Chapter 7. Conclusions

I. Aquifer parameters

Boundaries

An understanding of boundary conditions is of paramount importance in the construction of any ground water flow model. In this study relatively little is known about the boundary conditions of the model. The conceptual model of the study domain has governed the application of boundary conditions. For example, recharge was expected from the clinker nodes on the cropline, the head gradient was expected to be to the northwest in both layers, and the head gradient was expected to be flatter than the dip of the coal layer. These conditions were set at the beginning of the modeling effort and adhered to throughout. In the absence of data in these areas this is a reasonable approach, and one that has been used previously (Peacock, 1997b). This study has shown, however, that the model can be quite sensitive to head values on the boundary, which is to be expected from the PDE being solved. Although questions were answered regarding other model parameters, they were all based on the assumption that the boundary conditions were correct. This study established boundary conditions which were plausible, but would have benefited from a better understanding of the boundary conditions.

Coal heterogeneity

The conclusion that a heterogeneous coal layer better represents the system is important. Even conditionally simulated heterogeneous coal hydraulic conductivities represent the coal better than a homogeneous mean coal K value. Although homogeneous coal might be useful in generating a first order approximation of the flow system, a better assessment of the heterogeneity of the coal and its distribution will allow for the creation of a much better model.

Vertical hydraulic conductivity of the confining layer

It is clear from the results of this study that the value given to the vertical K of the confining layer dictates whether a calibration with the Wasatch sand lens can be achieved. This study has determined that 9.0E-06 is the best available estimate for the vertical hydraulic conductivity of the confining layer. It is interesting to note that the estimates of vertical hydraulic conductivity in the homogeneous coal case and the heterogeneous coal case differ only by a factor of two.

II. Recommendations for future study

Boundary conditions

Collection of data which will aid in the understanding of boundary conditions should be the first priority in any modeling effort. The two areas of most pressing need for this study are the western and eastern boundaries of the model. Wells should be drilled, and heads measured, in the vicinity of the western boundary of the domain.

Along the eastern boundary a better understanding of the nature of the aquifers is necessary. A tracer test would benefit the model by determining a recharge rate along the eastern boundary. A bomb tritium or chlorofluorocarbon tracer test would be ideal in this location because not only would the delineation of the tracer front allow for the calculation of a volumetric inflow rate, but a study of the geometry of the tracer front might shed some light on how areas of the cropline behave as recharge zones.

The nature of the clinker needs to be addressed along the cropline. An examination of the connection between clinker and coal would be beneficial. The transition zone should also be examined, and its hydrologic properties assessed.

Hydrogeologic properties of the Wasatch

The heterogeneity of the Wasatch makes it difficult to model. The scale of variation within the Wasatch Formation prohibits a good assessment of its aquifer characteristics. As this study has shown, a large sand body does exist within the Wasatch. Presumably there are others. This model would benefit from more aquifer tests in the Wasatch aimed at determining the degree of interconnection between this and other sand lenses. A few aquifer tests in the sand lens itself should be done to assess its hydrogeologic parameters. The boundaries of this model layer should be addressed as well.

Leaky aquifer test

The author recommends that a leaky aquifer test be done. The coal should be pumped while the sand lens is monitored. This would further address the premise of the study; the connection between the Wyodak coal and the Wasatch sand lens.

III. Modeling

The question remains, how much modeling can be supported by how much data? In this case the model domain was constructed in order to include sufficient area to model a transient state simulation at a later date. In so doing, much of the domain is without data, even though data from all available sources has been acquired. The result is a model which weighs heavily on a conceptualization of the domain, and methods, such as kriging, to fill the model with plausible parameter values. In addition, due to the size of the model, many simplifications of the stratigraphy were necessary. Such simplifications may have had an effect on the predicted heads and hence the estimated parameter values. Therefore, the estimates arrived at in this model are only internally consistent. About the behavior of the natural system which the model represents, there is far less certainty. Before applying these results outside of this model, the error resulting from simplification and estimation must be accounted for. If it is accepted that a model of near infinite complexity can describe the natural system, it must be accepted that the estimates of aquifer parameters and heads are only reliable to the degree that the model has been simplified.

The non-uniqueness of the model results is significant. If plausible values for model inputs are chosen, there can be some confidence that the results of the model will be plausible. However, it is necessary to accept that by balancing all of the factors involved, the result is not unique. And that the more numerous the parameters involved, the more numerous the possible solutions. Hence, the parameter estimates provided in this work should not be accepted directly into further models of the Powder River Basin. They may, however, provide a starting point to be used as a first approximation in such models.