered to represent the upper threshold for irrigation.

#### **Results**

The water budget model results are summarized in Table 2 and detail plots are provided in the Appendices. Based on the modeled soil zone water level falling generally in the range of 4-inches to 8-inches below the soil surface, adequate grass growth conditions were assumed for these irrigation levels.

**Table 2 – Results**

| <b>Model Depth (inches)</b> | <b>Irrigation (GPD)</b> | <b>Average Annual Runoff (Days)</b> |
|-----------------------------|-------------------------|-------------------------------------|
| 7                           | 0                       | 45                                  |
| 7                           | 105,000                 | 45                                  |
| 7                           | 108,000                 | 46                                  |
| 12                          | 0                       | 15                                  |
| 12                          | 196,000                 | 15                                  |
| 12                          | 197,000                 | 16                                  |

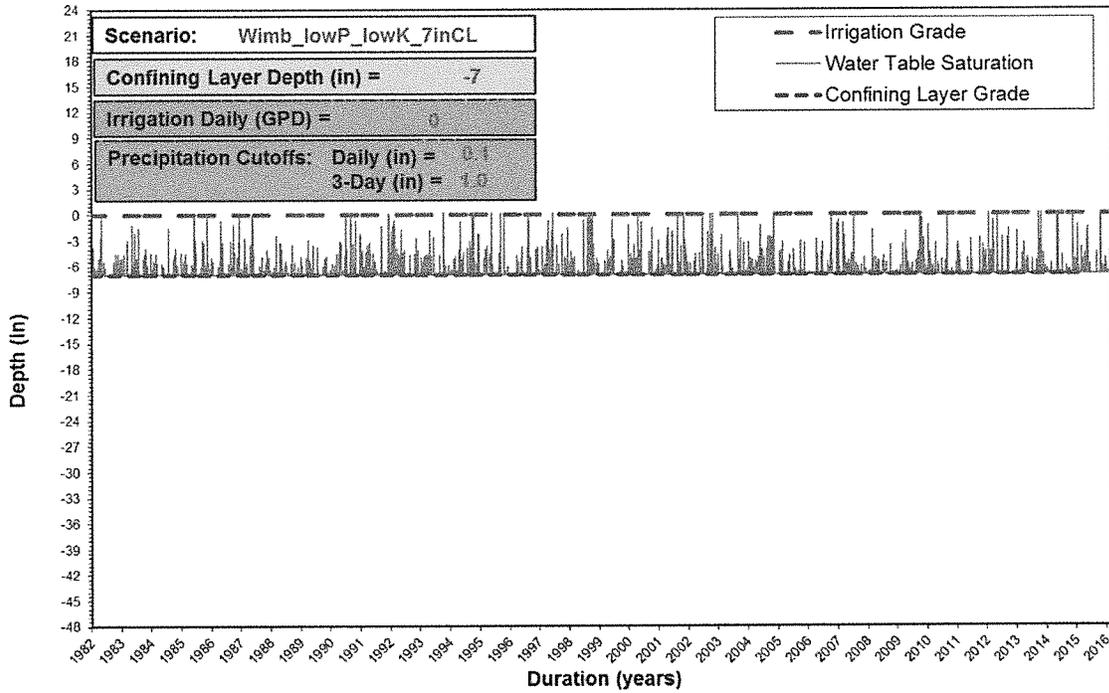
#### **Conclusions**

The study site can be irrigated with up to 108,000 GPD, assuming a 7-inch depth to the most restrictive layer. The site can be irrigated with up to 197,000 GPD for a 12-inch depth to the most restrictive layer.

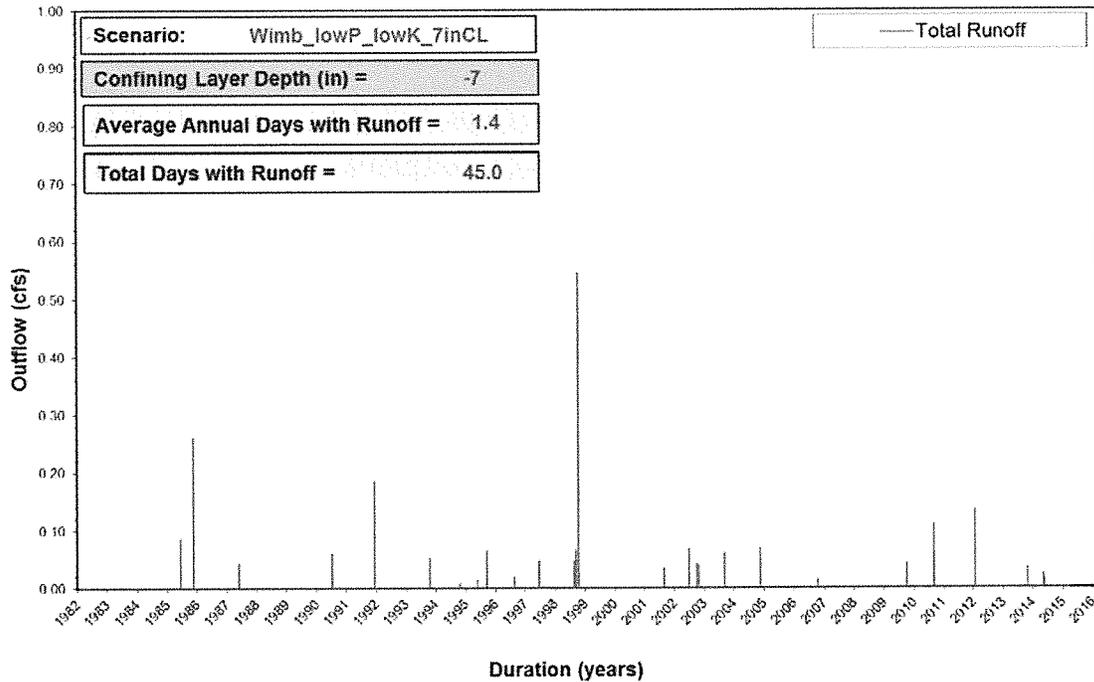
**Appendix A**  
**7-inch Depth to Confining Layer**

Worst Case, 7inch to confining layer, Irrigation = 0 GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

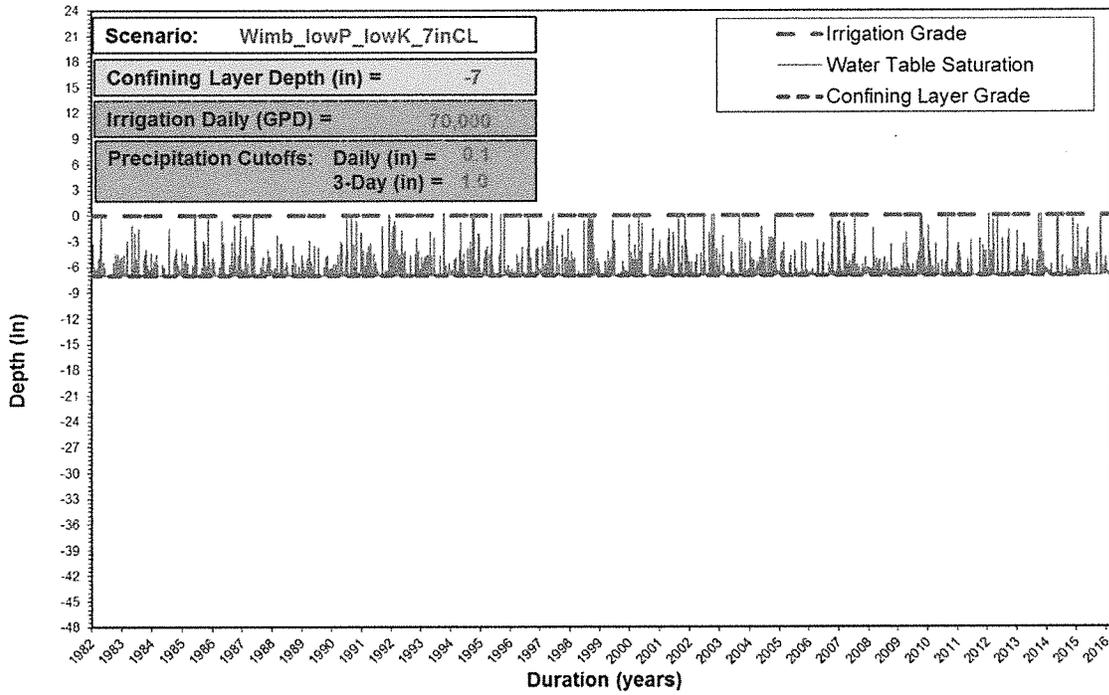


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

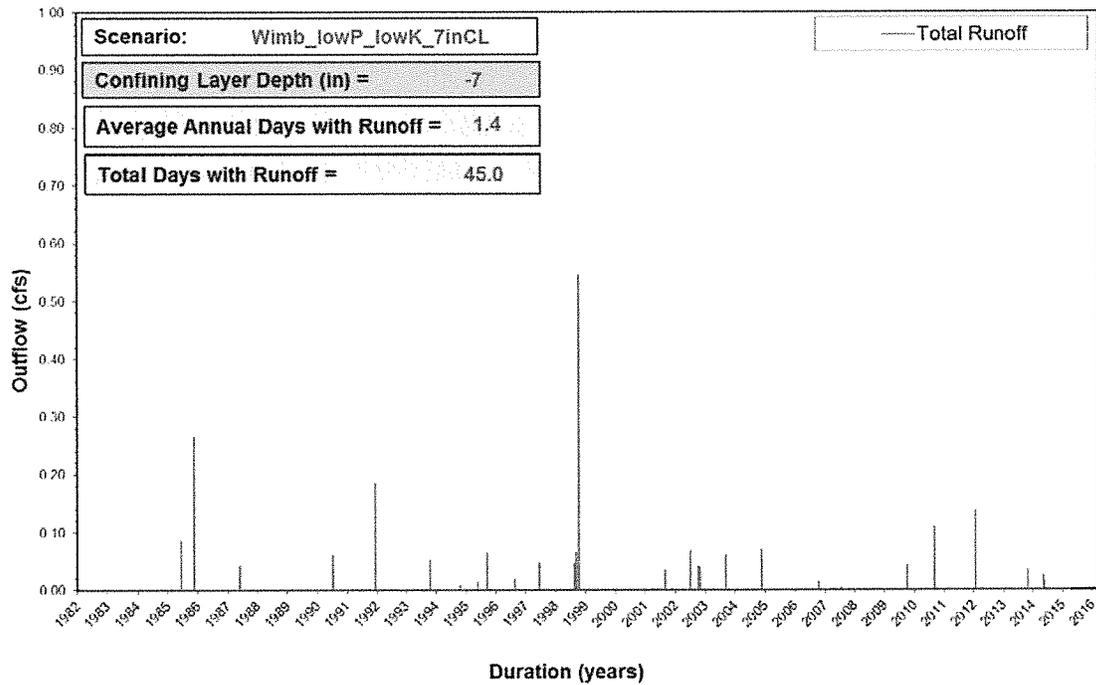


Worst Case, 7inch to confining layer, Irrigation = 70,000K GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

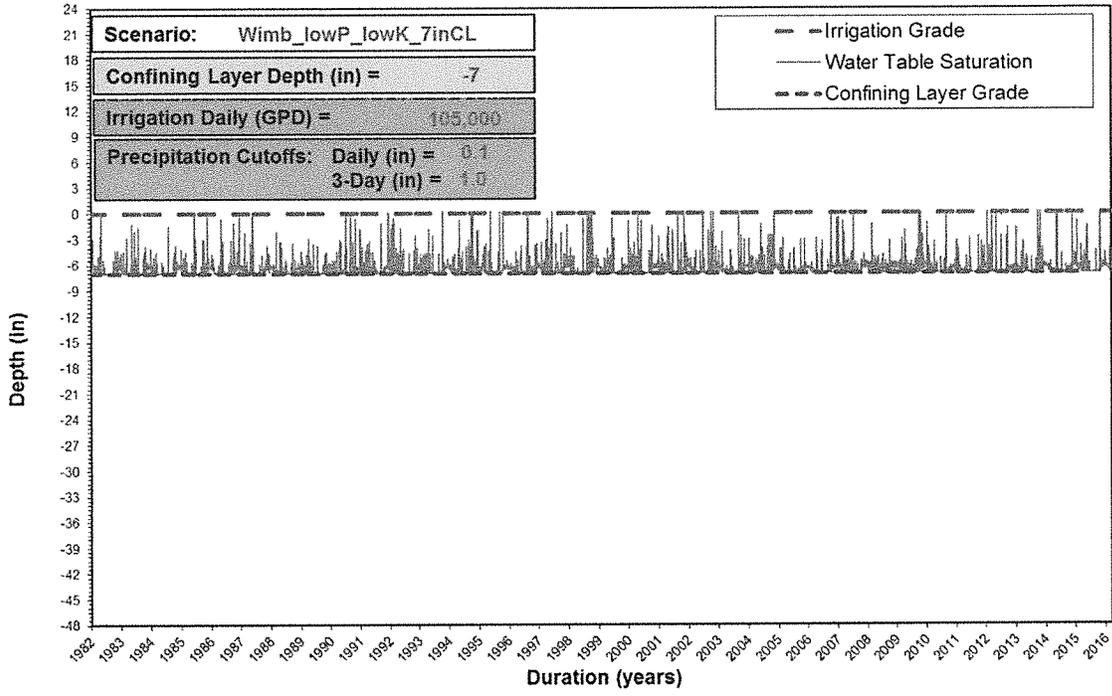


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

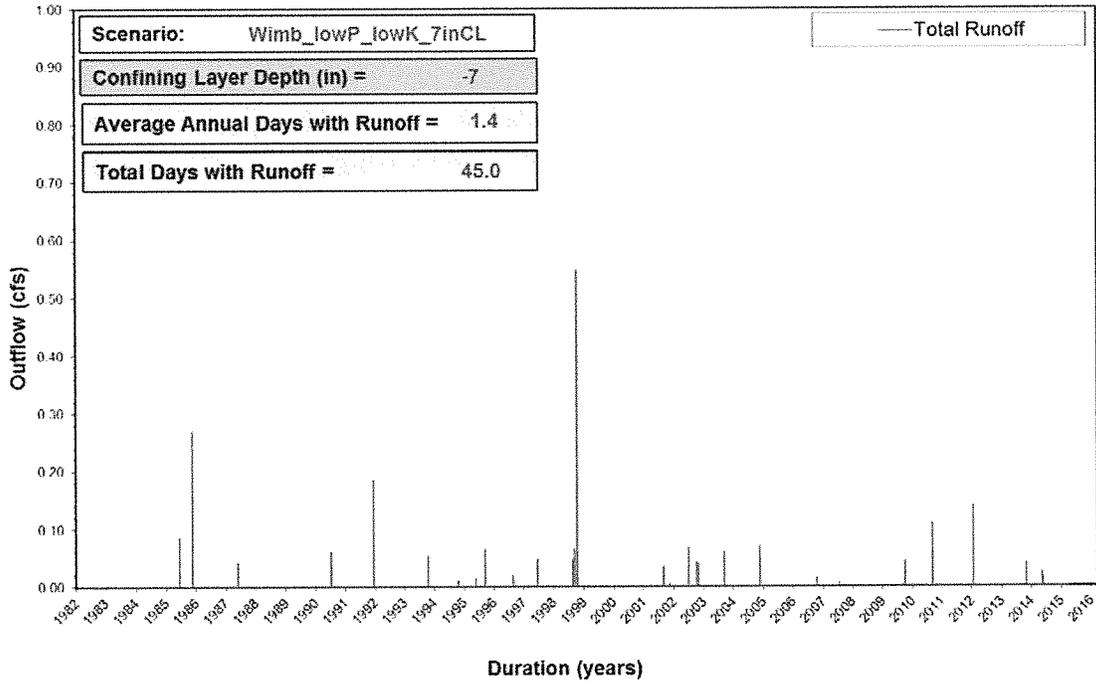


Worst Case, 7inch to confining layer, Irrigation = 105,000K GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

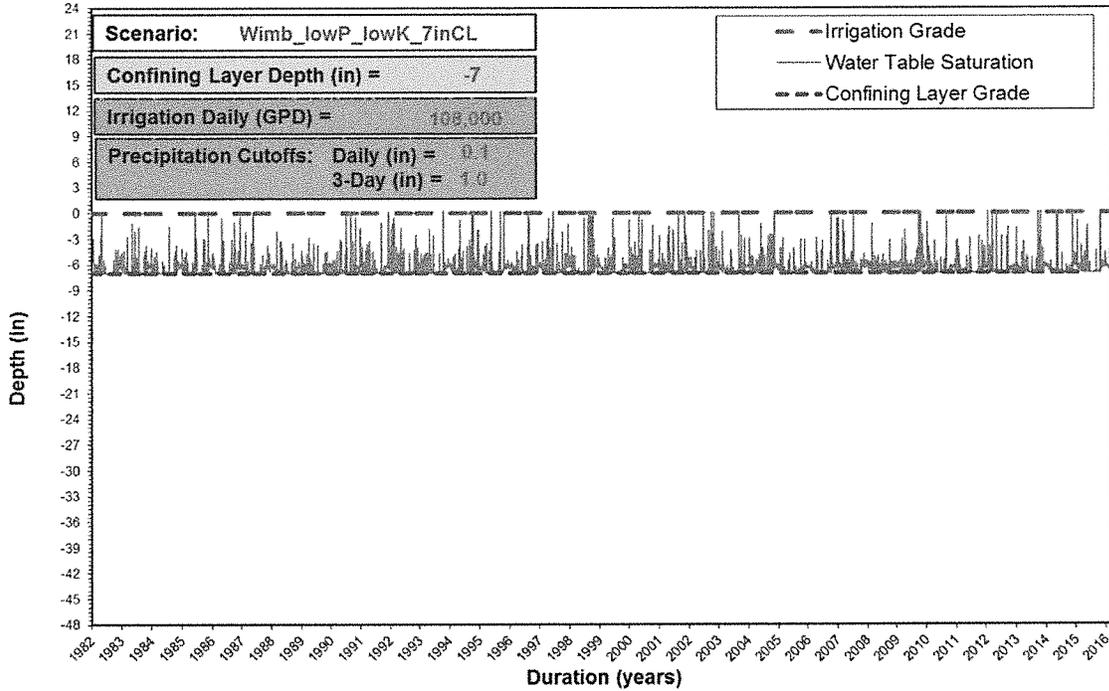


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

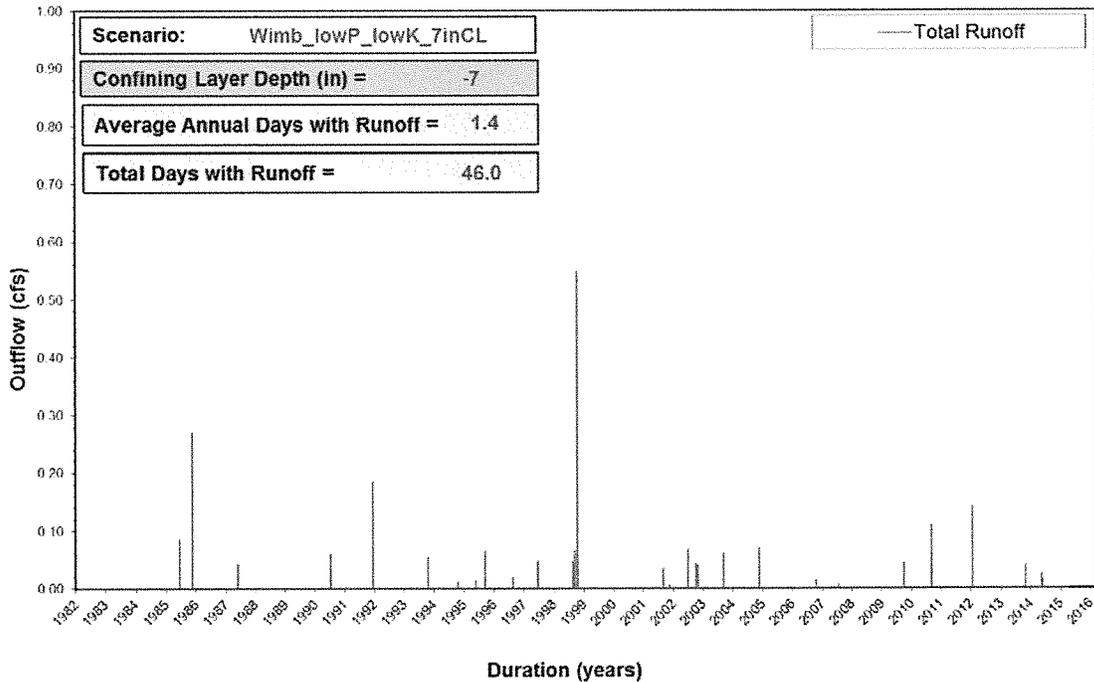


Worst Case, 7inch to confining layer, Irrigation = 108,000K GPD; Irrigation-based Runoff begins

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)



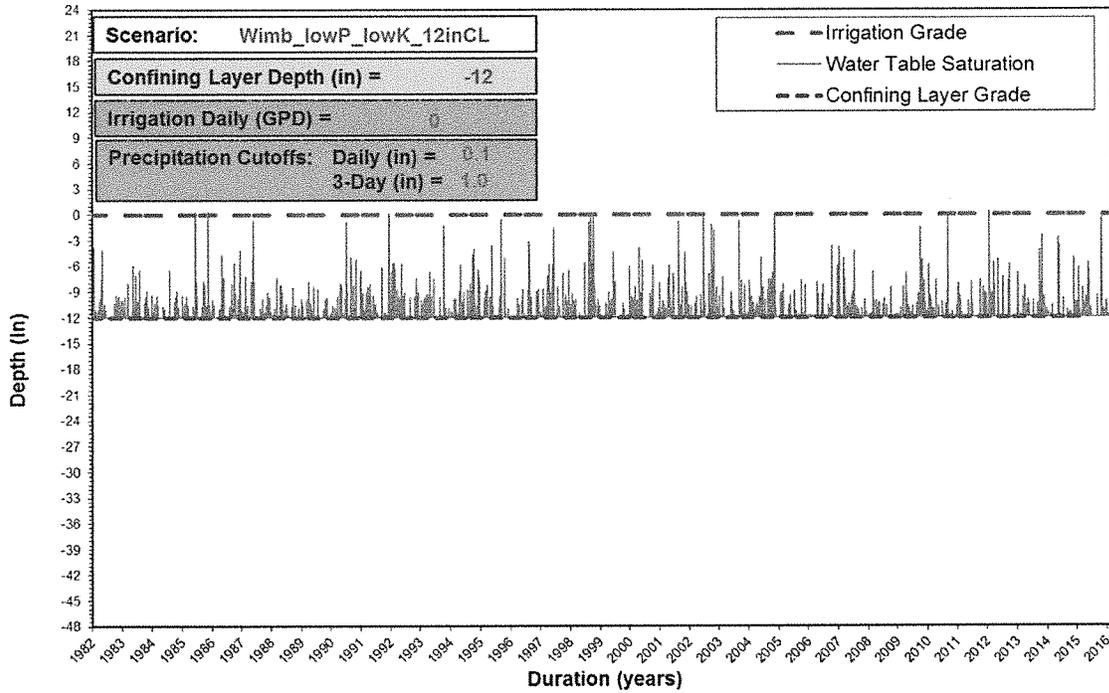
### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)



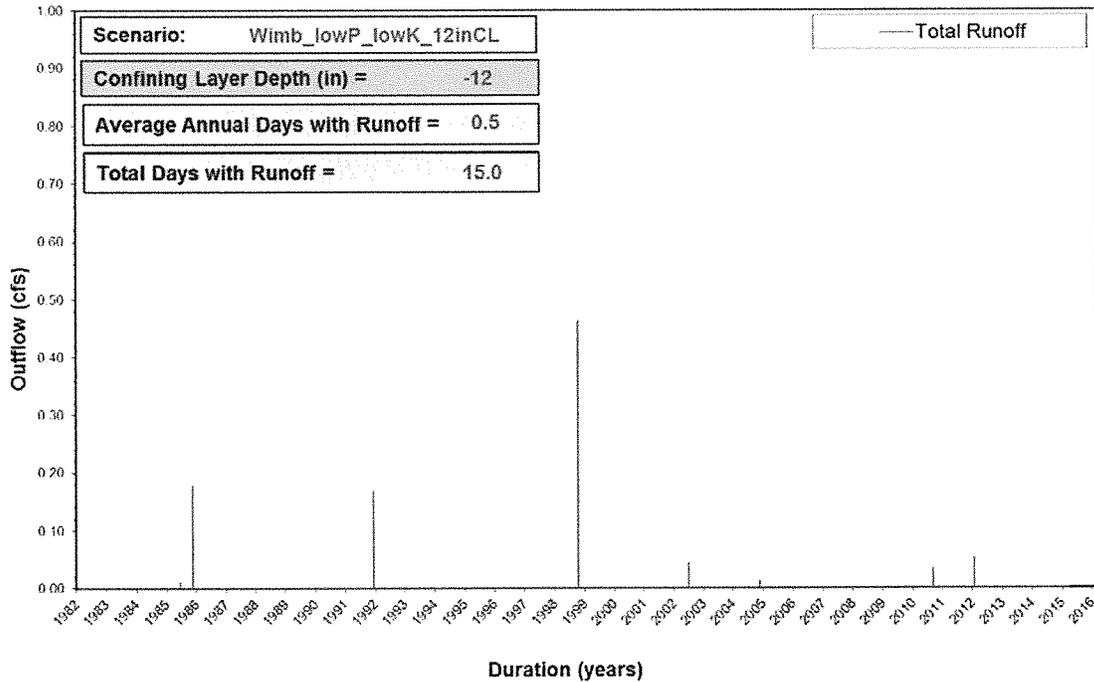
**Appendix B**  
**12-inch Depth to Confining Layer**

Worst Case, 12inch to confining layer, Irrigation = 0 GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

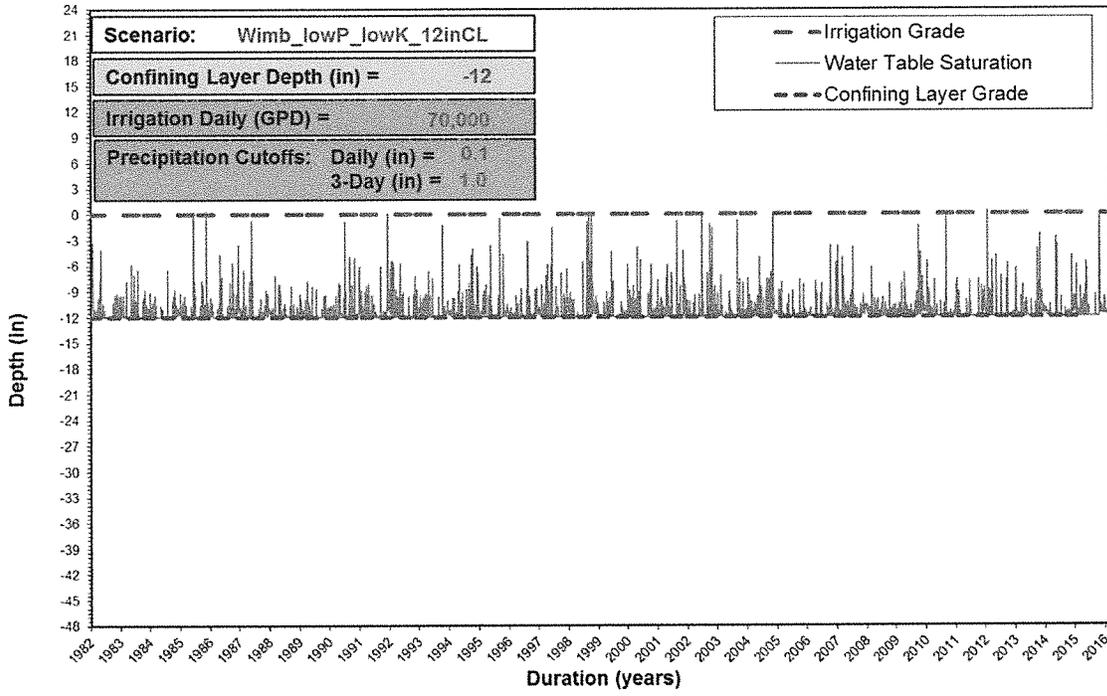


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

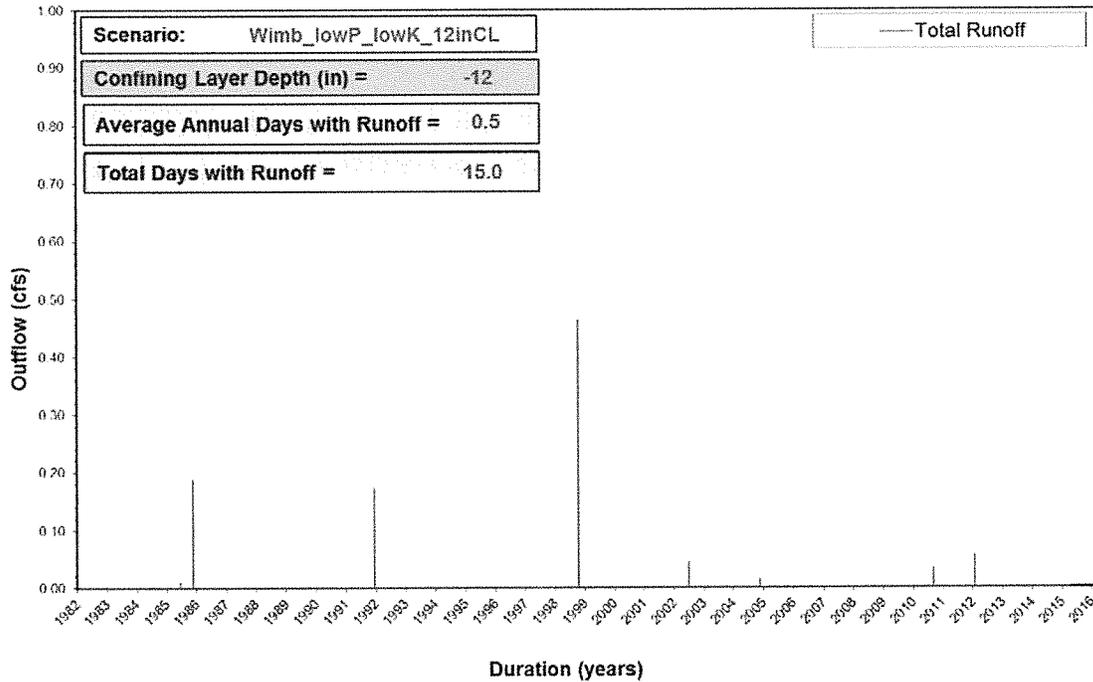


Worst Case, 12inch to confining layer, Irrigation = 70,000K GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

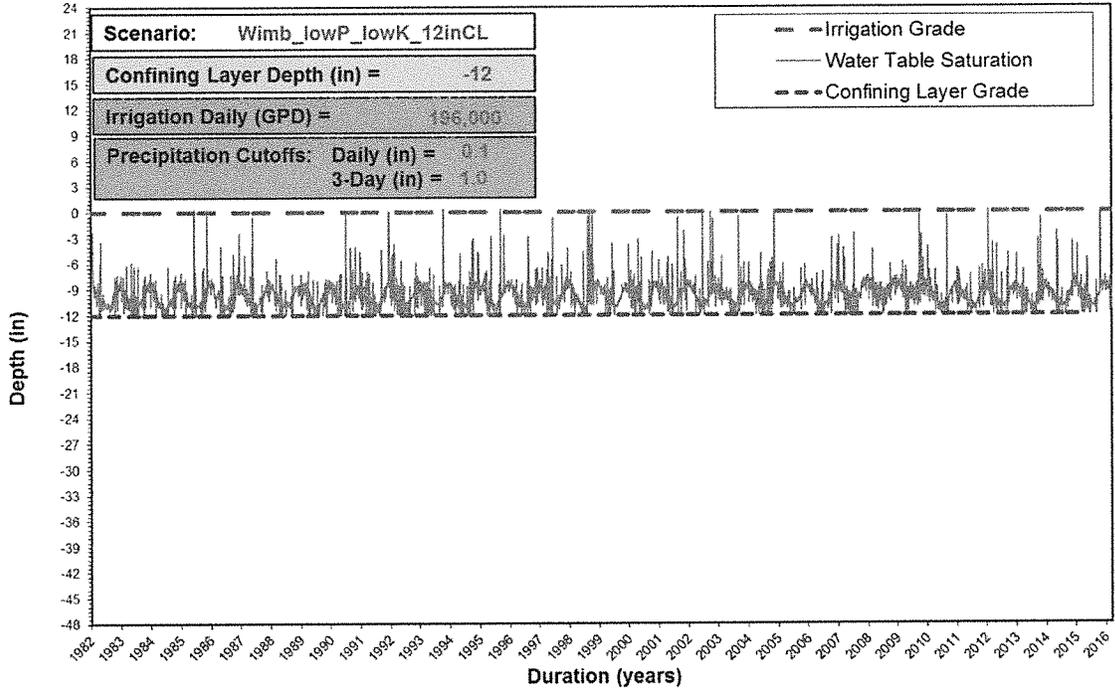


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

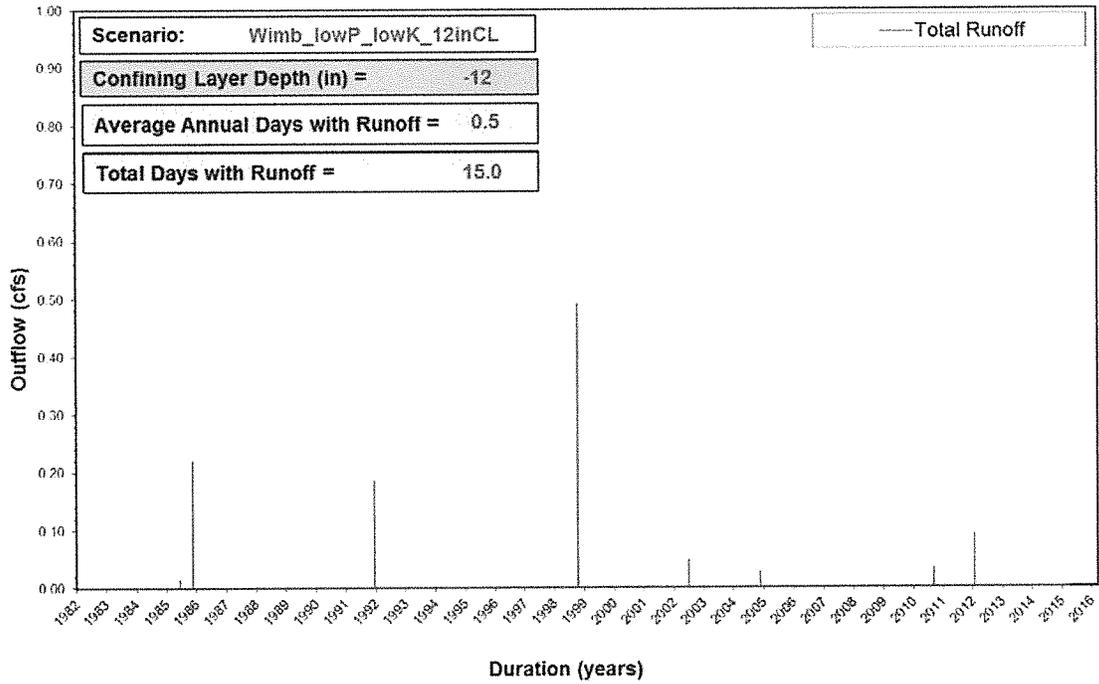


Worst Case, 12inch to confining layer, Irrigation = 196,000K GPD; all Runoff is Precipitation-driven

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)

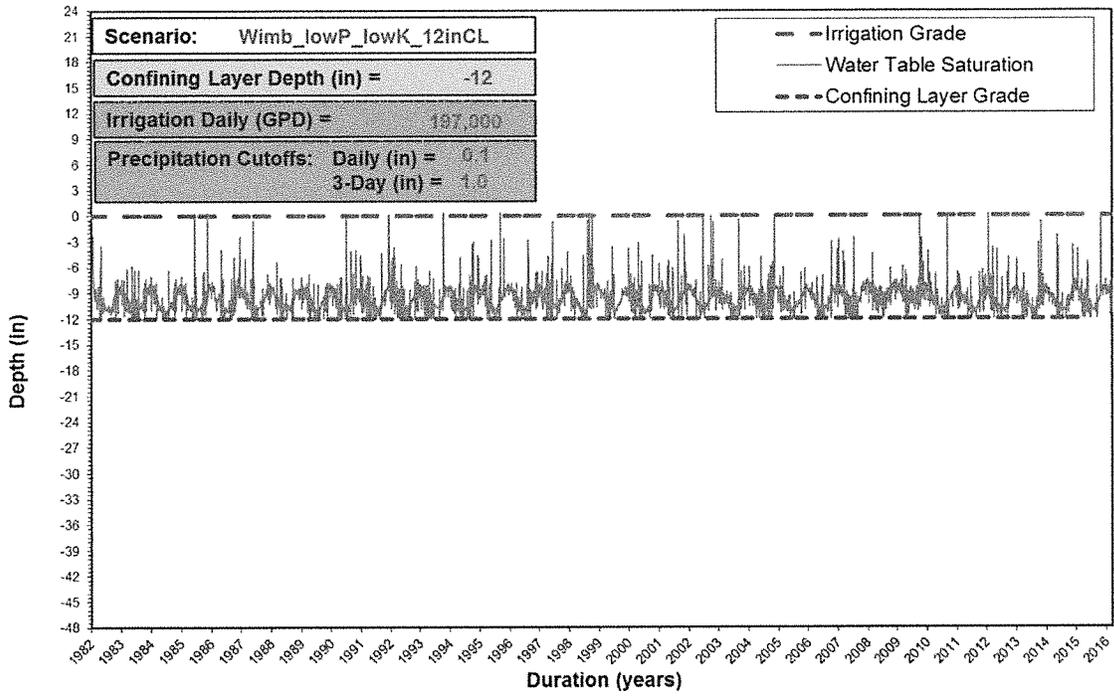


### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)

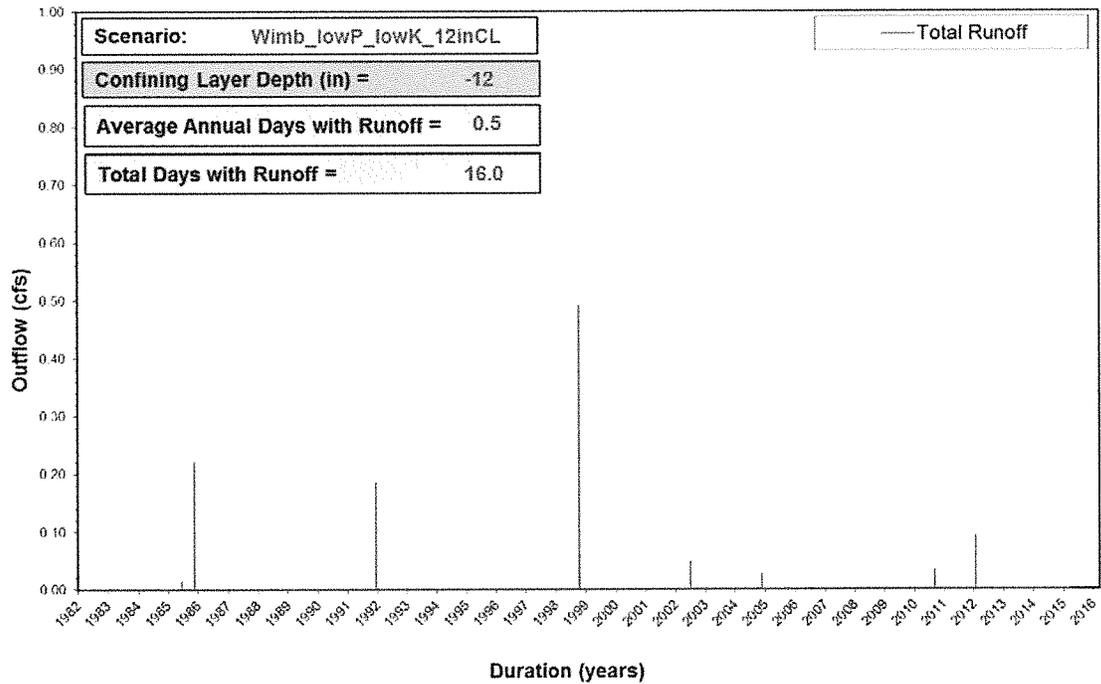


Worst Case, 12inch to confining layer, Irrigation = 197,000K GPD; Irrigation-based Runoff begins

### Water Table Fluctuation, Root Zone (DAILY 1982-2016)



### Total Runoff, Precipitation + Irrigation (DAILY 1982-2016)



**Subject:** Water Balance

**Date:** Wednesday, September 7, 2016 9:16:41 AM Central Daylight Time

**From:** Coonan, Steve

**To:** Don Ferguson (dferguson@cityofwimberley.com)

Don:

Attached is the water balance for the Blue Hole Park. Utilizing available soil characteristics, we built a model to see how water would flow through the soil matrix. We ran the model with historic rainfall data to determine the number of days that runoff would have occurred based on historic precipitation. Then we started applying irrigation water. We increased the amount of irrigation water applied until we started causing more runoff days based on historical precipitation. This set the upper boundary of how much water can be applied via irrigation before additional runoff occurs. The value is dependent on how much soil there is. The soil survey indicates that typically the soil in that area is between 7 and 12 inches deep so we ran the model for both 7 and 12 inches of soil. As you can see, in both cases we would not cause additional runoff (assuming that we are not irrigating on days where it rains more than 0.1 inches or where it has rained more than 1 inch in the previous three days) until we apply more than 100,000 gallons of water to the irrigation site.

**Stephen J. Coonan, P.E.** (TX No. 65516)

Principal

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