Model Layers

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Eastern Snake Plain Aquifer Model Enhancement Project
Scenario Document Number DDM-003

DESIGN DOCUMENTS

Design documents are a series of technical papers addressing specific design topics on the Eastern Snake Plain Aquifer Model Enhancement. Each design document will contain the following information: topic of the design document, how that topic fits into the whole project, which design alternatives were considered and which design alternative is proposed. In draft form, design documents are used to present proposed designs to reviewers. Reviewers are encouraged to submit suggested alternatives and comments to the design document. Reviewers include all members of the Eastern Snake Hydrologic Modeling (ESHM) Committee as well as selected experts outside of the committee. The design document author will consider all suggestions from reviewers, update the draft design document, and submit the design document to the SRPAM Model Upgrade Program Manager. The Program Manager will make a final decision regarding the technical design of the described component. The author will modify the design document and publish the document in its final form in .pdf format on the SRPAM Model Upgrade web site.

The goal of a draft design document is to allow all of the technical groups which are interested in the design of the SRPAM Model Upgrade to voice opinions on the upgrade design. The final design document serves the purpose of documenting the final design decision. Once the final design document has been published for a specific topic, that topic will no longer be open for reviewer comment. Many of the topics addressed in design documents are subjective in nature. It is acknowledged that some design decisions will be controversial. The goal of the Program Manager and the modeling team is to deliver a well-documented, defensible model which is as technically representative of the physical system as possible, given the practical constraints of time, funding and manpower. Through the mechanism of design documents, complicated design decisions will be finalized and documented.

Final model documentation will include all of the design documents, edited to ensure that the “as-built” condition is appropriately represented.

Introduction

The selection of the number of layers used in the model depends on the intended use of the model and the significance of three-dimensional flow in the aquifer. For example, if the objective was to evaluate the impact of Well A on Well B and the wells were open to the aquifer at different horizons, then three-dimensional flow may have a significant impact. On the other hand, if the two wells were both fully penetrating, then perhaps three-dimensional flow may not be as important and the problem can be approached in two-dimensions without introducing significant errors.

Problem Statement

The purpose of this model is to assist in managing the surface water and ground water resources within the Eastern Snake Plain Aquifer and the Snake River. The model will not be used in individual water user vs. individual water user cases. The intent is to use the model on a more regional basis to answer questions such as “What effect will a change in management practice in area B have on the aquifer and/or the Snake River?”

Considered Options

Two options are considered, a single-layer model, and a two-layer model. The single-layer model would include shallow aquifers as part of the regional aquifer. The two-layer model would have an upper layer active in the Rigby Fan and Burley to Rupert areas (Figure 1).

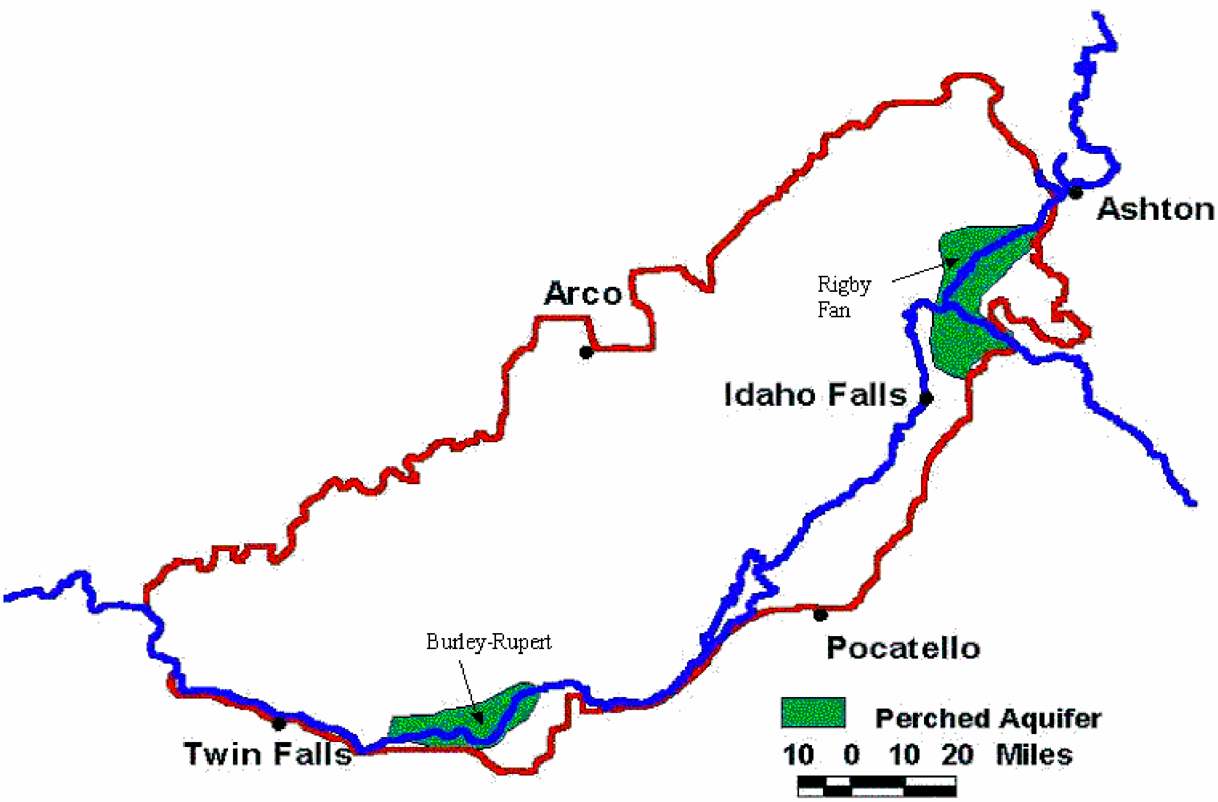

Figure 1. Location of shallow aquifers proposed for inclusion in the Snake Plain Aquifer Model Enhancement

Effect

Single-layer option

A single-layer model means there is no vertical flow component. A single-layer model will not properly simulate vertical flow between the shallow aquifer containing the river and the regional aquifer.

Two layer option

The two-layer option involves simulating the regional aquifer as one layer, with an overlying shallow layer, active only in selected areas, to simulate the three dimensional aspect of river-aquifer interactions. Rather than introducing a systematic error as with the single-layer option, the implication for this option centers around increased uncertainty in the model predictions. A multi layer model requires many more parameters than a single-layer model. For example, the state variables governing ground water movement in a multi layer steady state model are hydraulic conductivity and vertical conductance, where-as a single layer steady state model only requires hydraulic conductivity. The increase in the number of required parameters tends to add to model uncertainty rendering model predictions less clear.

The obvious question at this point is “Is the two layer option a significant enough improvement over the one layer option that it warrants the added degree of complication?” The low conductivity layer creating the perched body delays water on its way to the regional aquifer. In these selected areas this delay is administratively important.

Data Availability

Calibrating a two-layer model requires a large amount of data because the hydraulic conductivity distribution must be determined in both layers as well as the vertical conductance between the layers. A query of the IDWR Well Log database identified five ‘nested’ wells (vertically discrete wells in the same 10 acre plot) with time series data of at least 10 years in the Rigby Fan area. Figure 2 shows the location of the wells and plots of head vs. time are presented in Figures 3-7. All but one of these nested wells (nest 3341-42) show a significant downward vertical gradient indicating that the aquifer may be stratified in the Rigby Fan area. Elevations of the wells were obtained from a topographic map so the anomaly observed in nest 3341-42 could be due to an elevation error, the shallow aquifer could be less than 50’ thick in this area, or there could be a hole in the shallow aquifer. Pending successful resolution of the problematical 3341-42 nest, it appears there may be sufficient data to calibrate a two-layer model in the Rigby Fan area.

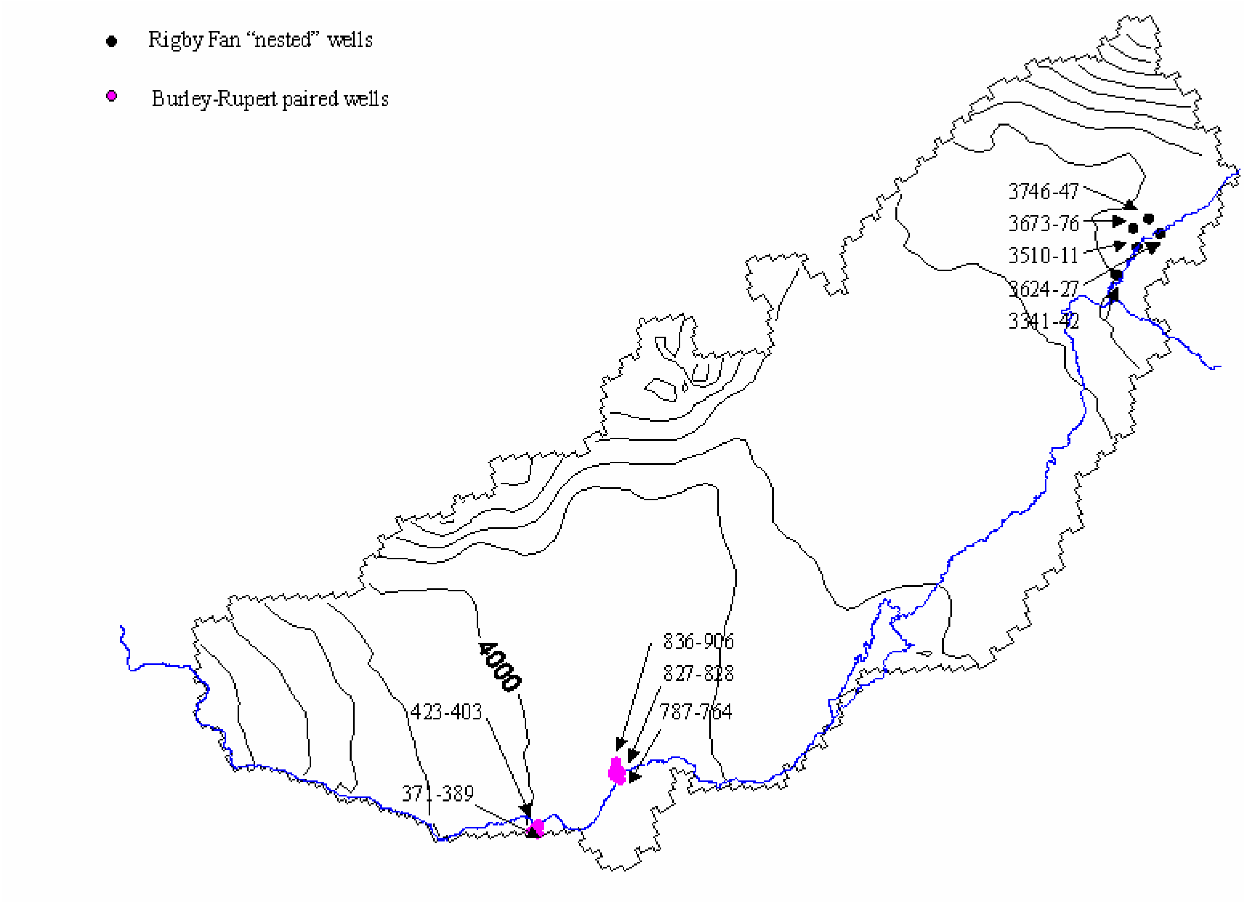

Figure 2. Location of "nested" wells in the Rigby Fan and Burley-Rupert shallow aquifers.

In the Burley-Rupert area there are no well nests with overlapping time series. The search was expanded to identify wells located in the same section (square mile). The well pairs identified are located in Figure 2. Time series plots are presented in Figures 8-12. For none of these well pairs are both wells measured regularly. In three of the wells paris the vertical gradient seems to be downward (Figures 8,11, 12,), and in one well pair the gradient appears to be upward (Figure 10). In Figure 9 the vertical gradient is not detectable due to the horizontal separation between the wells. A statistical t-test conducted using all data extracted from the IDRW Well Log data base in this area indicates that there is a statistically significant probability that a head difference exists between the wells over 100 ft in depth and wells less than 100 ft in depth. However, the paired data are sparse enough that calibration of a two-layer model seems less likely than in the Rigby Fan area.

All data mentioned in this analysis is available on the CD provided with this document.

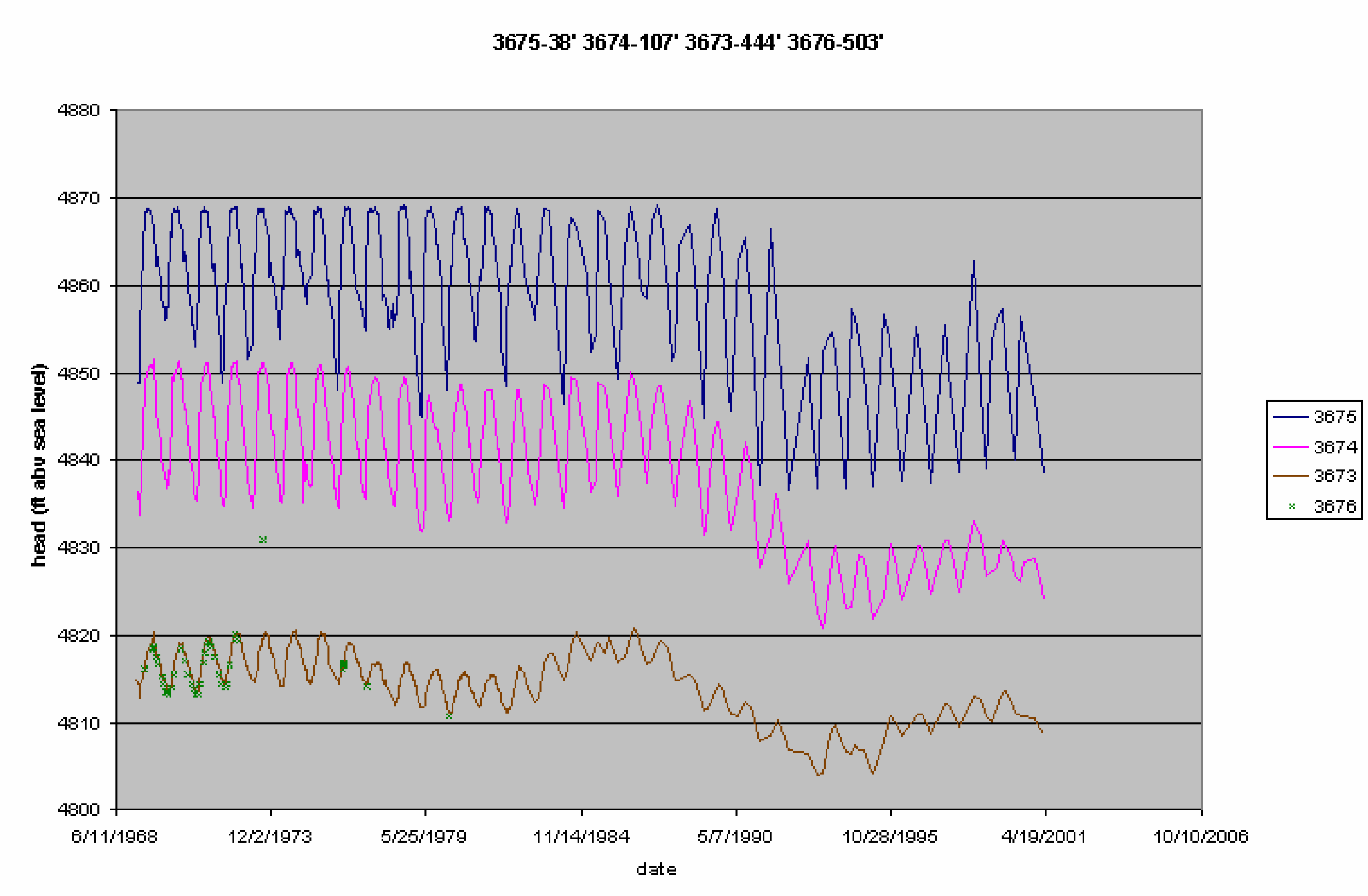

Figure 3. "Nested" well cluster in Rigby Fan.

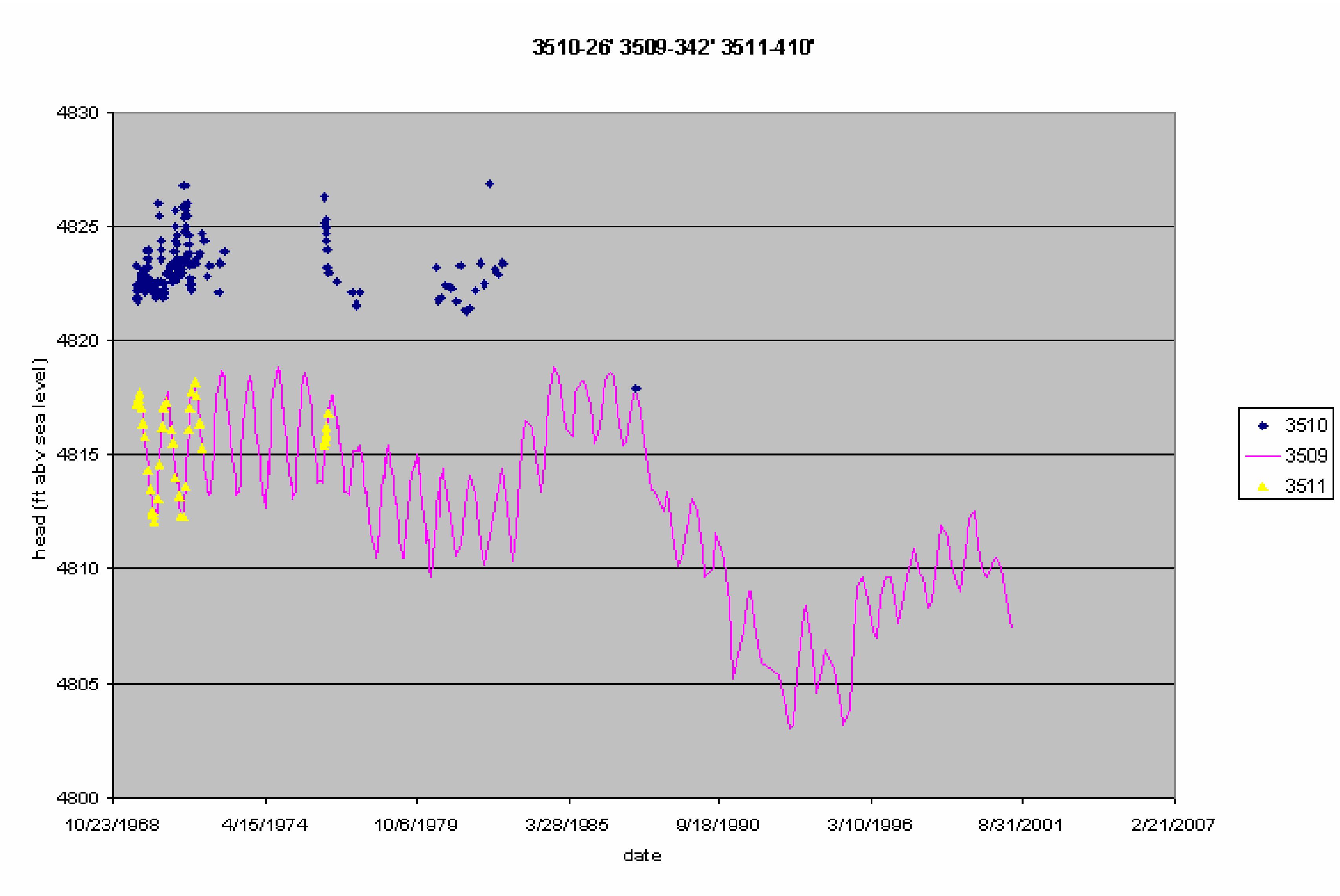

Figure 4. "Nested" well cluster in Rigby Fan.

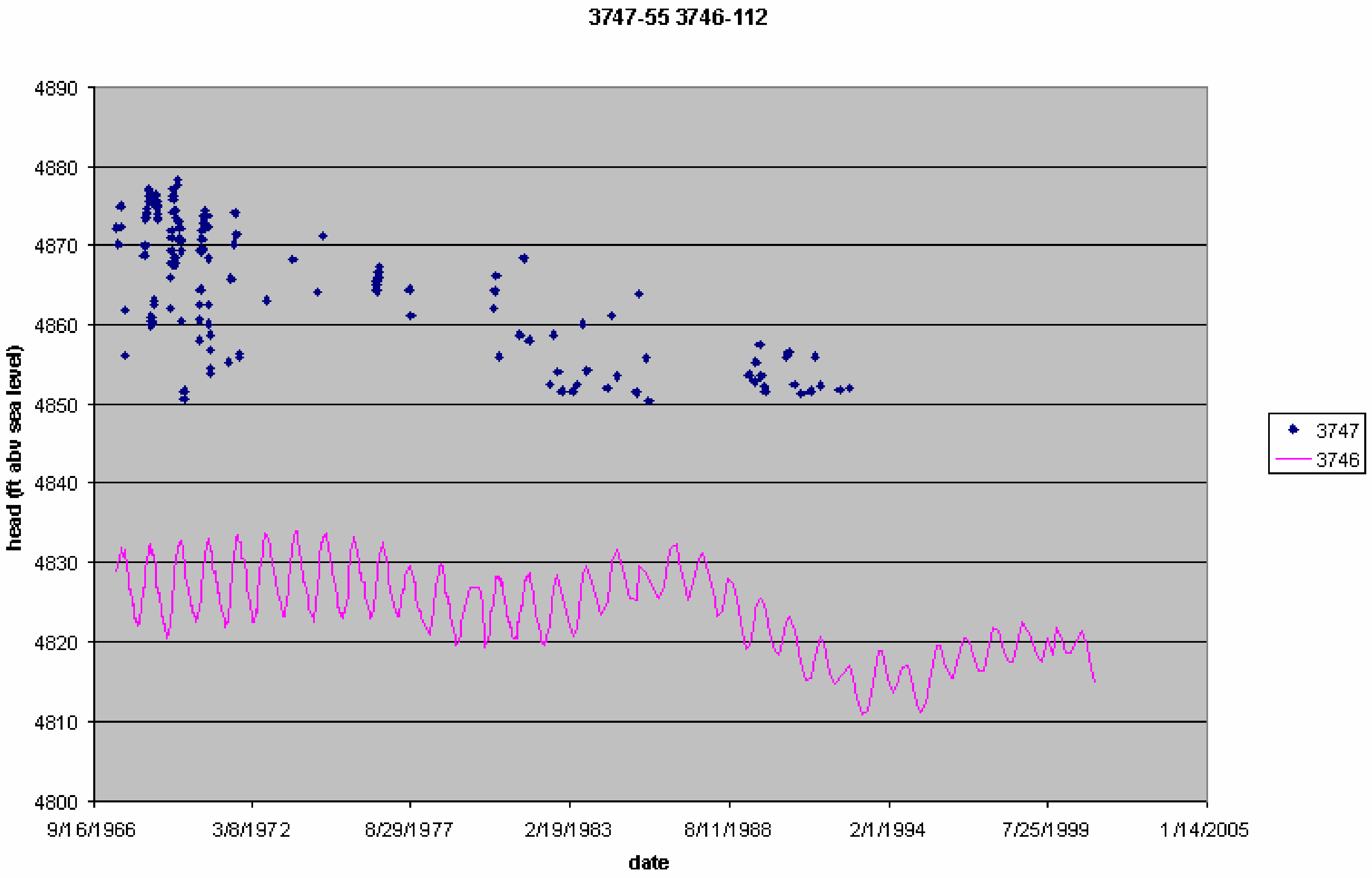

Figure 5. “Nested” well cluster in Rigby Fan.

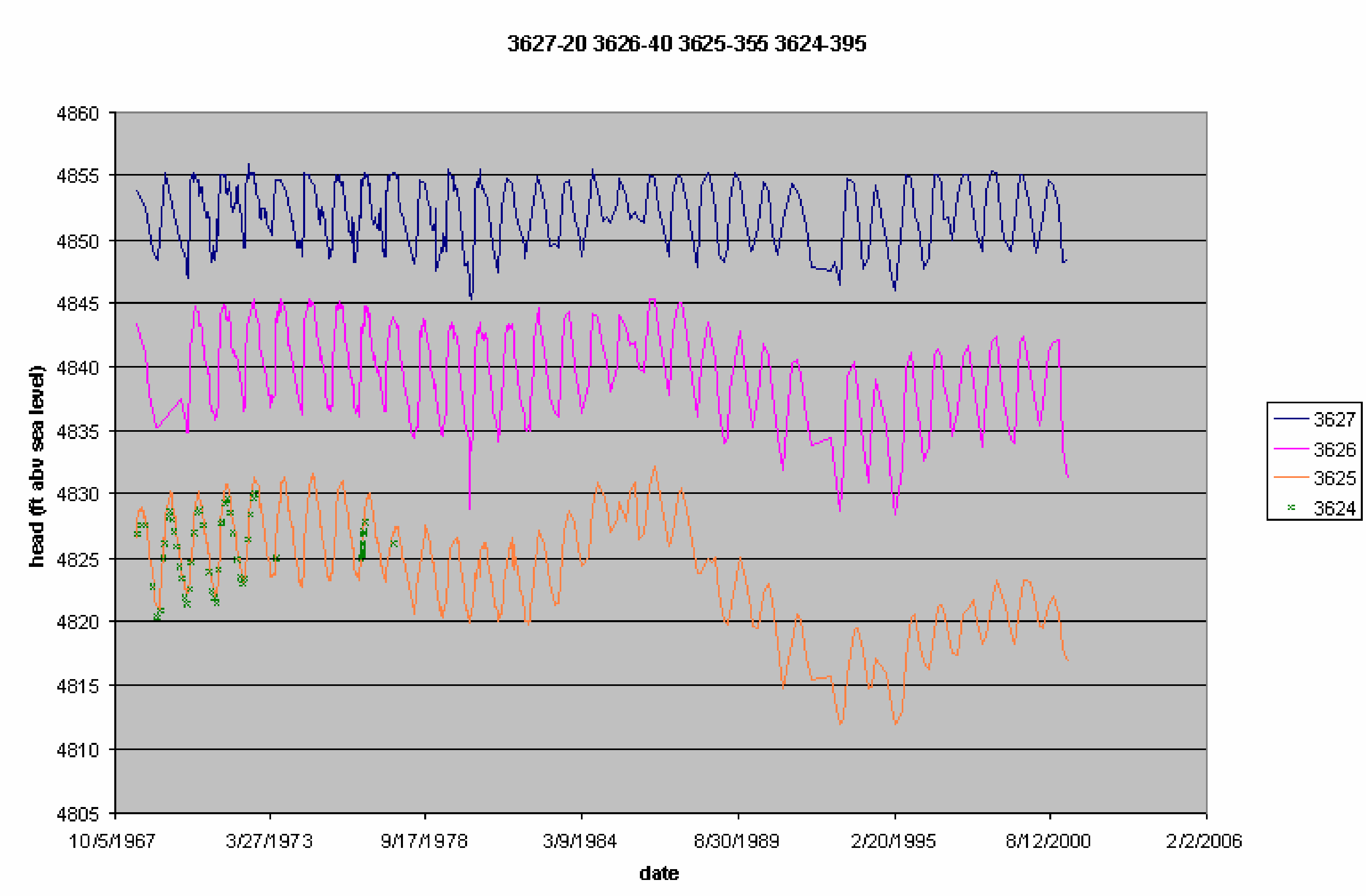

Figure 6. “Nested” well cluster in Rigby Fan.

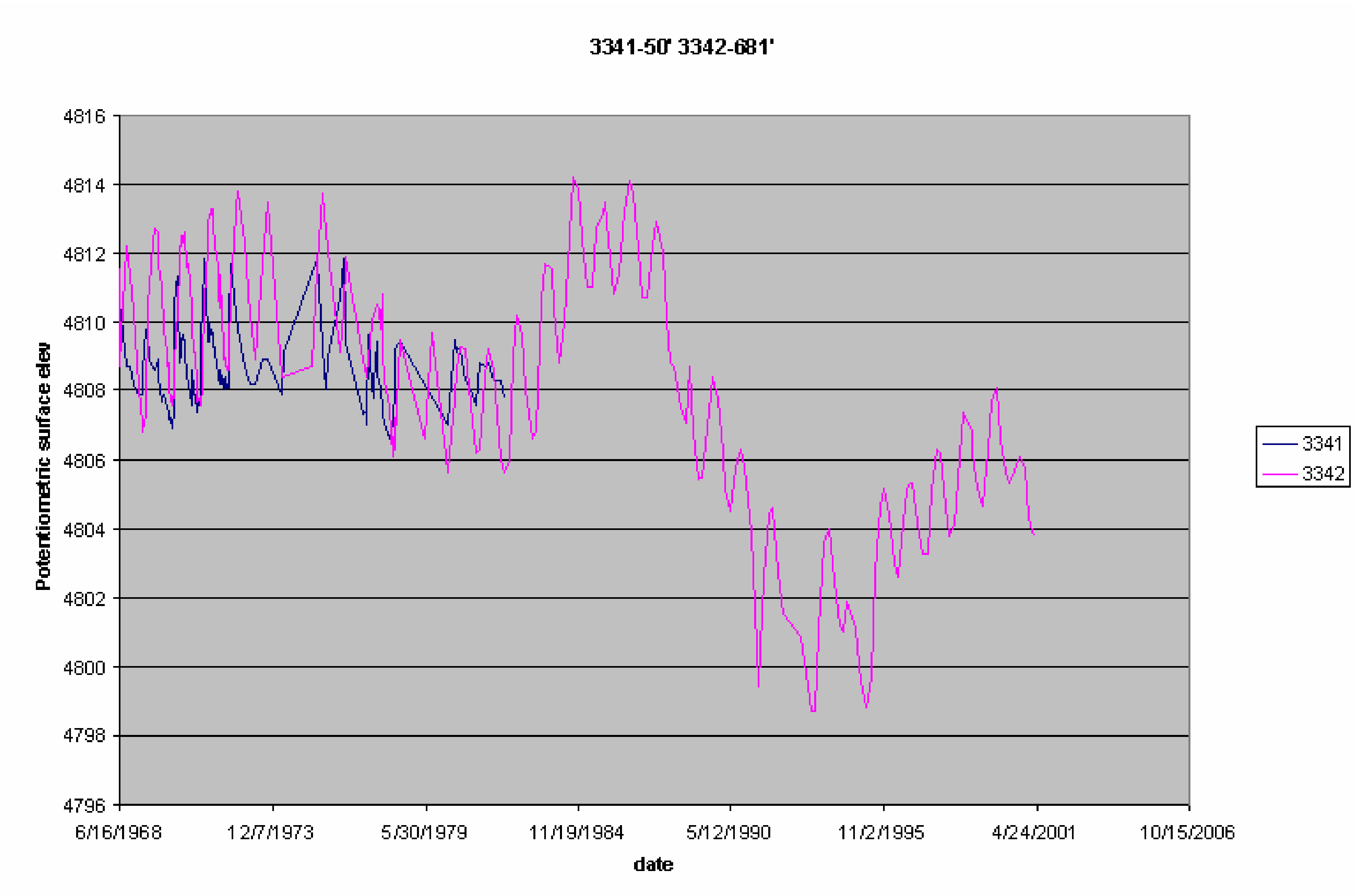

Figure 7. "Nested" well cluster in Rigby Fan.

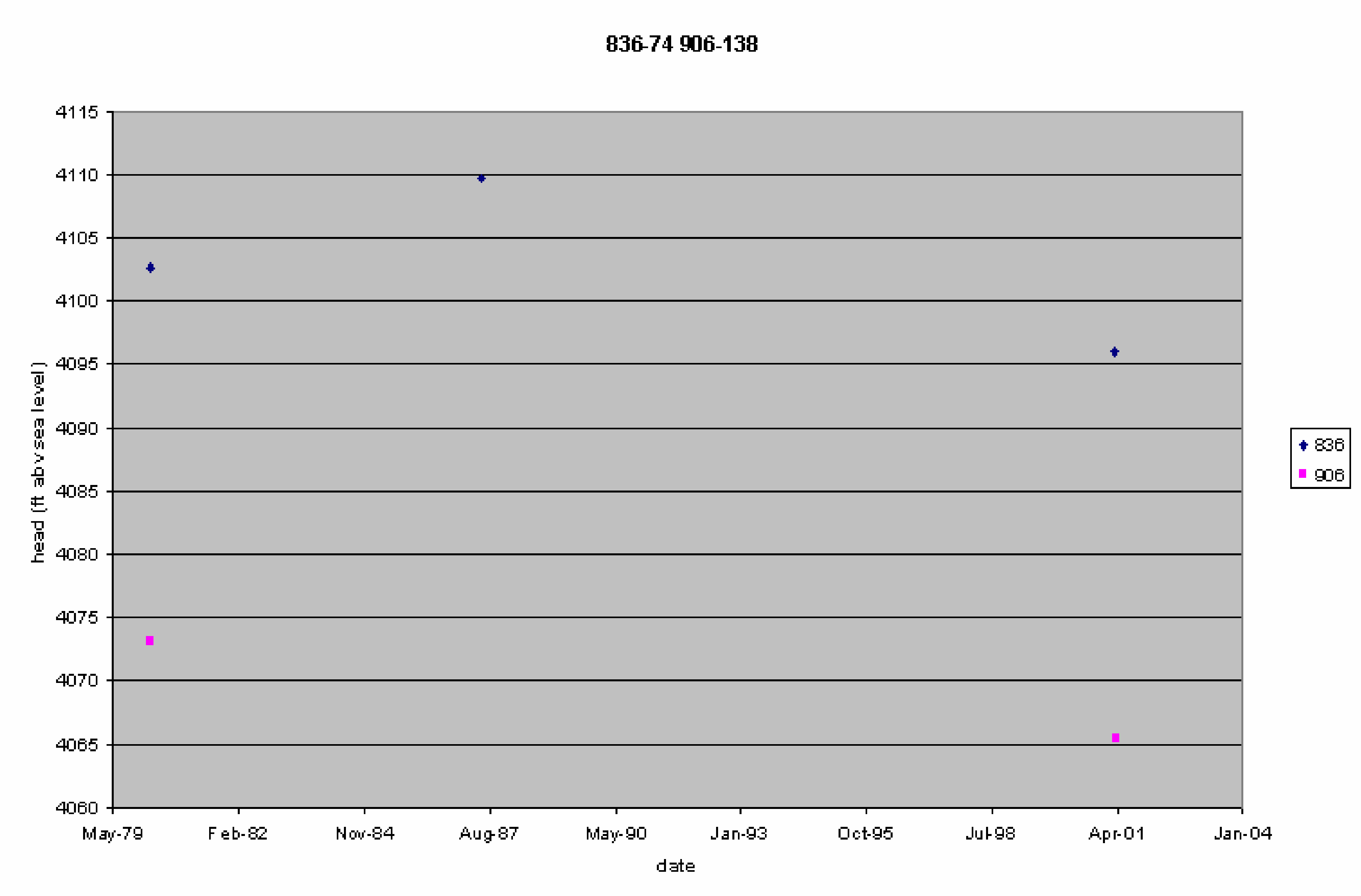

Figure 8. Well pair in Burley-Rupert area.

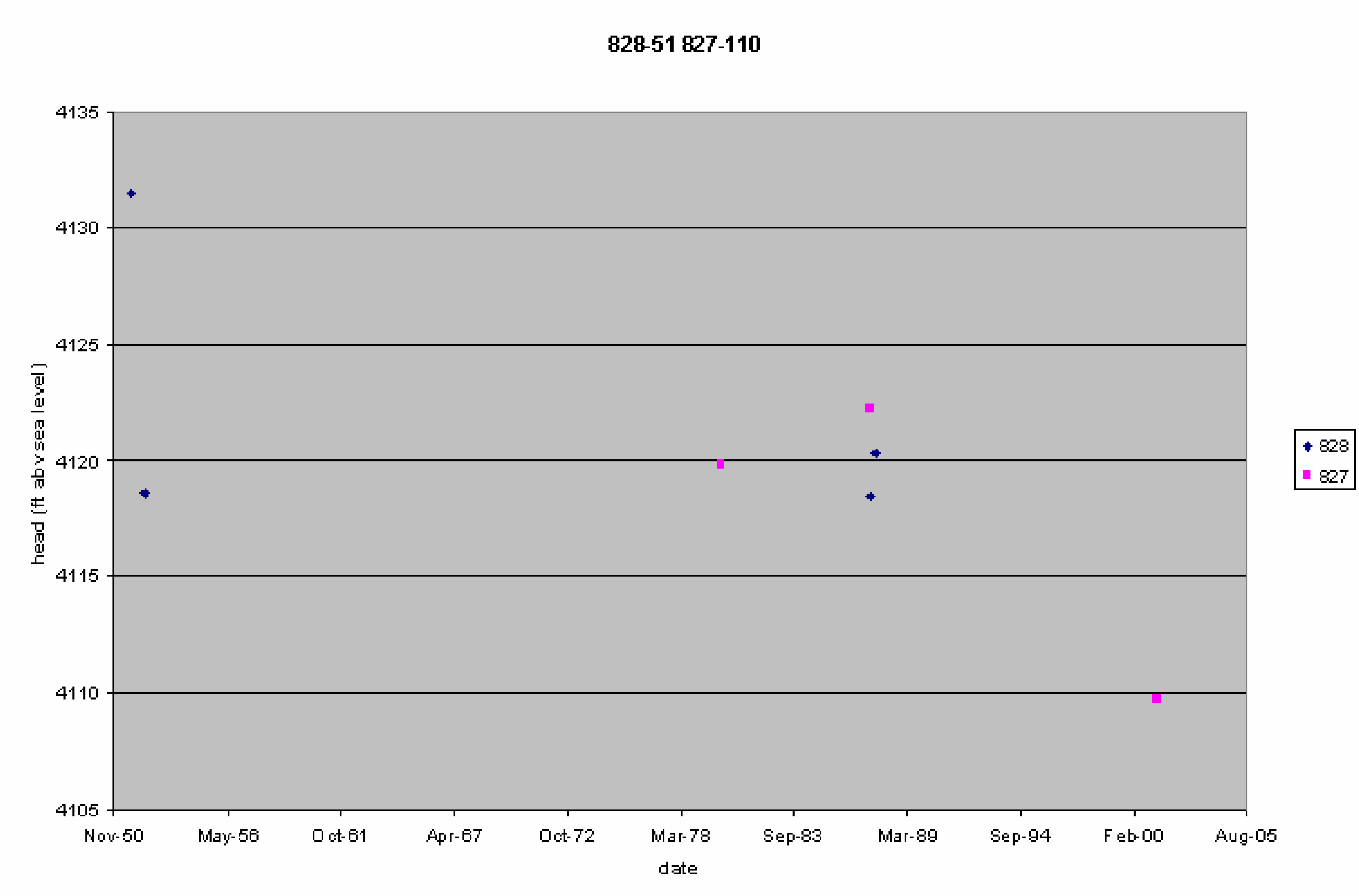

Figure 9. Well pair in Burley-Rupert area.

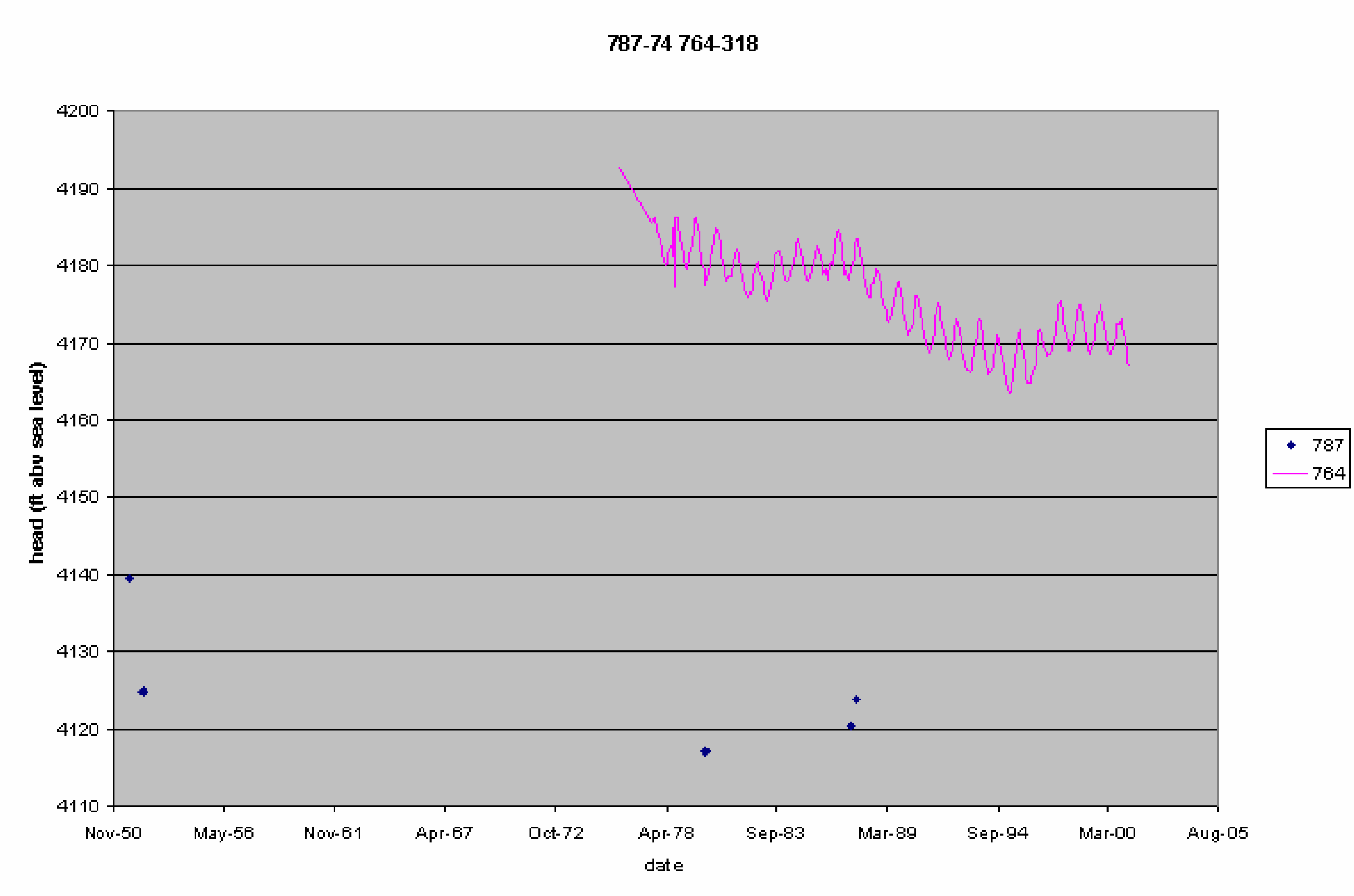

Figure 10. Well pair in Burley-Rupert area.

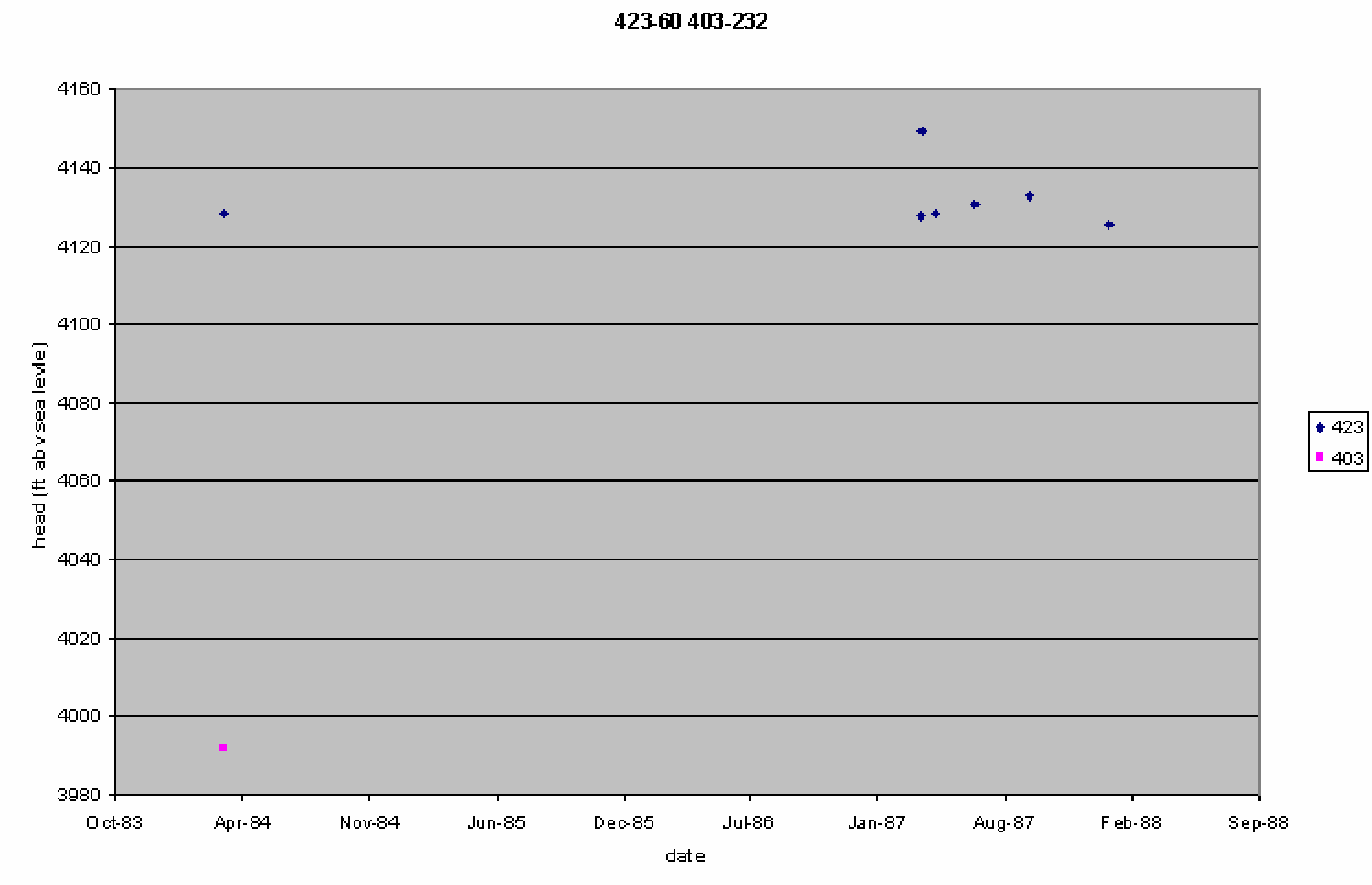

Figure 11. Well pair in Burley-Rupert area.

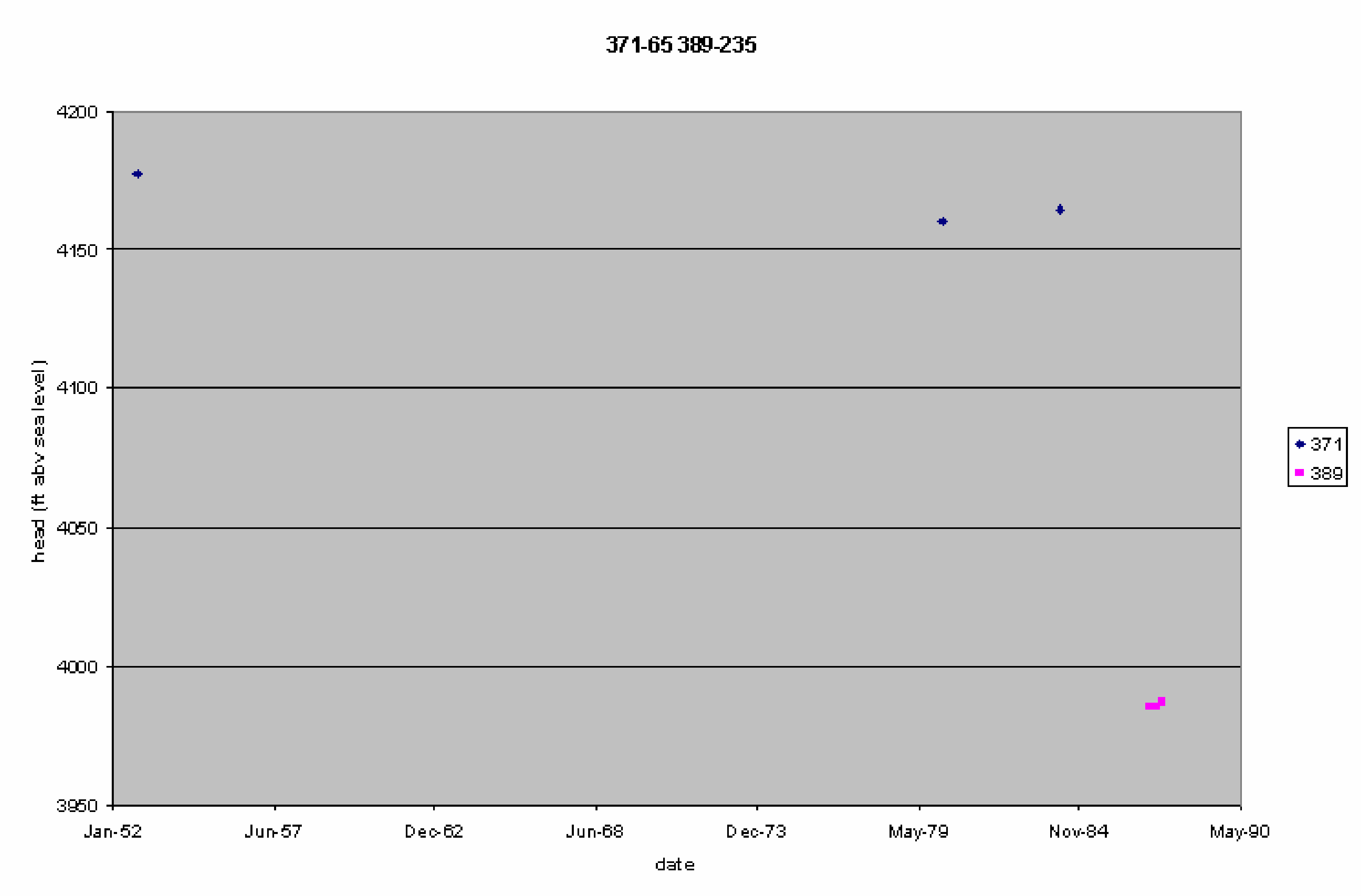

Figure 12. Well pair in Burley-Rupert area.

Design Decision

An approach which progresses from less complicated to more complicated is recommended. A one-layer model will be attempted. Upon completion of both steady state and transient calibrations, then a two-layer model will be attempted by activating an upper layer in the Rigby Fan area. If calibration is successful in both steady state and transient conditions, then an upper layer will be activated in the Burley-Rupert area. Attempts to calibrate the shallow aquifer in both areas will progress as outlined below:

1. Homogeneous hydraulic conductivity and vertical conductance, if successful then;
2. Heterogeneous hydraulic conductivity and homogeneous vertical conductance, if successful then;
3. Heterogeneous hydraulic conductivity and vertical conductance.

Success of each step will be judged by the relative magnitude of uncertainty in parameter values. Usually uncertainty problems are associated with parameters that are insensitive to the available observations (Doherty, 2001).

References

Doherty, J, 2001. Parameter Estimation in Environmental Modeling. Short Course October 8-12, 2001, University of Idaho, Idaho Falls, ID.