SIMULATION OF GROUND WATER CONTROL METHOD

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ملخص البحث:

يهدف البحث إلي محاكاة طرق التحكم في المياه الجوفية باستخدام برنامج (modflow) وتم تطبيق تلك الدراسة علي (منطقة أبوالهول والمعابد الأثرية المجاورة) حيث تعاني المنطقة من خطر ارتفاع المياه الجوفية الأمر الذي أدي إلي تدهور المنطقة الأثرية وكذلك تراجع السياحة بالمنطقة والهدف هو دراسة كل البدائل التي تعمل علي تخفيض المياه الجوفية إلي المستوي الأمن للتنبؤ بآثار تلك البدائل واختيار البديل الأمثل وحيث أن التخفيض سيكون بشكل دائم فكان لابد من الدراسة الاقتصادية أيضا للبدائل .

ABSTRACT

In terms of the importance of preserving the area of the Sphinx, pyramids, temples and monuments of Egypt, where population growth will introduce new sources of water will certainly increase the rise of groundwater levels, began with the main objective is to protect the Sphinx from the dangers of rising groundwater levels. Through the development of the research objectives, the research methodology was planned. This methodology includes an introduction to the importance of the research topic, 5 stages of investigation. The theoretical stage, the data collection stage, the numerical modeling phase, the analytical stage and the theoretical stage. The previous research in the field of groundwater was presented to utilize the previous studies through simulations, which are collected. The data collection stage, Where a complete picture of the area was filmed. Numerical Emphasis Several alternatives have been proposed to limit the rise of groundwater in the Sphinx region in order to keep it from deteriorating. In addition, the Sphinx was designed before and after the implementation of alternatives to predict the impact of such countermeasures. For the analytical phase, numerical modeling results were analyzed and the impact of the proposed measures analyzed. With regard to the deductive phase, conclusions were made; recommendations were proposed and an appropriate measure was commended in order to preserve the region from the risk of rising groundwater. By modeling groundwater using mod flow, calibrating the model to verify its validity in all cases and suggesting measures (alternatives) to counter the rise of groundwater in the Sphinx (sinks, horizontal wells, vertical barriers), and simulating the Sphinx Before and after the implementation of the proposed alternatives to predict the impact of these measures. The results of the numerical modeling were analyzed and the impact of the five proposed measures was evaluated.

KEY WORDS:

 Ground Water Modeling , Modflow, conceptual model, Numerical model, Drain, Horizontal well, Barrier, vertical wells.

PROPOSED ALTERNATIVES

Based on the results of the previous researches that investigated the study area, several alternatives and their combinations were proposed. These are, as follows:-Linear drains in trenches, Combined Linear drains and Barrier, Horizontal well , Combined horizontal well and Barrier, Barrier and vertical wells.

LINEAR DRAINS IN TRENCHES

Based on the linear drain system simulation, it was recommended to lower the drain by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (13.00) m target level is achieved in Sphinx Area. In addition, the flow to the drain would be 11050 m^3/d, figure (1).

Finally, one of the most important features least total cost and the most important disadvantages greatest construction impact.

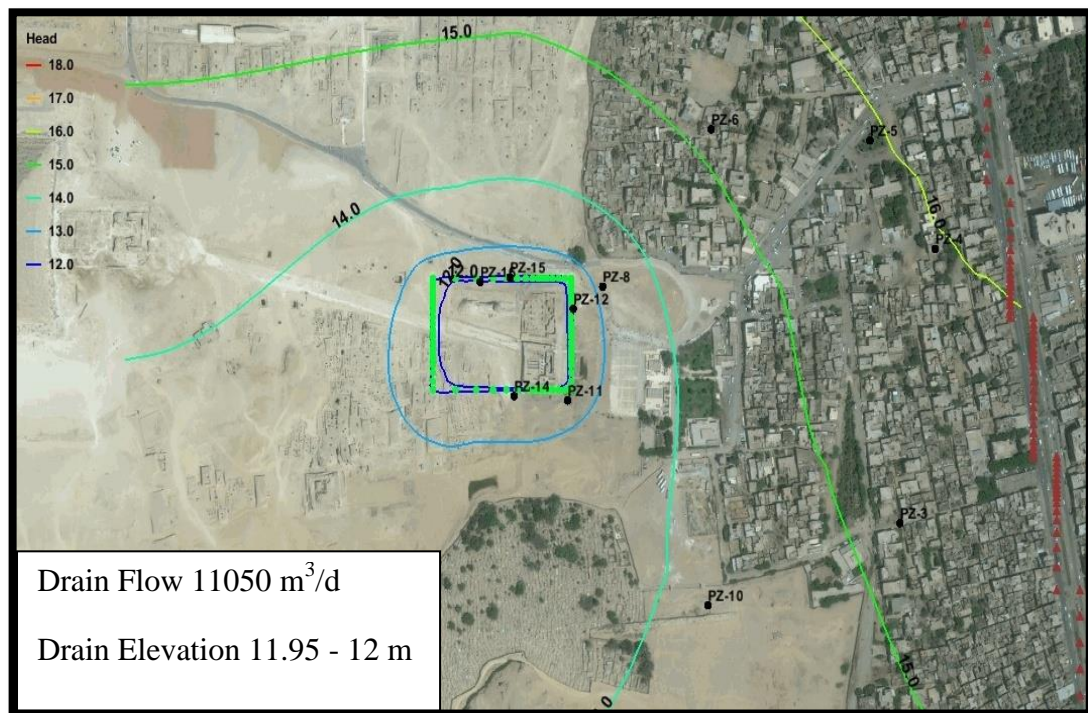

Drain Flow 11050 m^3/d

Drain Elevation 11.95 - 12 m

Figure (1) Calculated Groundwater Levels for Linear Drain

COMBINED LINEAR DRAINS AND BARRIER

Based on the simulation of the linear drain system with a barrier, it was recommended to lower the drain system by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the drain would be 9805m^3/d, figure (2).
As for cost , total cost (L.E) 69 million Including capital cost (45 million), operation and maintenance(24 million) up to 40 years.
Finally, one of the most important features high drawdown and the most important disadvantages greatest construction impact and high total cost.

Drain Flow 9805 m^3/d
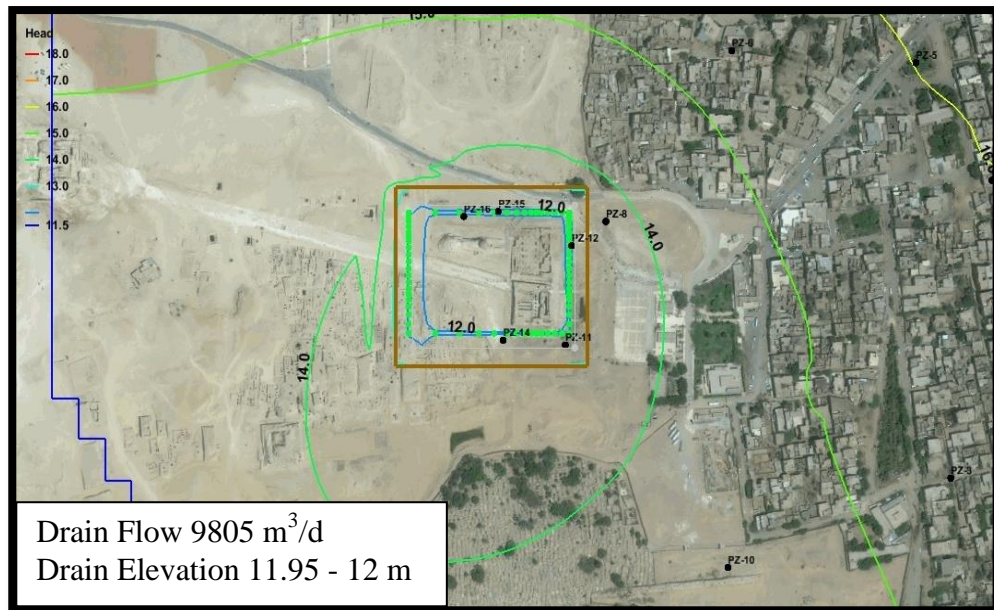Drain Elevation 11.95 - 12 m

Figure (2) Calculated Groundwater Levels for Liner Drain- with barrier

HORIZONTAL WELL

Based on the simulation of the horizontal well, it was recommended to lower the horizontal well by an additional 0.5 m. Thus, the horizontal well invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the horizontal well would be 11500m^3/d, figure (3).

As for cost , total cost (L.E) 54 million Including capital cost (30 million), operation and maintenance(24 million) up to 40 years.

Finally, one of the most important features small Implementation period and the most important disadvantages requires importation of equipment and materials and high capital cost.
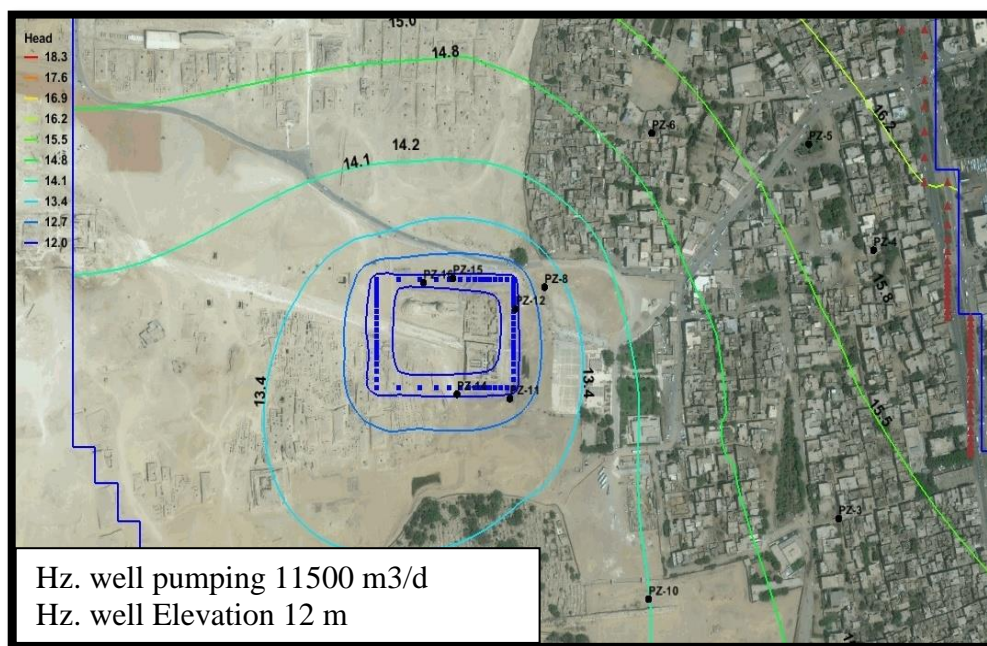

Hz. well pumping 11500 m3/d
Hz. well Elevation 12 m

Figure (3) Calculated Groundwater Levels for Horizontal well

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HORIZONTAL WELL WITH THE BARRIER

Based on the simulation of the horizontal well with the barrier, it was recommended to lower the horizontal well by an additional 0.5 m. Thus, the trench invert should be lowered by 1.5 m. Accordingly, the (12.00) m target level is achieved in the Sphinx Area. In addition, the flow discharging into the horizontal well would be 9000m^3/d, figure (4).

As for cost , total cost (L.E) 69 million Including capital cost (45 million), operation and maintenance(24 million) up to 40 years.

Finally, one of the most important features high drawdown and the most important disadvantages requires importation of equipment and materials and high capital cost.
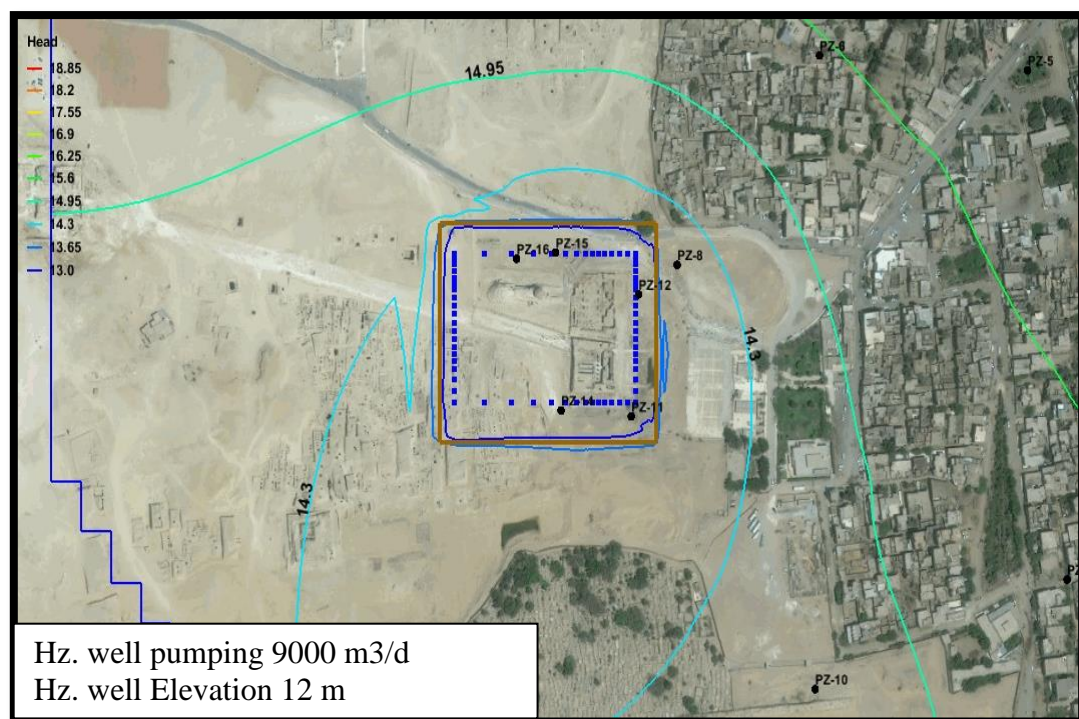

Figure (4) Calculated Groundwater Levels for Horizontal well- with barrier

BARRIER

Based on the barrier simulations, the calculated groundwater levels are presented on figure (5).The16.25m target level was not achieved in Sphinx Area. This indicated that it is not recommended to use the barrier, as it does not achieve the desired goal but when used on low permeable layers achieves the target level and reduce the ground water level to (11.08) m.

As for cost , total cost (L.E) 39.6 million Including capital cost (9.6 million), operation and maintenance(30 million) up to 40 years.

Finally, one of the most important features least running cost and the most important disadvantages greatest construction impact and high capital cost.
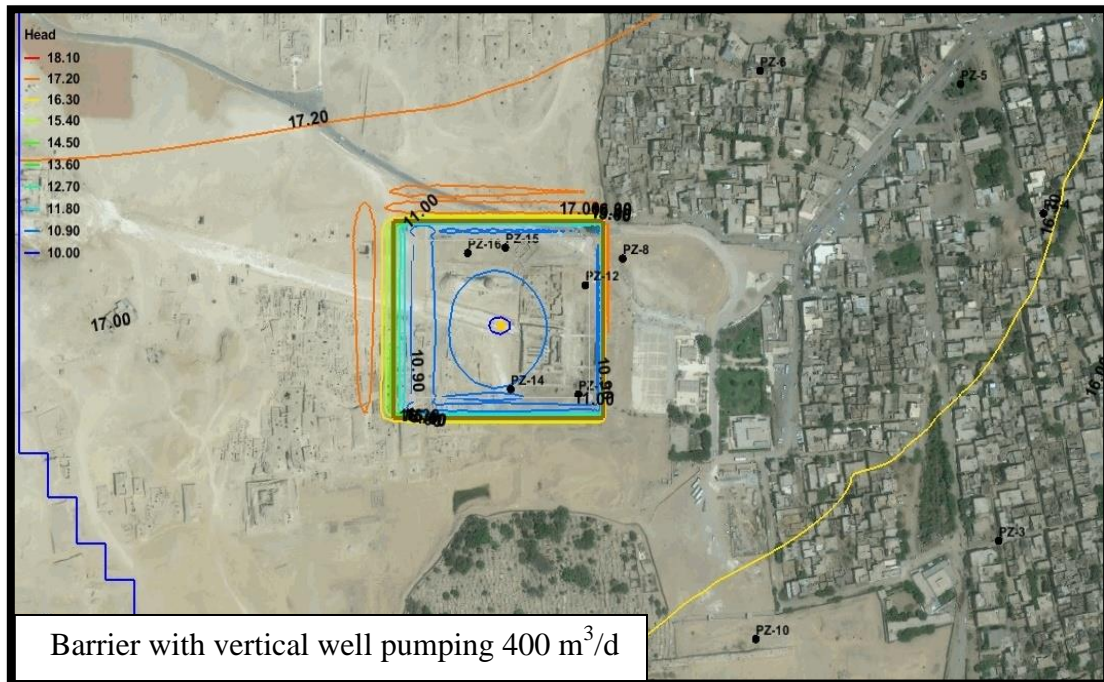
Barrier with vertical well pumping 400 m^3/d

Figure (5) Calculated Groundwater Levels for Barrier

CONCLUSIONS

Based on the obtained results and their analysis, the following conclusions were deduced:

- Alternative I and III (Linear drains and horizontal wells) are the economic measures and could reduce the groundwater table to a target level of (12.00)m. However, alternative I is the most economic.
- Alternative II and IV (Linear drains and horizontal wells with barrier) could reduce the groundwater table to a target level of (12.50)m. However, it is relatively uneconomic as the barrier could not be implemented, as it requires a low-permeable layer to prevent vertical flow.
- Alternative V(barrier) did not achieve the target level in Sphinx Area. Therefore, it is not recommended to use it at places with layers with high hydraulic conductivity, but when used on low permeable layers achieves the target level and reduce the ground water level to (11.08) m.

RECOMMENDATIONS

Based on the deduced conclusions, the following recommendations were suggested:

- Regarding the Engineering practice, the following are suggested:
- ✓ The first and third alternative (Linear drains and horizontal wells) is suitable to preserve the area of the Sphinx from the damage of groundwater, where the security level (12.00) m above the sea level and preferably the first alternative

(linear drain) as it is economically feasible and recommend to put it on 1.5 m of the security level.

✓ The second and fourth (Linear drains and horizontal wells with barrier) alternative is suitable to preserve the area of the Sphinx from the damage of groundwater, where it achieves a more secure level is economically inappropriate in addition to the use of vertical barriers in this area does not fit the nature of the layers in the area of lime limestone highly hydraulic conductivity where does not prevent the vertical flow, Groundwater security is not achieved at the Sphinx for the above reasons. It was studied only to illustrate its effect on the assumption of a low hydraulic conductivity layer and is only suitable in areas with green or soil injection with a research that prevents vertical flow.

✓ Alternative V is not recommended to be implemented, as it does not achieve the target level.

✓ vertical wells are used where there has been security level, but you must be careful where the highest value will be recorded for the decline of alternatives, but easily characterized by implementation and less to create value.

✓ The choice should be governed by the economic condition, the applicability of the measure without affecting the tourism in the Sphinx Area and Scalable to increase the expected groundwater level .

SUMMARY FOR STUDY ALTERNATIVES.

After completion of the study of all alternatives from the point of drawdown and subsidence resulting from that drawdown and the cost of each alternative for the following is a summary of the study in the following table to facilitate the process of comparison between alternatives and choose the best alternative of all interfaces.

NO	ALTERNATIVE	HEAD (ASL-M)	PUMPING RATE (CMD)	VERTICAL DISPLACEMENT (MM)	CAPITAL COST (LE)	TOTAL RUNNING COST (LE) /40 YEARS	TOTAL COST(LE)	THE BEST RANKING
1	LINEAR DRAIN	(12.05)	11050	1.4	15000000	24,000,000	39,000,000	1
2	LINEAR DRAIN WITH BARRIER	(12.08)	9805	2	45,000,000	24,000,000	69,000,000	6
3	HORIZONTAL WELLS	(11.90)	11500	2.4	30,000,000	24,000,000	54,000,000	3
4	HORIZONTAL WELLS WITH BARRIER	(12.00)	9000	2	45000000	24,000,000	69,000,000	5
5	BARRIER WITH BASE PLUG	(11.08)	400	1.7	30,000,000	9,600,000	39,600,000	4
6	BARRIER	(16.25)	0	0	15,000,000	-	15,000,000	7
7	VERTICAL WELLS	(12.05)	25000	5	7,200,000	43,200,000	50,400,000	2

Table (1) Summary For Study Alternatives.

LIST OF REFERENCES

1. AECOM (2010) "Groundwater Lowering Alternatives, Pyramids Plateau Groundwater Lowering Activity", USAID Contract No. EDH-I-00-08-00024-00-Order No.02, Technical Memorandum, submitted to USAID, February 20, 2010, AECOM in Association with ECG and EDG.
2. American British Consultant "AMBRIC" (1989): "Greater Cairo Wastewater in the Pyramids Area Project"- Ministry of Reconstruction, New Communities, Housing and Utilities
3. Arnold, J.G., Allen, P.M. (1999). "Automated methods for estimating base flow and groundwater recharge from stream flow records". J. American Water Resource. Assoc. 35 (2), 411–424.
4. Arnold, J.G., Allen, P.M., Bernhardt, G. (1993). "A comprehensive surface-groundwater flow model". J. Hydrol. 142, 47–69.
5. Arnold, J.G., Fohrer, N. (2005). "SWAT2000: current capabilities and research opportunities in applied watershed modeling". Hydrol. Process. 19 (3), 563–572.
6. Arnold, J.G., Srinivasan, R., Muttiah, R.S., Williams, J.R. (1998). "Large area hydrologic modeling and assessment: part I. Model development". J. American Water Resource. Assoc. 34 (1), 73–89.
7. Atef Al-Kharabsheh (2000)."Ground-water modelling and long-term management of the Azraq basin as an example of arid area conditions (Jordan)", Journal of Arid Environments 44: 143–153
8. Bunbury, J., Lutley, C., and Graham, A. (2007). "Giza Geomorphological Report", In Giza Plateau Mapping Project, Seasons 2006-2007, Preliminary Report. Giza Occasional Papers 3, Ancient Egypt Research Associates, Inc.
9. Cairo University (2007). "Factual Geotechnical Investigation and Geological Report for Groundwater Control of Elwadi Temple of Khafra'a Pyramid – Sphinx Zone", Giza Governorate.
10. Cairo University (2008). "Drilling and Testing of Three Wells at the Sphinx Area", Technical Report.
11. Cairo University (2008). "Lowering of Groundwater at Wadi Temple and Sphinx Area", Final Technical Report.
12. Cairo University (2008). "Operation of Production Wells and Piezometer Readings below the Sphinx and Wadi Temple", from July to October 2008.
13. Cairo University (2008)." Technical Report for the Drilling of Four Boreholes around the Sphinx", Video Logging and Water Level Monitoring
14. Cairo University (2009). "Lowering of Ground Water below the Sphinx and Wadi Temple", Final Report.