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# Background Groundwater Inflow Analysis

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**Abstract: As a consequence of centuries of impacting on natural aquifers and exploitation of the reserves of the subsurface, and under current climate changes, numerous urban areas now suffer severe and irreversible remote damage. This example will demonstrate the use of MODRET to estimate the amount of background groundwater seepage into a ditch or a pond, and the groundwater drawdown effects adjacent to a pond or a ditch and also demonstrate the procedures to utilize the limited data of a soil survey book, which does not have the benefit of pond specific soil data, and therefore, the data must be used conservatively.**

**Keywords: runoff, groundwater table, overflow**

## 1. INTRODUCTION

This example will demonstrate the use the program named Modret, to estimate the amount of background groundwater seepage into a ditch or a pond, and the groundwater drawdown effects adjacent to a pond or a ditch. Figure 1 presents a typical ditch detail in a high groundwater table area. The site soil data is limited to USDA/SCS soil survey book.

This example will also demonstrate the procedures to utilize the limited data of a soil survey book, which does not have the benefit of pond specific soil data, and therefore, the data must be used conservatively.

For this example, the ditch is located in an area of mostly Felda Sand (Fd), with typical soil profile summarized below:

| Depth Interval (inches) | Soil Description |
|---|---|
| 0 - 3 | Topsoil |
| 3 - 26 | Light gray fine sand |
| 26 - 34 | Dark grayish brown sandy loam |
| 34 - 38 | Grayish brown loamy fine sand |
| 38 - 62 | Pale brown loamy fine sand with shell fragments. |

| Depth Interval (inches) | Permeability From SCS Book (in/hr) | Permeability Average (in/hr) |
|---|---|---|
| 0 – 30 | 6.3 - 20.0 | 13.0 |
| 30 - 42 | 0.63 - 2.0 | 1.3 |
| 42 - 60 | 6.3 - 20.0 | 13.0 |

The normal seasonal high groundwater table (SHGT) is at 12 inches below ground surface as indicated in the SCS soils book.

Use the SCS soil survey book and the ditch system presented on Figure 1 to estimate aquifer characteristic and the ditch geometry. The drainage ditch of Figure 1 has a control overflow weir with the following characteristics:

| | |
|---|---|
| Type of weir | Typical broad crested weir |
| Weir crest elevation (OWE) | 11.25 feet |
| Weir crest length | 8.0 feet |
| Weir flow coefficient | 3.13 |
| Weir exponent | 1.5 |
| Number of end constrictions | 2 |

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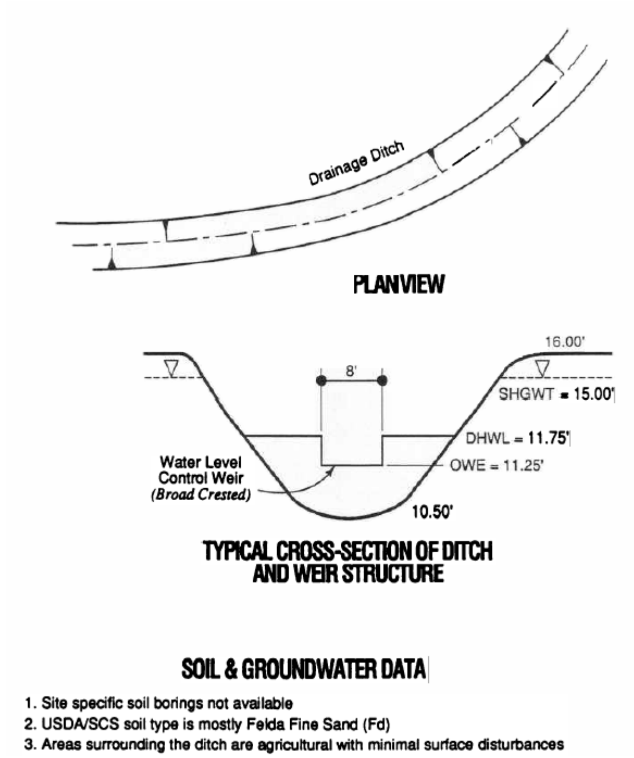



Figure 1 Drainage Ditch

Calculate the rate of background groundwater seepage into the ditch under average normal wet season groundwater level conditions. Provide background flows for short term condition (within a week after heavy storm and an average flow for 30 days after a storm), and for long term condition (at the end of 120 days).

Also, evaluate the extent of influence of the ditch on the groundwater table drawdown created by the ditch, for the 7 and the 120 day time periods modeled. It is assumed that the 7 day model represents typical background flow under peak wet season conditions and the 120 day model represents the typical average flows at the end of a wet season (or beginning of dry season).

## 2. MODEL SETUP AND EXECUTION

### 2.1 Selection of Aquifer Parameter

From the available data the normal wet season groundwater table (NWSGWT) can be calculated as follows: NWSGWT = 16 ft (surface) - 1 ft (depth to NWSGWT) = 15.0 ft. The aquifer bottom will be assumed at the bottom of ditch (10.5 ft), since deeper soil data is not available. The ditch length to width ratio will be set arbitrarily set at 10.0, since infiltration pond ratios of equal to or greater than 4.0 behave similarly (Groundwater Hydrology: Bouwer, 1978). Values of slightly less or more than 10.0 should give the same results. For a L/W = 10 and a ditch width of 25 feet (Figure 1), the ditch length would be 250 feet; thus, the **Area at Starting Water Level** would be 6,250 ft2 (25 ft x 250 ft) [6].

To calculate the average horizontal coefficient of permeability for the layered soil data provided in the SCS book, the following assumptions and conversion factors can be used[6].:

- Assume aquifer base at elevation 10.5 feet (bottom of ditch-based on available data)
- Convert permeability values reported in the SCS book from inches/hour to ft/day (the conversion factor is ft/day = inches/hour x 2.0)
- Convert each value from Kv to Kh by a factor of 1.5, conservative factor (since the values in the SCS book represent vertical coefficient of permeability)

Based on these conversion factors and the layered soil strata provided in the SCS book, the average horizontal coefficient of permeability can be calculated as follows:

1.5 ft x 39 fpd + 1.0 ft x 3.9 fpd + 2.0 ft x 39 fpd

Use, **K**Havg = 30 ft/day

The effective storage coefficient was estimated from Table A-1, for h = 1.8 ft ( average between NSHGWT of 15.0 ft and overflow water elevation (OWE) of ditch of 11.25 ft), at *f* = 0.1.

The elevation of starting water level will be set at 11.25 feet to correspond with the OWE of the ditch.

The OWE in this example indicates the controlled water level in the ditch, which is accomplished by a broad crested overflow weir with crest elevation at 11.25 feet. Since the ditch will have a continuous background inflow the water level in the ditch should always be at (or above) the weir crest elevation[4]..

Although, the high water level of the ditch is not known and does not affect the modeling efforts herein, the MODRET model does require input of the design high water level to size the pond to be modeled.

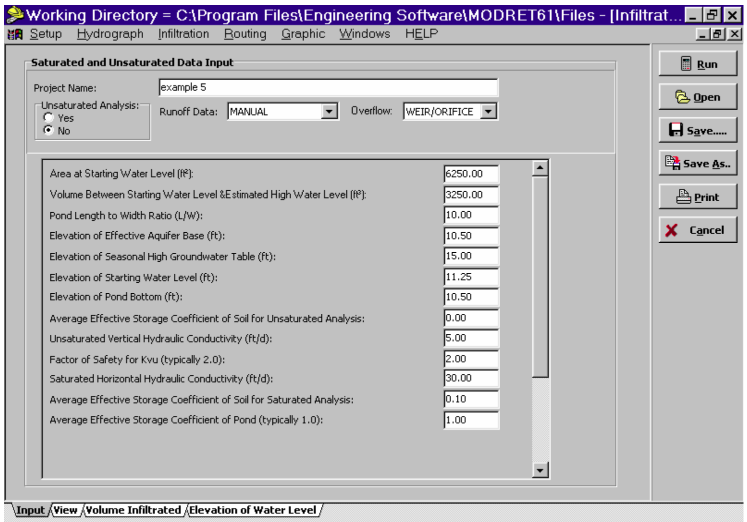
Therefore, an approximate value of 0.5 feet above the weir crest will be used in this analysis (i.e., elevation 11.75 feet). For side slopes of 2H:1V, and a distance of 0.5 feet between OWE (11.25 ft) and DHWL (11.75 ft), the Volume of Pond was calculated at 3,250 ft2 ((25 ft + 2(0.5 ft)) x 250 ft x 0.5 ft) [6]..

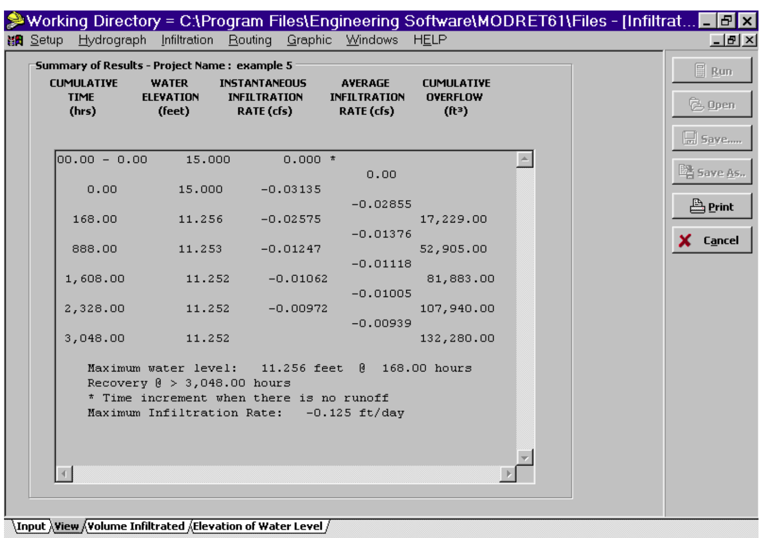
Many assumptions and interpretations were used for this example to demonstrate the feasibility of modeling such a system with limited data. The accuracy of the results will depend on the accuracy of the estimated and/or assumed data. For better results, site specific soil and groundwater data should be obtained[2].[4].

### 2.2 Model Execution

For the execution of this model setup, it is not necessary to utilize the unsaturated analysis, and there is no runoff to the ditch. Therefore, the option of **No** was specified for Unsaturated Analysis and the option of manual was specified for Runoff Data. A total of 5 time increments were specified; the first was an increment of 7 days and the next 4 increments were 30 days each [3], [6].

A volume of runoff of zero (0) was specified for each time increment. This allows the MODRET model to calculate background groundwater inflow at the end of each time increment. The results of the model run (printouts of input data and output tables and graphs) follow:



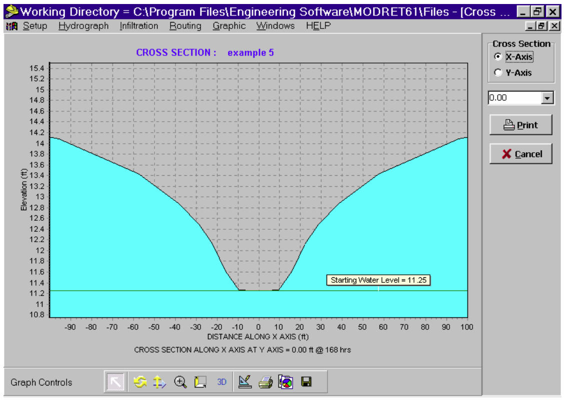



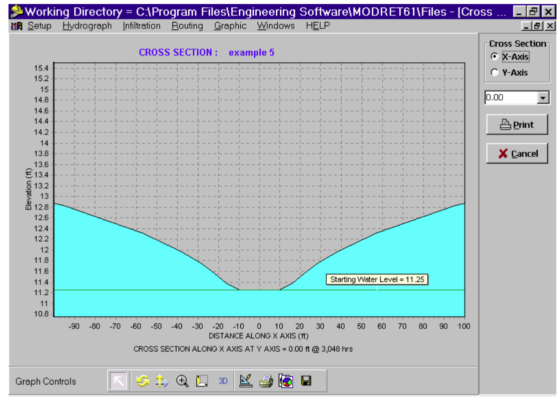

### 2.3 Model Results and Evaluation

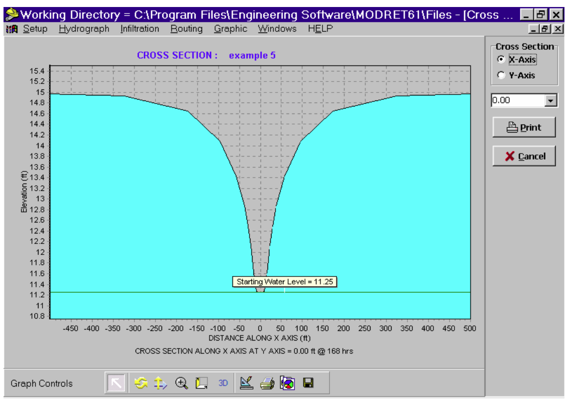
The results of the program modeling can be observed on the tabular and graphical printout formats attached. The background groundwater inflow can be obtained from the tabular results, under the right most column "Cumulative Overflow". At the end of the first stress period (7 days) the overflow volume is 17,229 ft3.

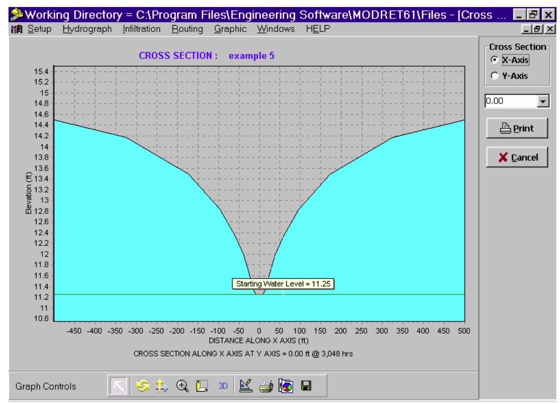
This total overflow volume was divided by the modeled length of the ditch of 250 feet and by the time increment of 7 days, which resulted in a background groundwater flow rate of 9.8 ft3/day per lineal foot of ditch. Similarly, the 30 day average and the long term (120 day) average background groundwater inflows were calculated at 35,676 ft3 (52,905 - 17,229) and 24,340 ft3 (132,280 - 107,940), which convert to an average of 4.8 and 3.2 ft3/day per lineal foot of ditch, respectively [4], [6]..

Note that the infiltration rates in this example appear as negative values. This is because the groundwater is flowing into the modeled pond (ditch in this case) instead of water flowing out of the pond[6]..




## CONCLUSIONS

The groundwater drawdown effects can be observed on the groundwater cross-sectional graphics generated by the program. Both 7 day and 127 day cross-sections were created and are attached. The groundwater cross-sectional data indicates that the influences of the ditch on the groundwater drawdown for the 7 day simulation are about 0.9 feet at a distance of 100 feet from ditch center and about zero (0) at a distance of about 500 feet, while for the 127 day simulation are about 2.1 feet at a distance of 100 feet and about 0.5 feet at a distance of 500 feet.

## REFERENCES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[5] http://www.epa.gov/owmitnet/mtb/wetdtnpn.pdf

[6] Modret 6.1, User Guide Manual