A Review on Optimal Dewatering of Aquifers

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ABSTRACT

Water that occurs below the surface of earth is generally termed as groundwater (Subramanya, 2010).In many construction sites water table is found near the ground surface. To ensure stability of side slopes and to prevent significant groundwater seepage into excavation, it is necessary to lower groundwater levels in advance of excavation so that construction of structure can be accomplished. Groundwater hydraulic management models enable the determination of optimal locations and pumping rates of numerous wells under a variety of restrictions placed upon local drawdown, hydraulic gradients and water production rates (Gorelick, 1983). There are two models namely embedding technique and response matrix method.

I. INTRODUCTION

In the past decades the field of groundwater hydrology has turned toward numerical simulation models to help evaluate groundwater resources. The application of finite difference and finite element methods to groundwater flow equations has permitted complex, real world systems to be modeled. Numerical simulation models have enabled hydrogeologists to develop a better understanding of the functioning of regional aquifers and to test hypotheses regarding the behavior of particular facts of groundwater systems. The simulation method has provided a framework for conceptualizing and evaluating aquifer systems. Models have become tools to evaluate the longterm impacts of sustained water withdrawals, groundwatersurface water interaction.

1.1 EMBEDDING TECHNIQUE

The embedding method for the hydraulic management of aquifers uses linear programing formulations that incorporate numerical approximations of the groundwater equations as constraints. This technique was initially presented by*(Aguado and Remson ,1974*) for groundwater hydraulic management. That work demonstrated with one- and two-dimensional examples that the physical behavior of the groundwater system could be included as an integral part of an optimization model. Finite difference approximations were used in both steady state and transient problems. In all examples, physical objective functions maximized hydraulic heads at specified locations. Constraints were placed upon heads, gradients, and pumping rates. The examples treated confined and unconfined aquifer hydraulics. For the confined case the governing equation is linear, and the resulting finite difference approximations were treated as linear constraints. For the unconfined aquifer case the steady state equation was treated as linear with respect to the square of the hydraulic heads [Remson ,1971]. This linear form was then amenable to treatment using the embedding approach. For the transient confined case the governing equation was discretized over space and time. A set of equations for each time step was included in the linear program as constraints. Itshould be noted that this approach can result in an extremely large constraint matrix. If a groundwater model consists of 1000 nodes and 30 time steps are taken, there will be 30,000 decision variables corresponding to hydraulic heads over space and time. There will be an equal number of constraints representing the finite difference equations. The transient unconfined case is truly nonlinear and was treated by Aguado and Remson [1974] using the predictor-corrector method of Douglas and Jones [1963]. A succession of linear programing problems was solved for the corrector step while the predictor step was solved by direct numerical simulation. The latter approach is limited in that management is possible only from one time step to the next. Objective spanning long management time horizons are not possible. The embedding method was described in detail in the dissertation of Aguado,1979.

1.2 RESPONSE MATRIX METHOD

The second technique in groundwater hydraulic management is the response matrix approach. Incorporation of a response matrix into a linear program was initially proposed in the petroleum engineering literature by Lee and Aronofsky [1958]. They developed a linear programing management model which sought to maximize profits from oil production. A response matrix was used to linearly convert pumping stresses into pressure changes in a petroleum reservoir. The pressure response coefficients were developed using an analytic solution to the flow equation [Van Everdingen and Hurst, 1949]. Constraints ensured that reservoir pressures were maintained above one atmosphere, limited total production to the reservoir capacity, and guaranteed that oil purchased from an outside source did not exceed the pipeline capacity. Their solution gave optimal production rates for each of five potential sources during four time periods of two years each. Aronofsky and Williams [1962] extended this work to the scheduling of drilling operations.

II. REVIEW OF LITERARURE

Lee and Aronofsky (1958) explained methods are indicated for the introduction of two, three, or any number of wells following the procedure., The inclusion of additional wells merely increases the size of the linear programming model.It is worthwhile to examine the limitations of the present model.According to him the one very obvious shortcoming is that only four time periods were considered. It would be much more realistic if there were 20 or more time periods rather than four. Then the well pressure could decrease to 1 atm at 20 points instead of only four points.

Buras (1963) The Conjunctive use of a surface reservoir and a ground-water aquifer was analyzed from the point of view of optimal operation. A mathematical model was established considering the system to be operated for N consecutive years. The method of dynamic programming was used in developing an optimal operating rule.

Deininger (1970) described the use of systems analysis and operations research tech- niques for the planning, design, and operation of specific parts of a water supply system. of current research studies are indicated. The optimal design and develop- ment of ground water sources, particularly the operation of well fields. The second topic deals with regional development of future supply sources.

Maddock (1972) distributed parameter groundwater simulation models are difficult to couple explicitly with management models that seek to optimize an economic objective. For a ground- water system whose drawdown in response to pumping was modeled by a two-dimensional linear partial differential equation

Aguado (1977) Groundwater variables are included directly as decision variables in a LP aquifer management mode. Sensitivity analysis should be an integral part of any groundwater optimization study.

Gorelic (1983) Distributed parameter models of groundwater hydraulic or solute behavior have been combined with optimization techniques in mathematical programing to inspect a variety of aquifer management problem. In addition to mathematical programing techniques, parameter estimation models that use regression methods might be linked with management models. The result could be models that use the best set of hydraulic parameters, that determine optimal management plans, and that give information about the reliability and sensitivity of management solutions. Such innovations would be a tremendous aid in the management of groundwater resources and stream-aquifer systems.

Faust (1984) gave an overview on ground water modelling Models can be used in all phases of the aquifer and data collecting as well as prediction. To be most effective, the hydrologist must have a thorough understanding of the specific aquifer studied.

Casola (1986) A linear-quadratic optimal control model was formulated that computes the optimal spatial and temporal allocation of groundwater. The optimal control model maximizes the present discounted value of the benefits of water use derived by a linear programming model and the cost of pumping. If no development were allowed, the model solution indicates that a common-property situation probably exists with the result that a greater than optimal amount of water is being extracted in the basin at the present time.

CONCLUSIONS

From the above study it can be concluded that embedding technique is simpler to simulate ground water modelling.It will be developed for minimizing the total cost of pumping system satisfying the requirements of dewatering at minimum cost. It also requires less computational time and hence for small scale embedding technique should be applied.

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