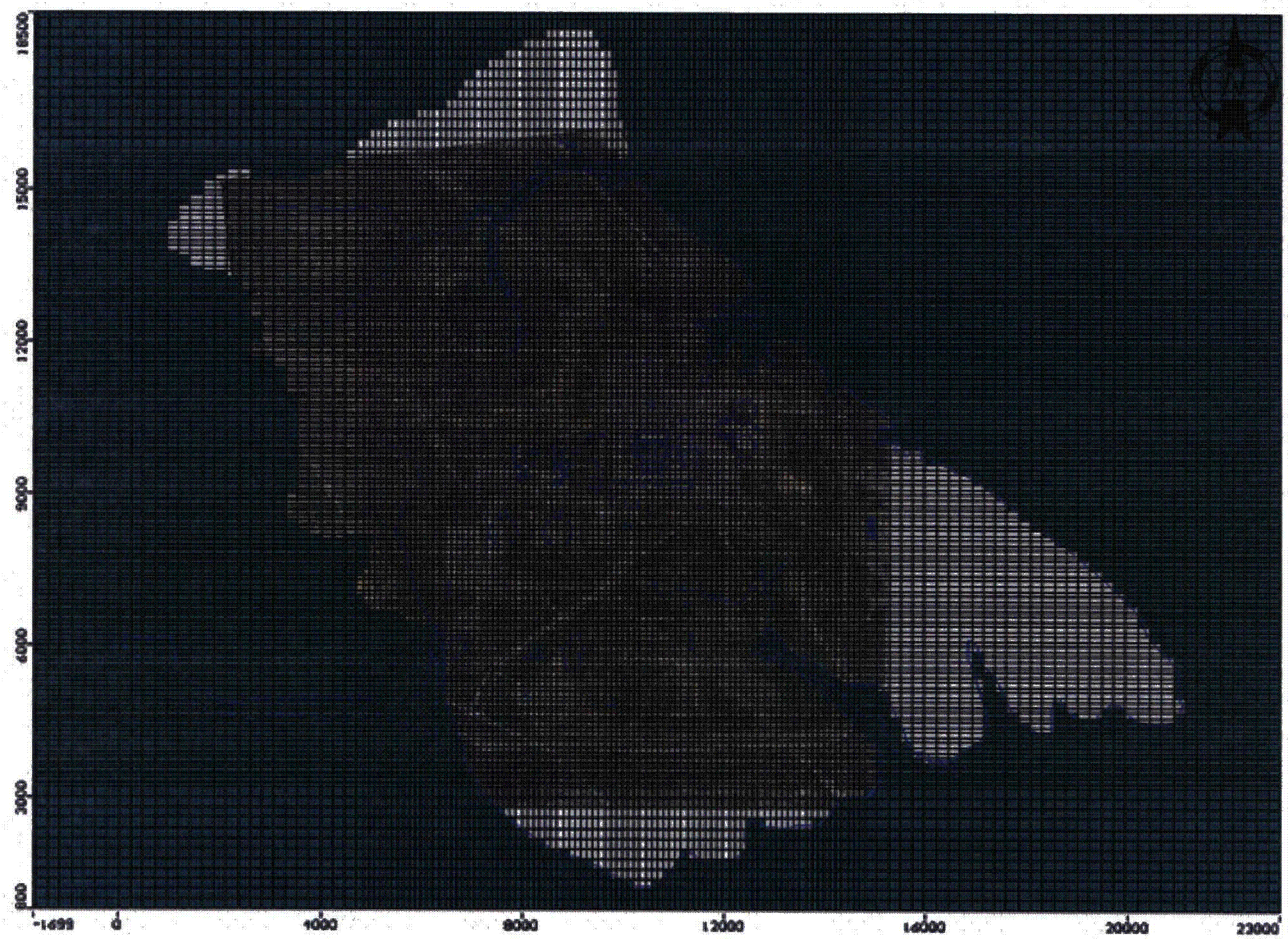


Figure 19: Numerical Model Grid and Boundary Conditions

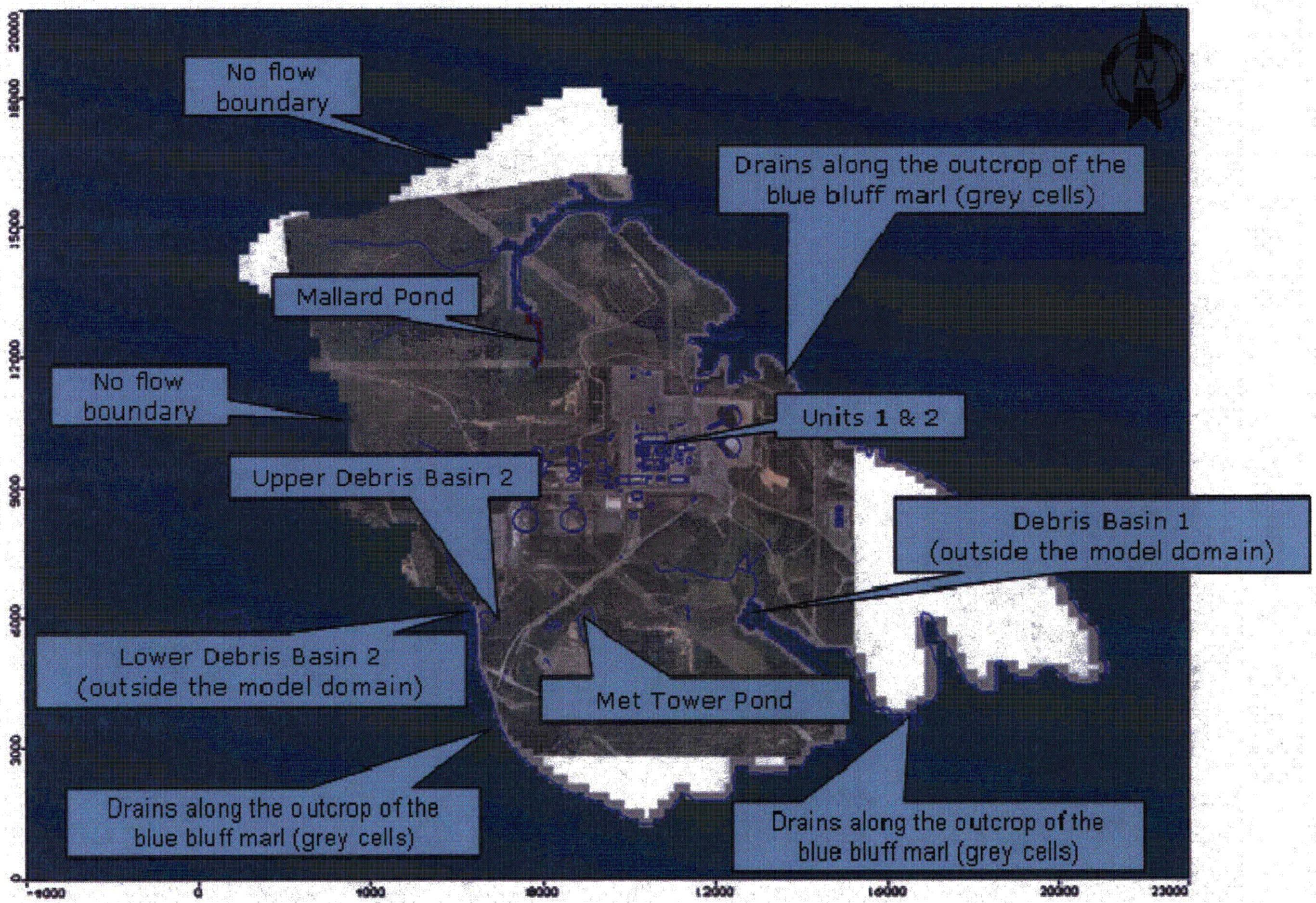


Figure 20: Numerical Groundwater Model Domain with Key Physical Features and Respective Flow Boundaries

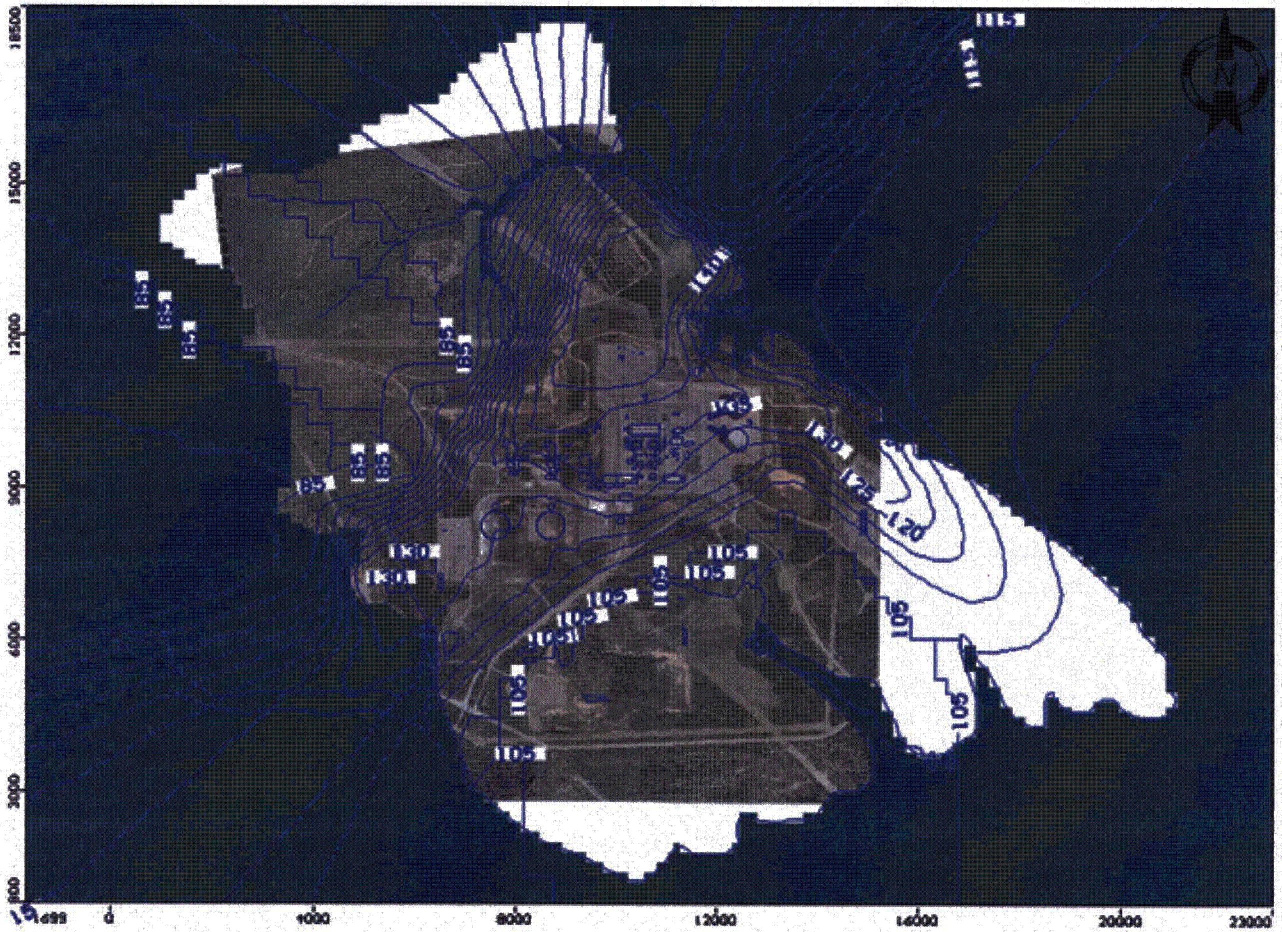


Figure 21: Bottom of the Model Domain (Top of Blue Bluff Marl) as Described in the Model

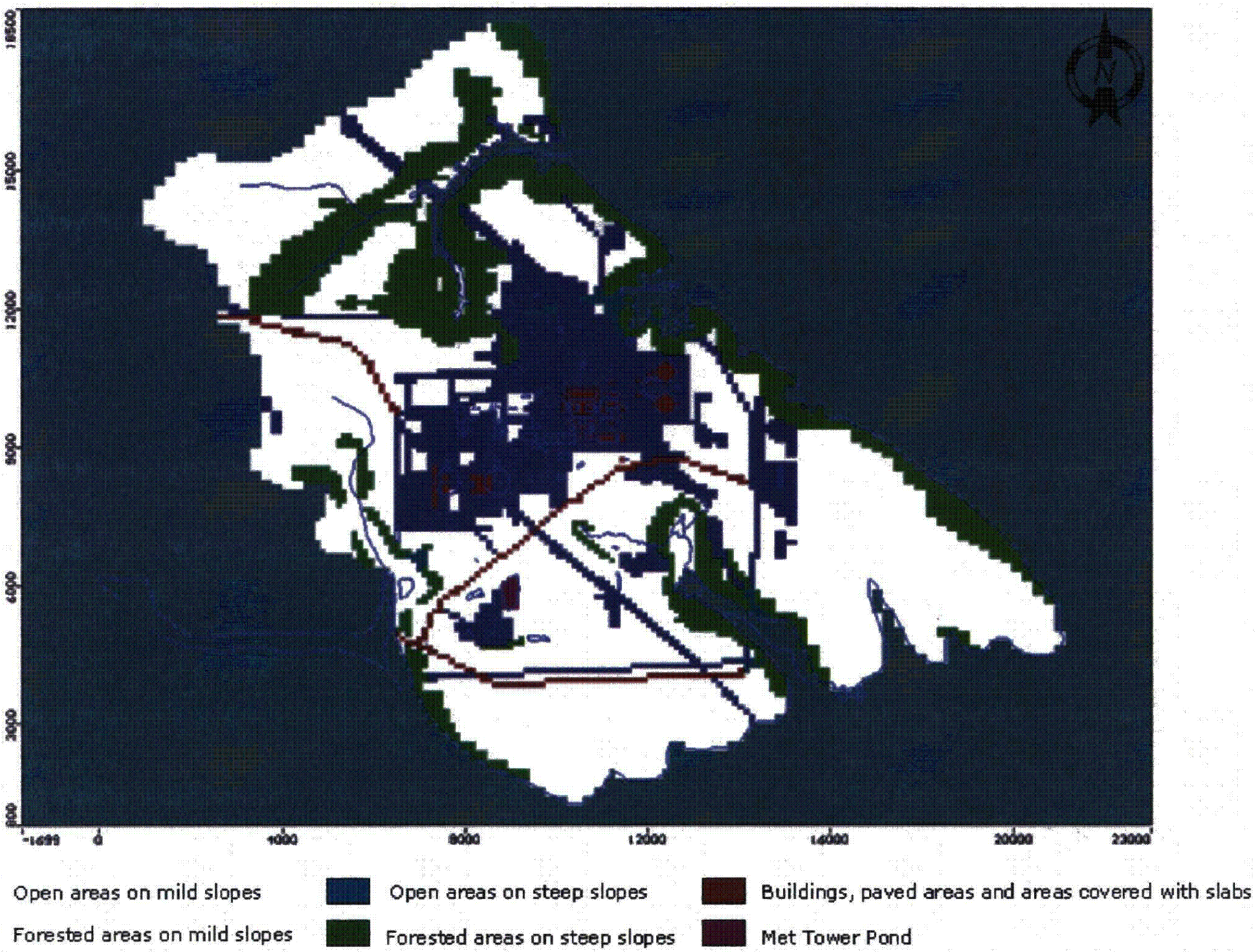


Figure 22: Groundwater Recharge Zones Used in the Model

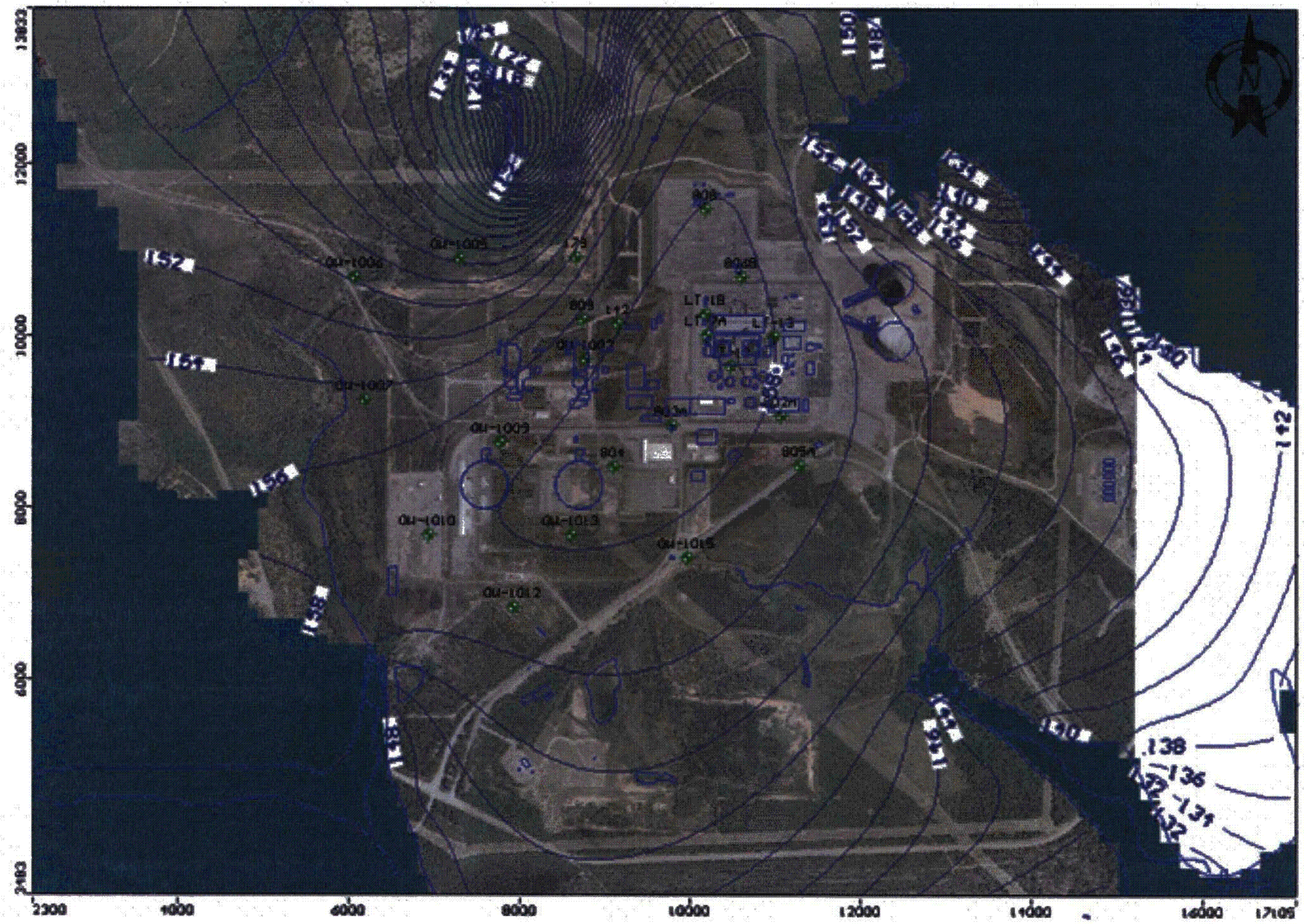


Figure 23: Model 1 - Simulated Water Levels for Run 109
(K_1 = 27 ft/day; R_1 =7 in/yr)

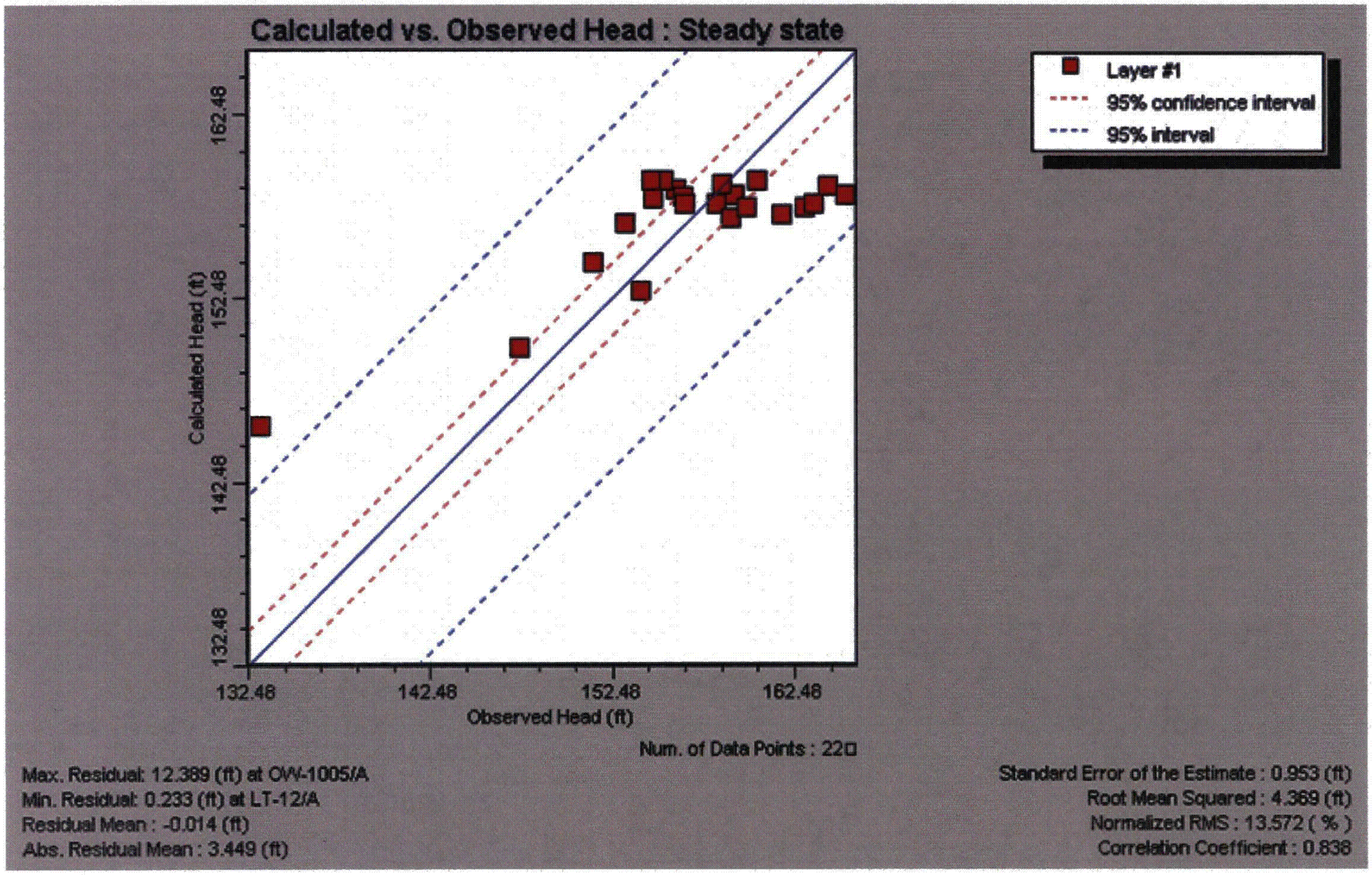


Figure 24: Model 1 - Simulated Vs. Observed Water Levels for Run 109 (K_1 = 27 ft/day; R_1 =7 in/yr)

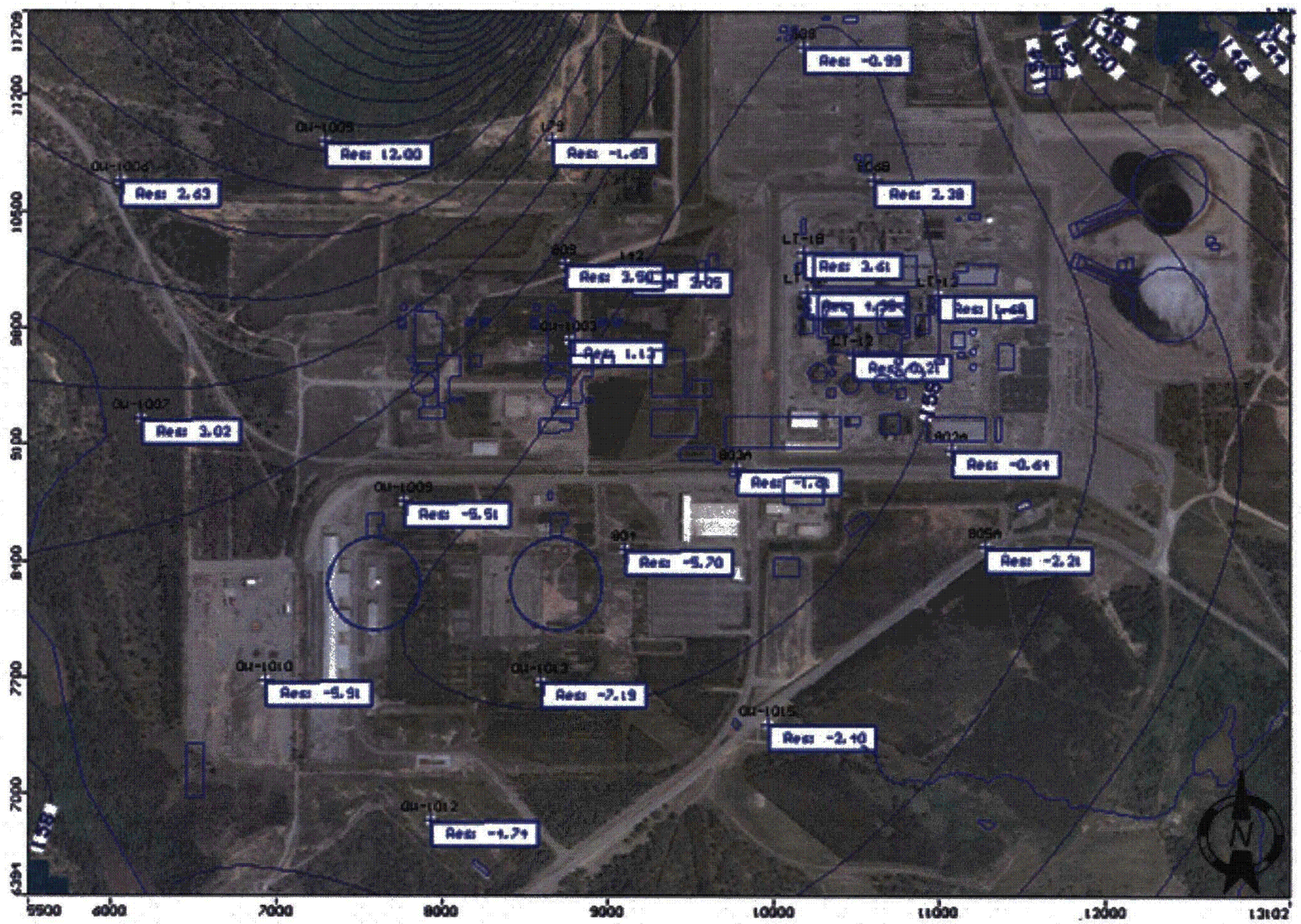


Figure 25: Model 1 - Estimated Residuals for Run 109 (K_1 = 27 ft/day; R_1 =7 in/yr)

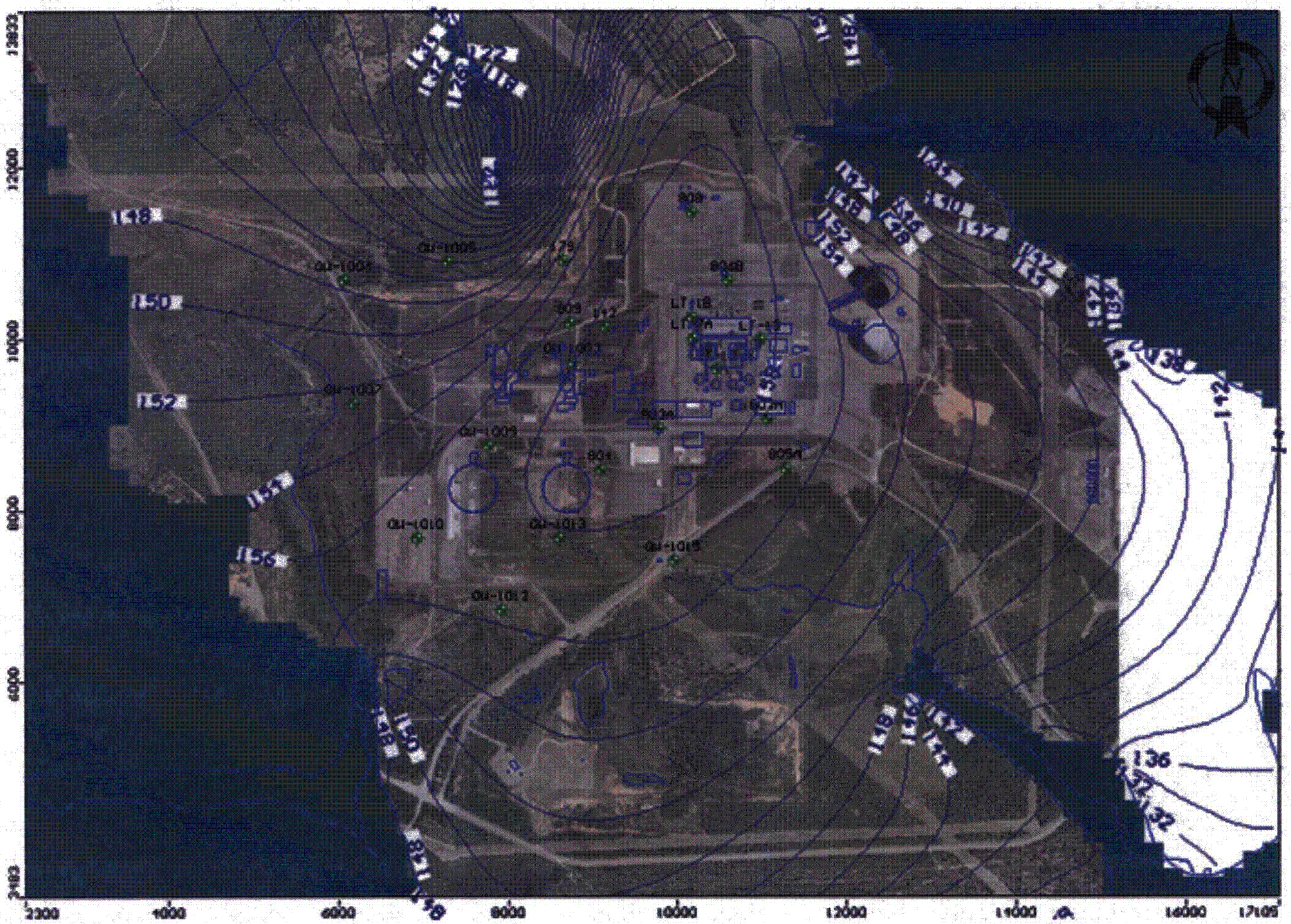


Figure 26: Model 2 - Simulated Water Levels for Run 201
(K_1=27 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

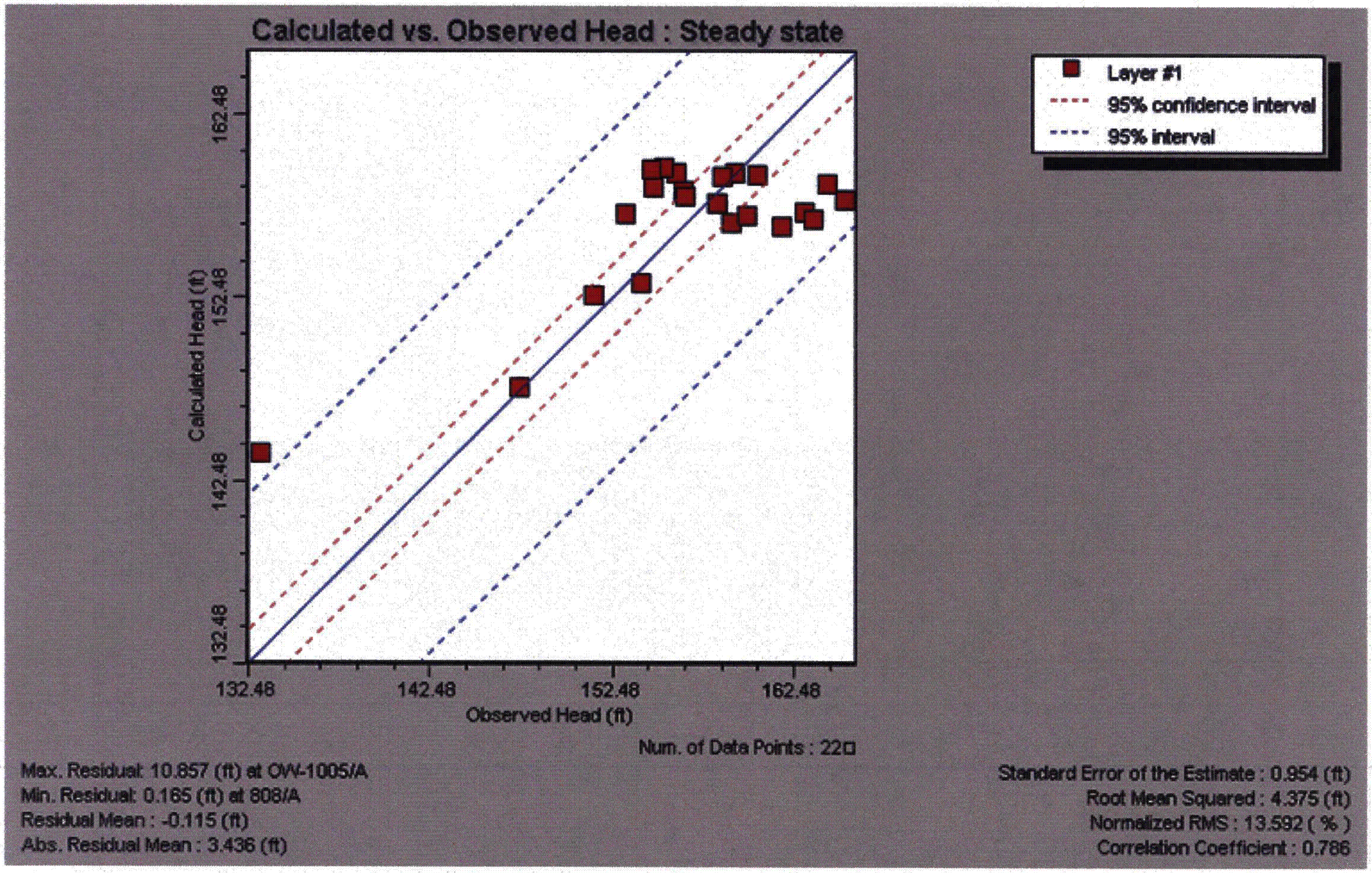


Figure 27: Model 2 - Simulated Vs. Observed Water Levels for Run 201 (K_1=27 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

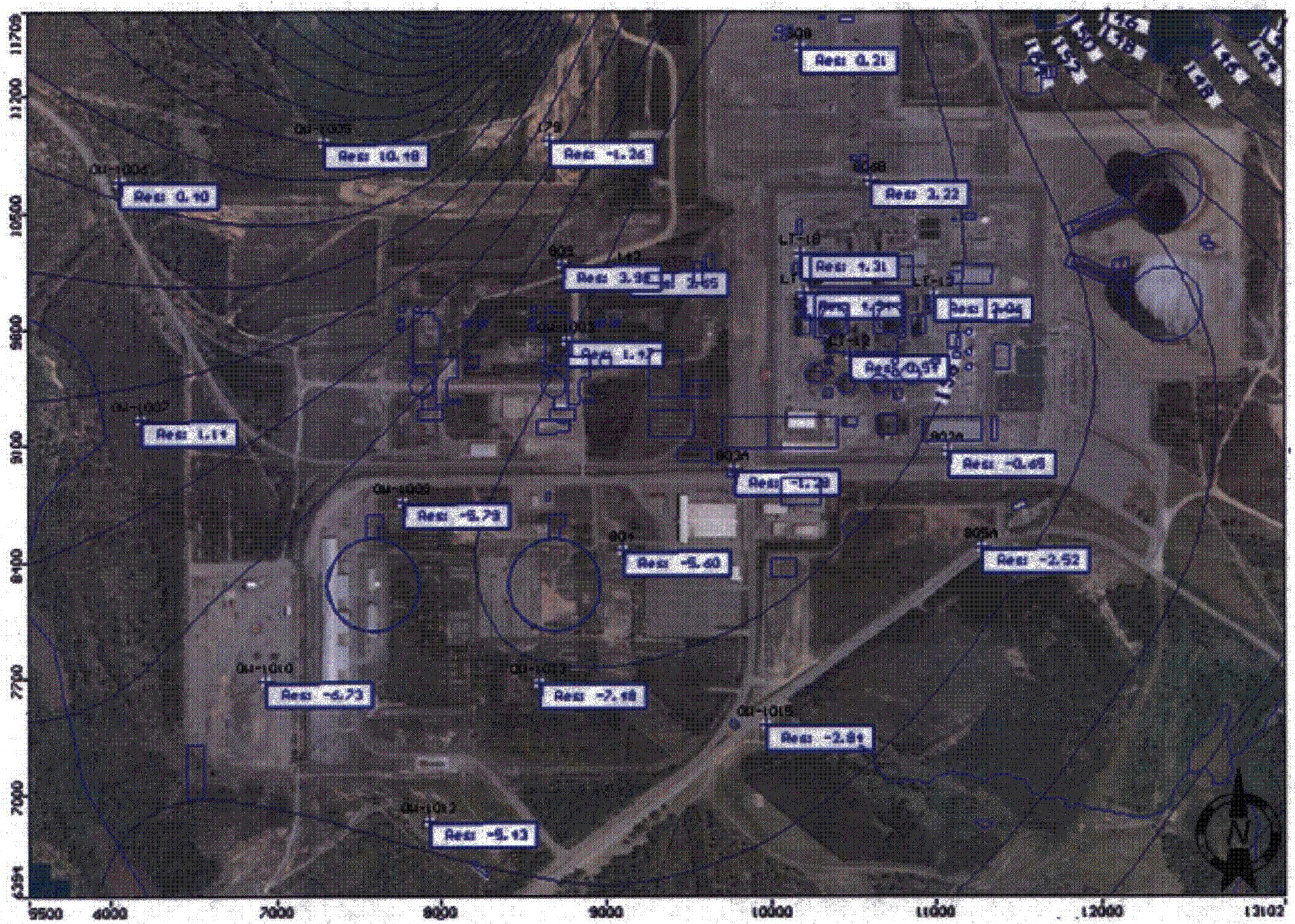


Figure 28: Model 2 - Estimated Residuals for Run 201
(K_1=27 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

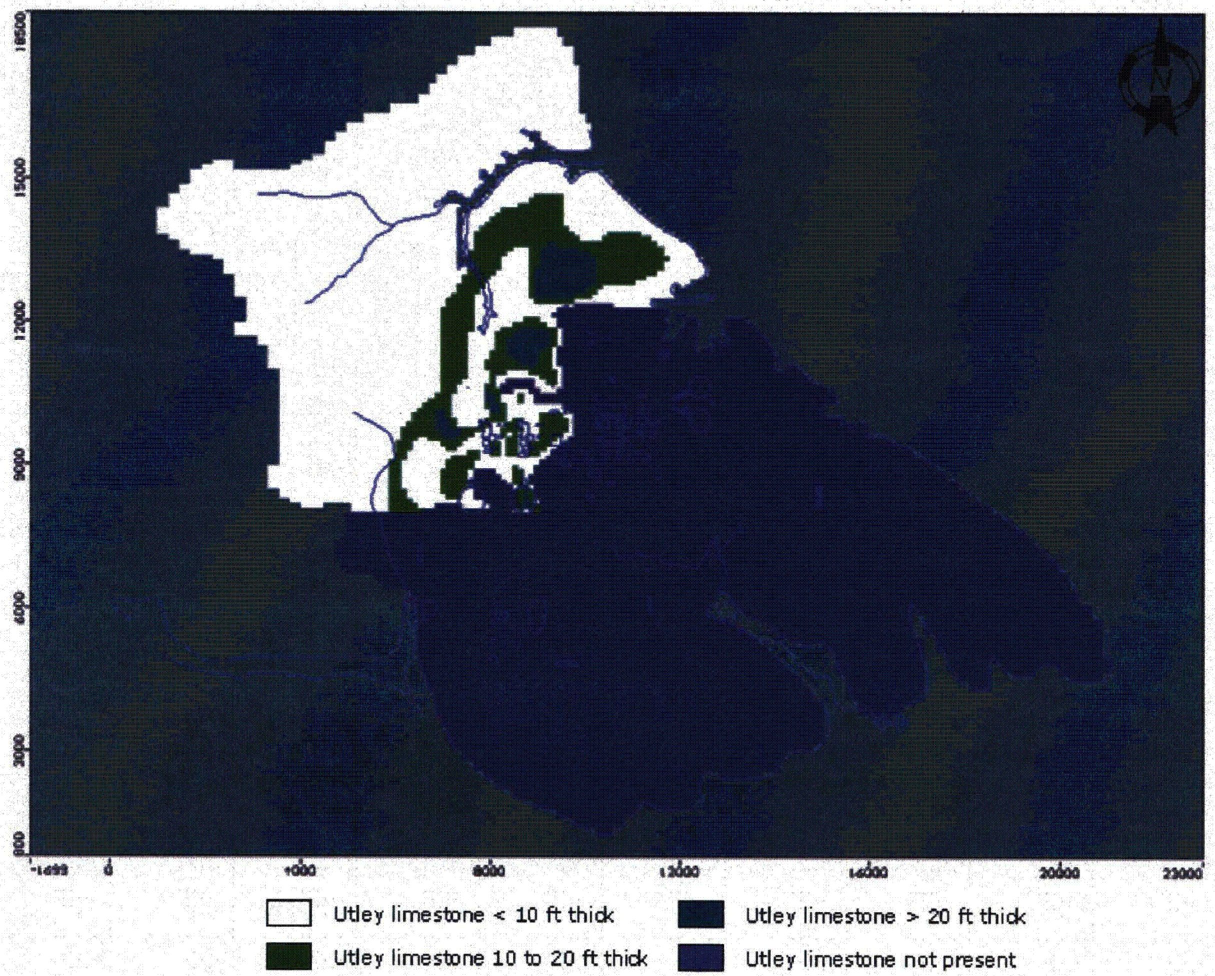


Figure 29: Model 3, Run 305 - Hydraulic Conductivity Zones Accounting for the Presence of the Utley Limestone (K_1=27; K_2=20; K_3=30; K_4=60 ft/day)

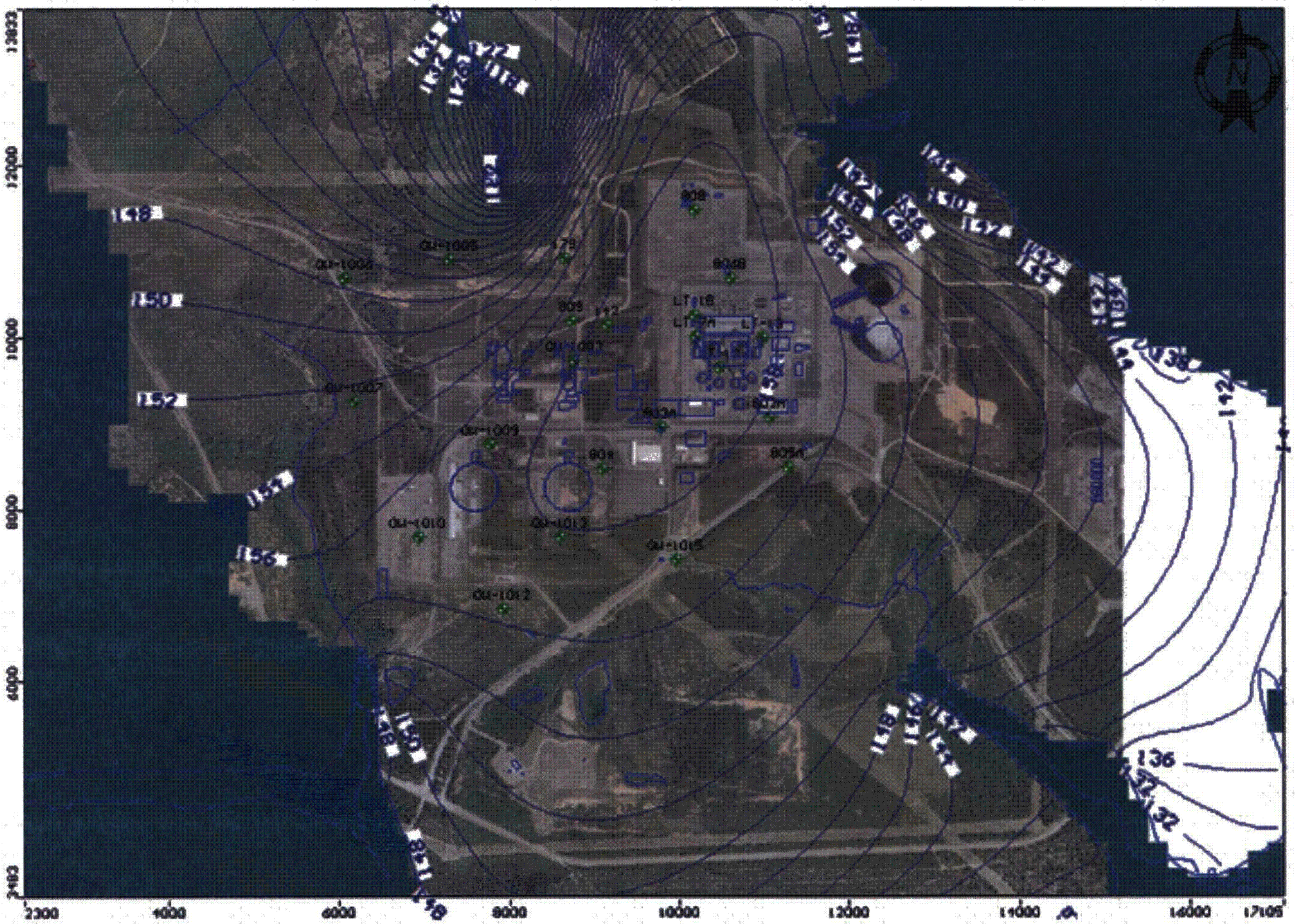


Figure 30: Model 3 - Simulated water levels for Run 305
(K_1=27; K_2=20; K_3=30; K_4=60 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

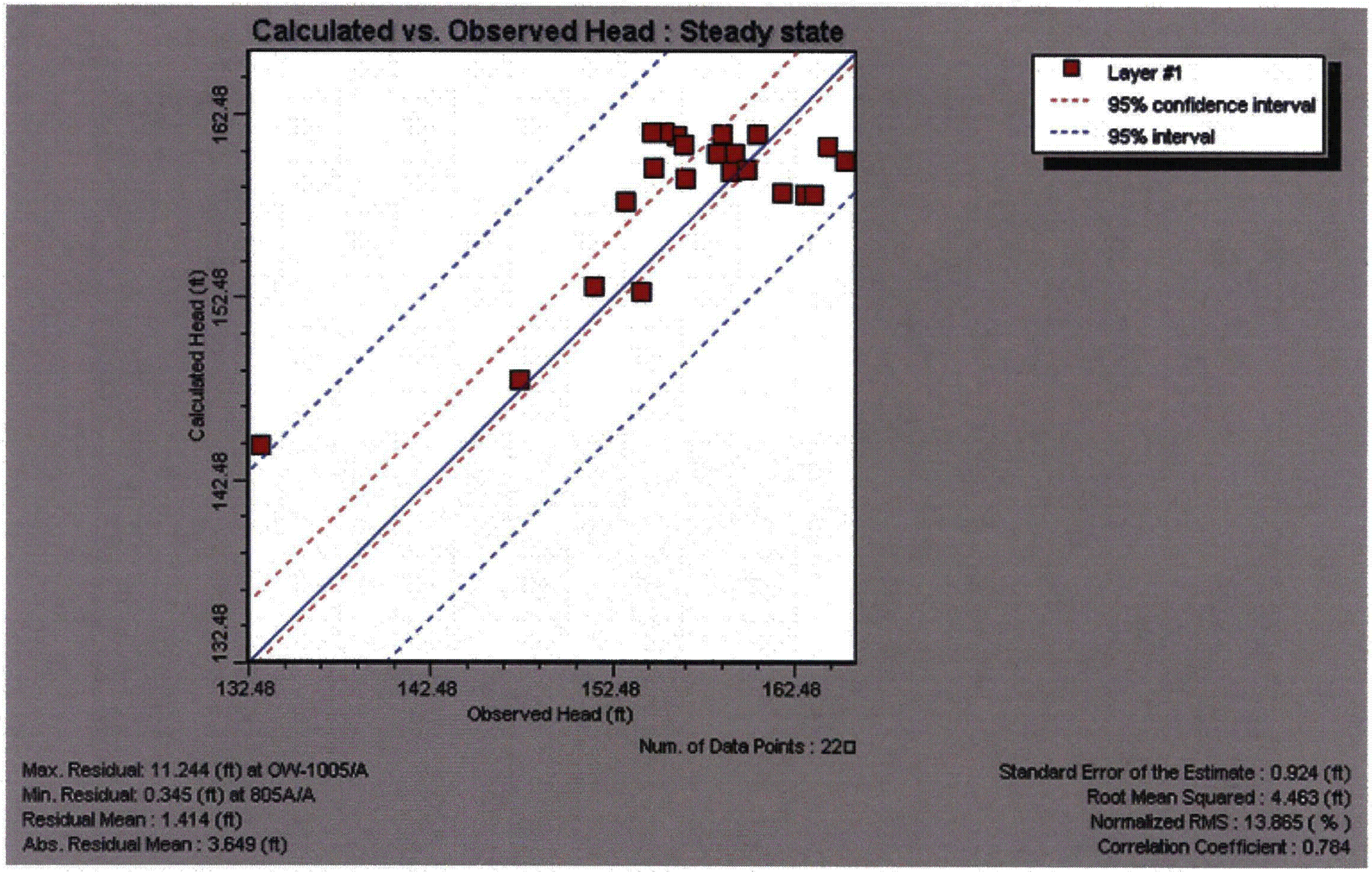


Figure 31: Model 3 - Simulated Vs. Observed Water Levels for Run 305 (K_1=27; K_2=20; K_3=30; K_4=60 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

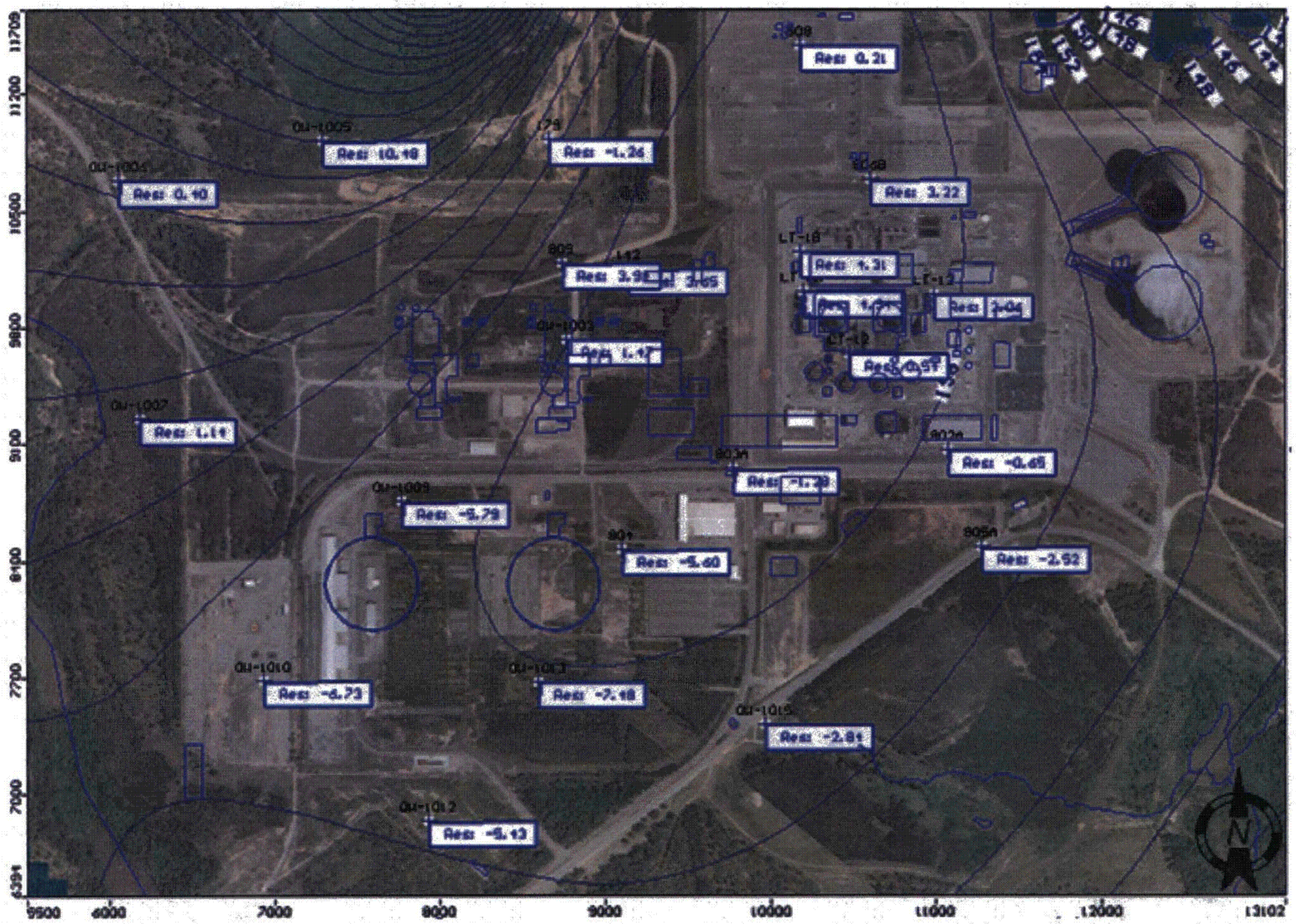


Figure 32: Model 3 - Estimated Residuals for Run 305
(K_1=27; K_2=20; K_3=30; K_4=60 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

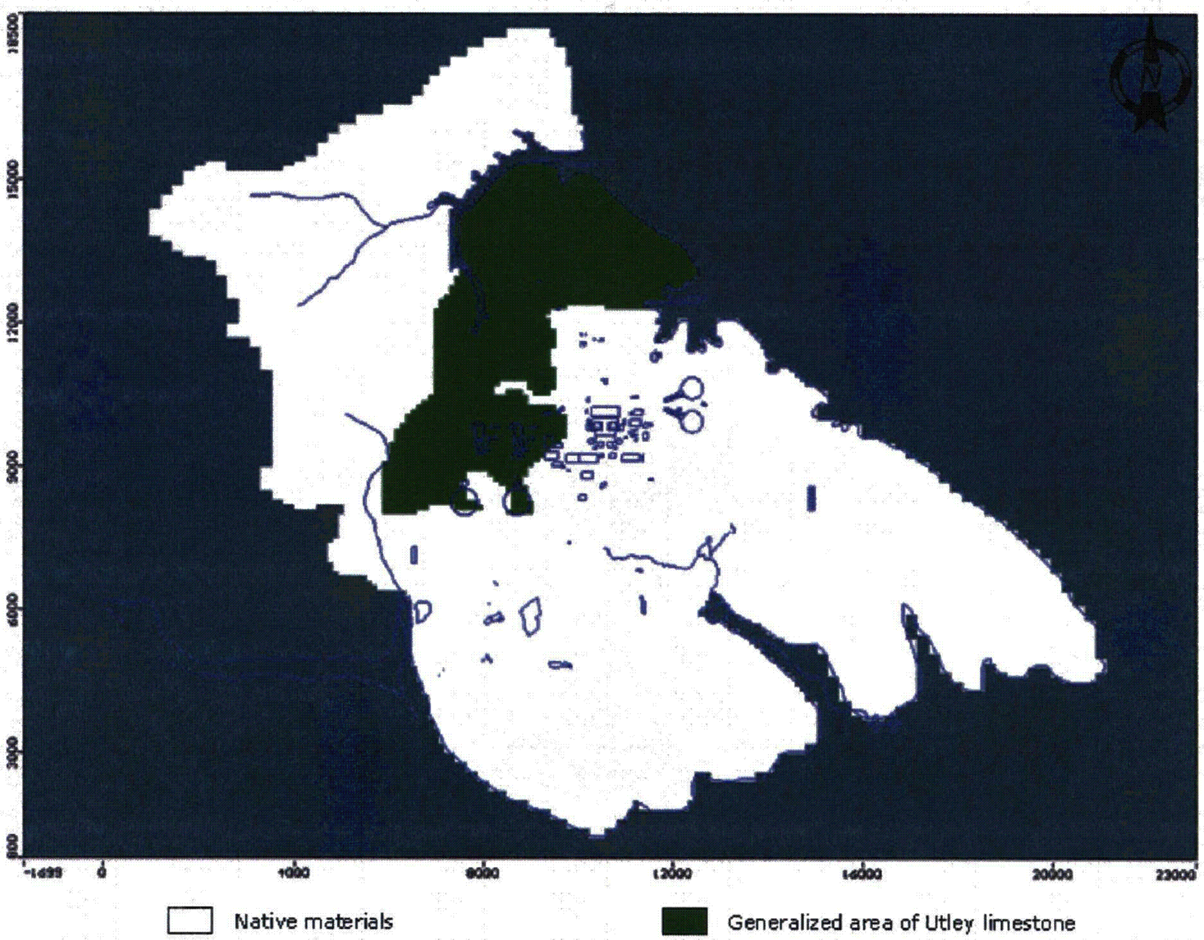


Figure 33: Model 4, Run 403 – Simplified Hydraulic Conductivity Zones Accounting for the Presence of the Utley Limestone (K_1=20; K_2=35 ft/day)

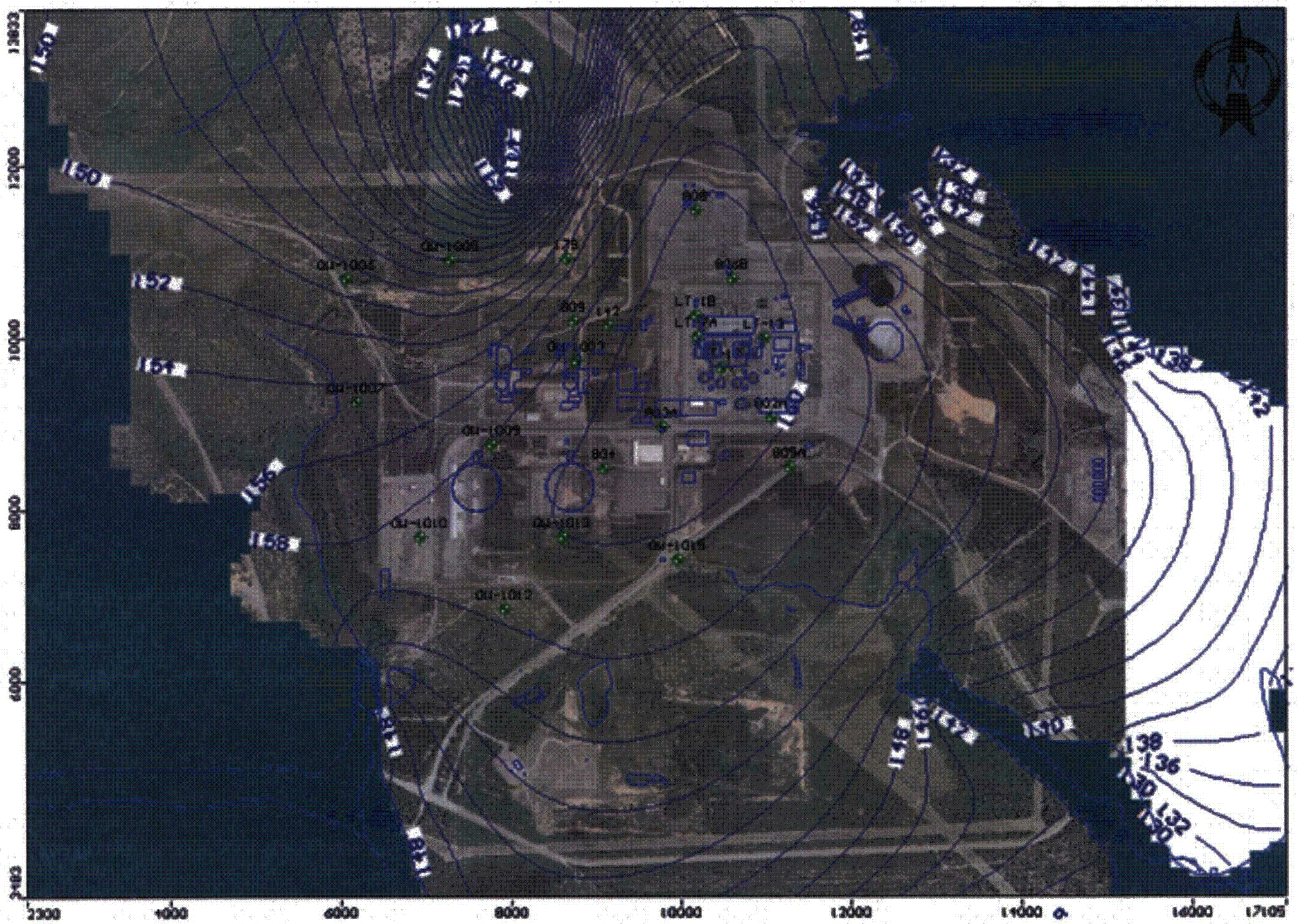


Figure 34: Model 4- Simulated Water Levels for Run 403
(K_1=20; K_2=35 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

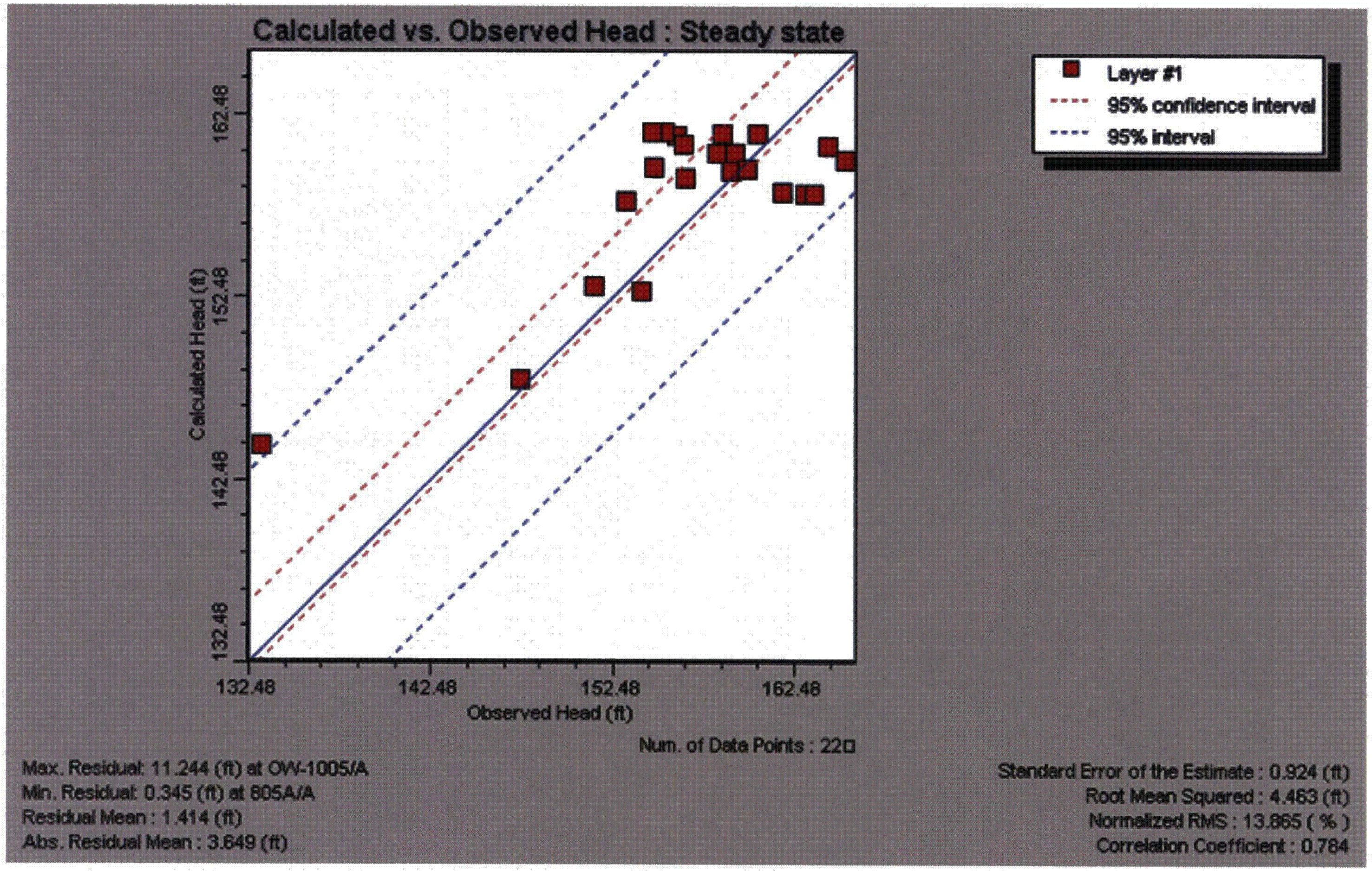


Figure 35: Model 4- Simulated Vs. Observed Water Levels for Run 403
(K_1=20; K_2=35 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

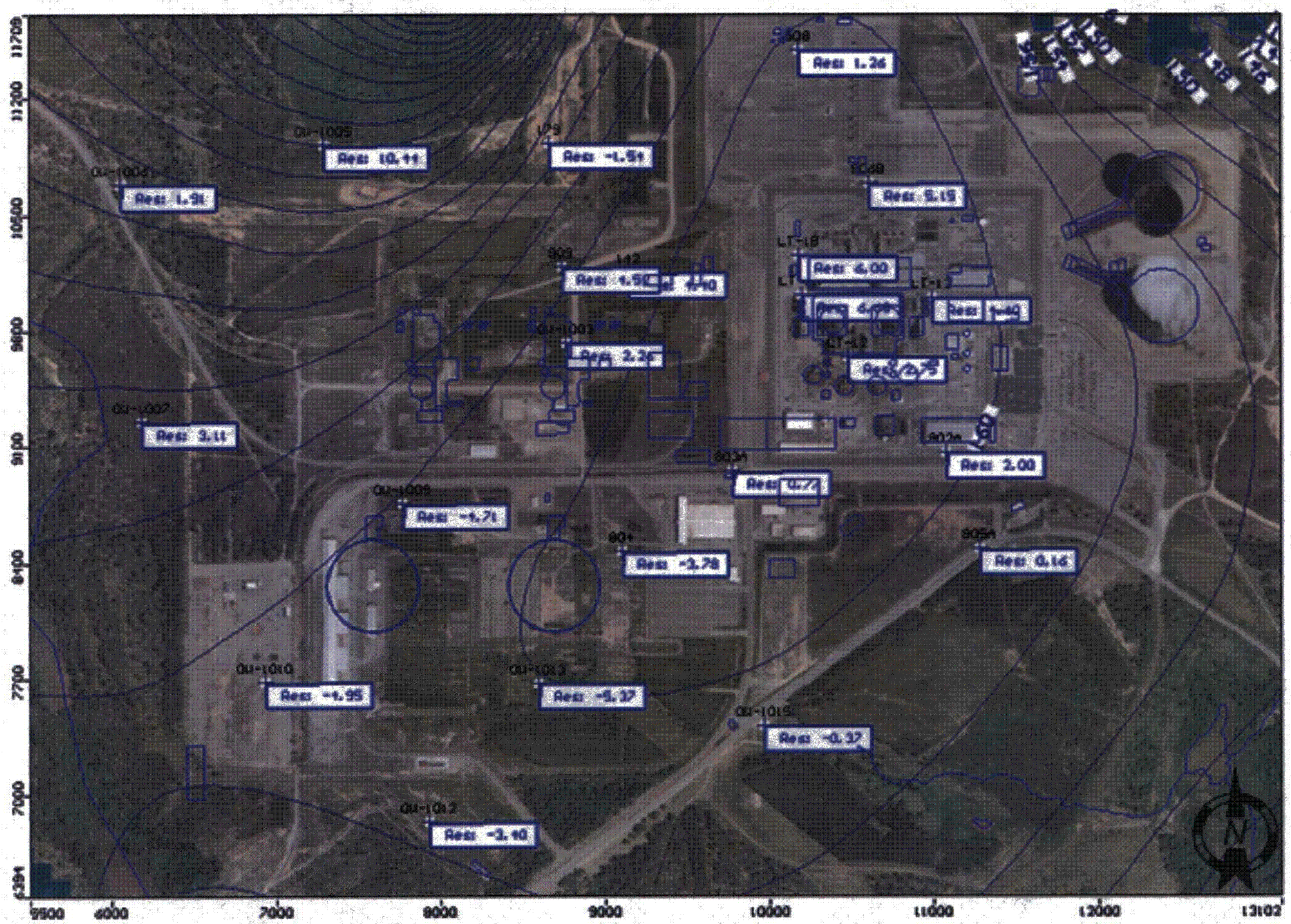


Figure 36: Model 4- Estimated Residuals for Run 403
(K_1=20; K_2=35 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

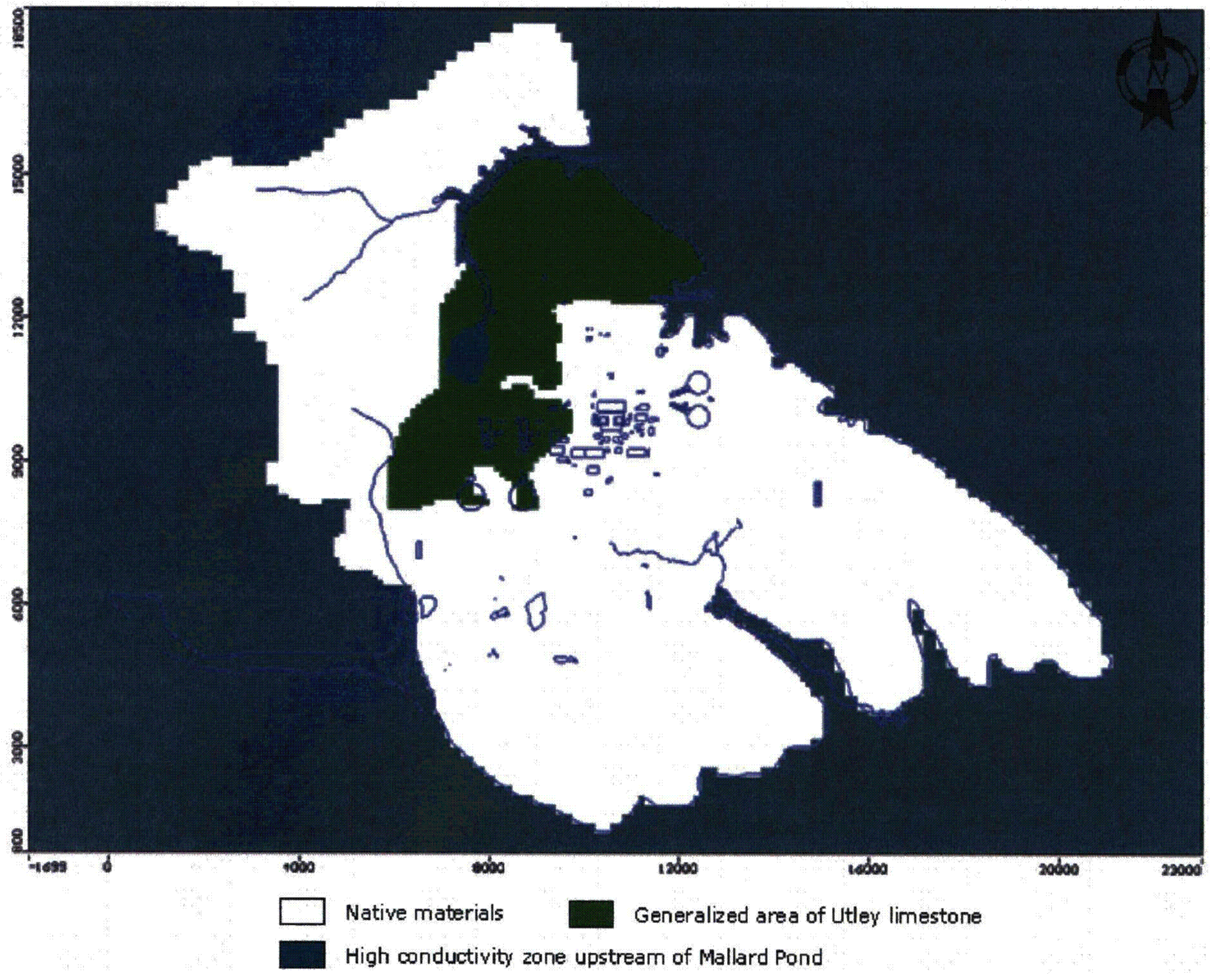


Figure 37: Model 5, Run 504 – Hydraulic Conductivity Zones as for Model 4 and a High Conductivity Zone Upstream of Mallard Pond (K_1=20; K_2=35; K_3=100 ft/day)

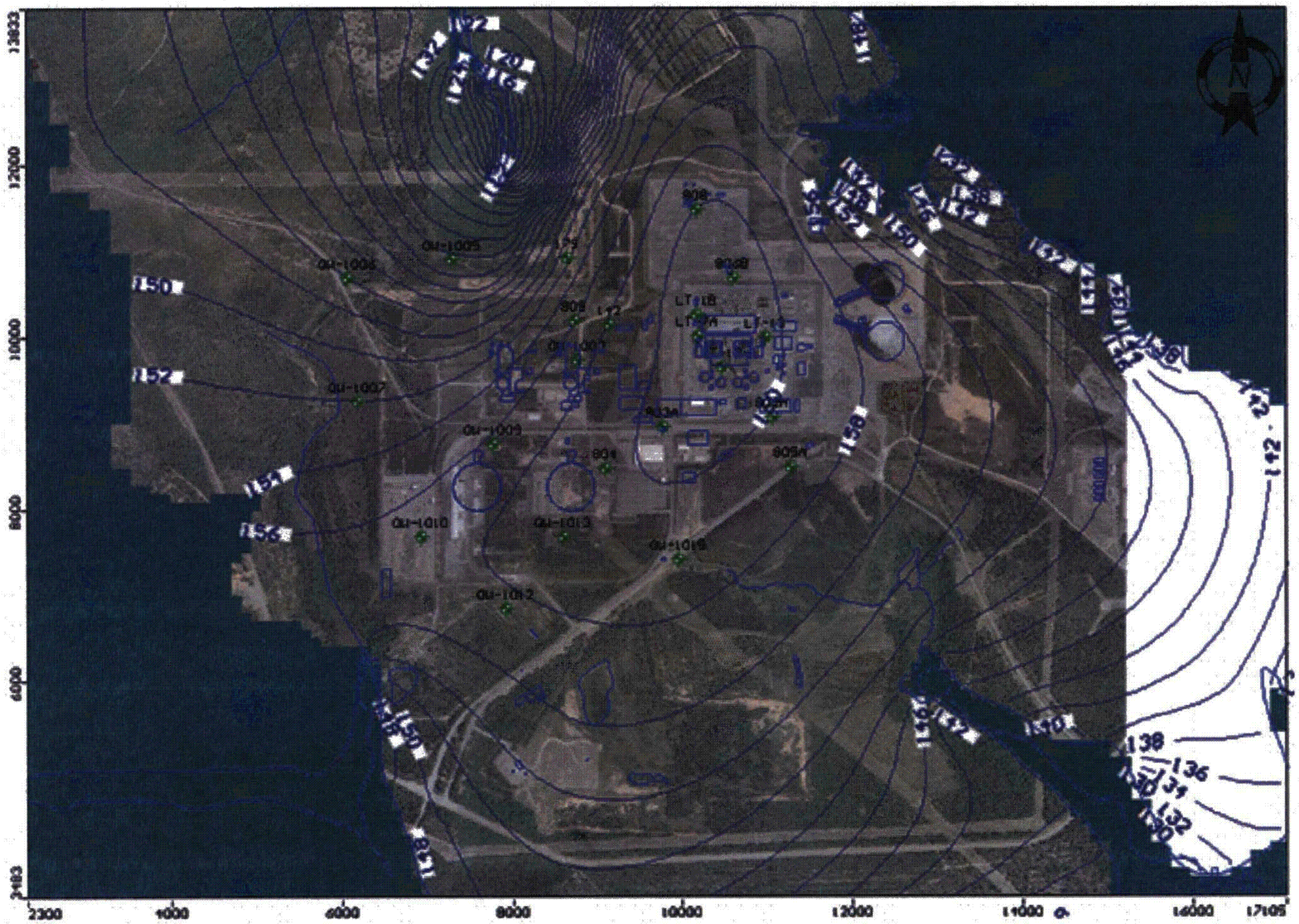


Figure 38: Model 5- Simulated Water Levels for Run 504
(K_1=20; K_2=35; K_3=100 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

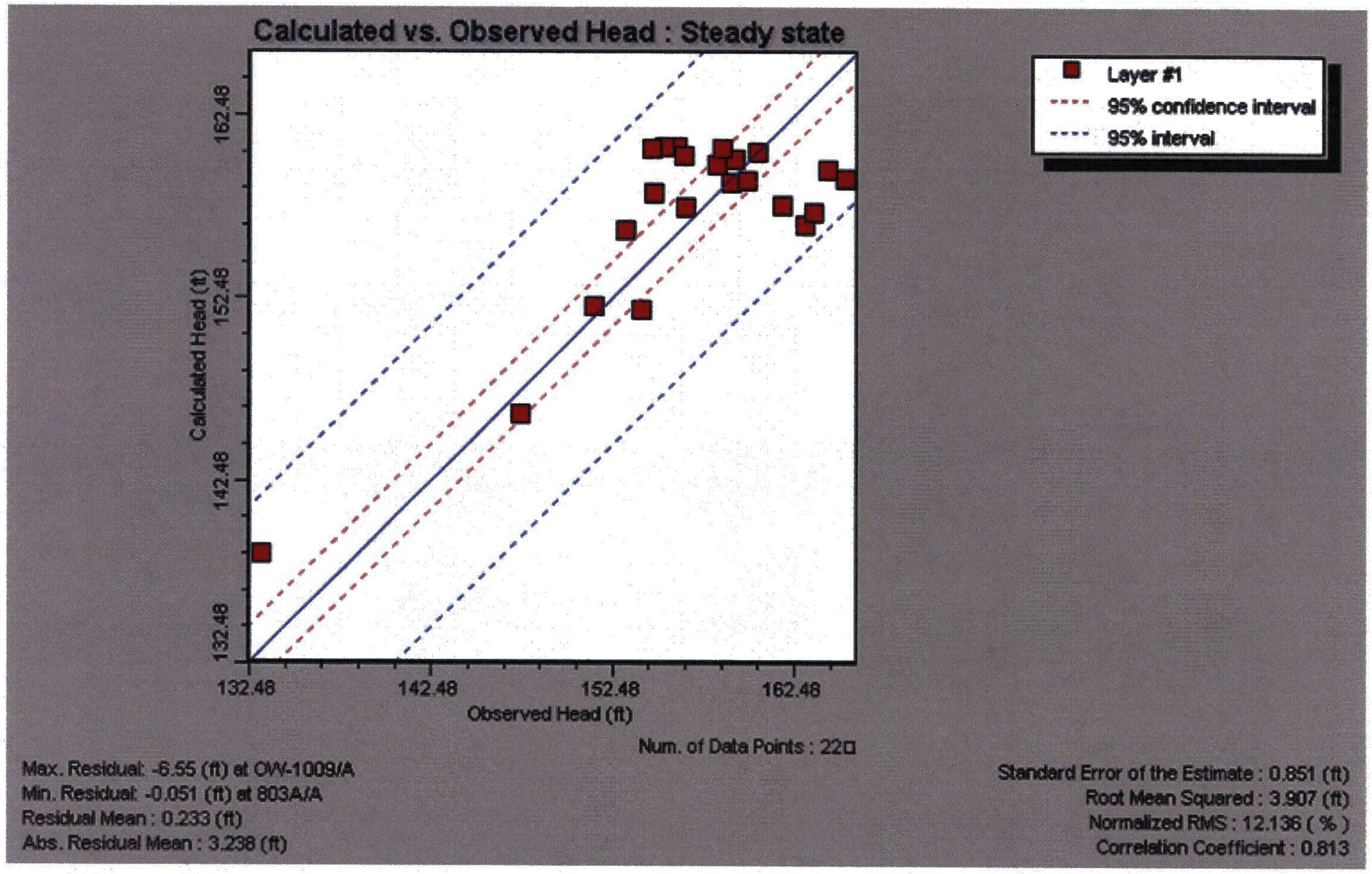


Figure 39: Model 5- Simulated Vs. Observed Water Levels for Run 504 (K_1=20; K_2=35; K_3=100 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

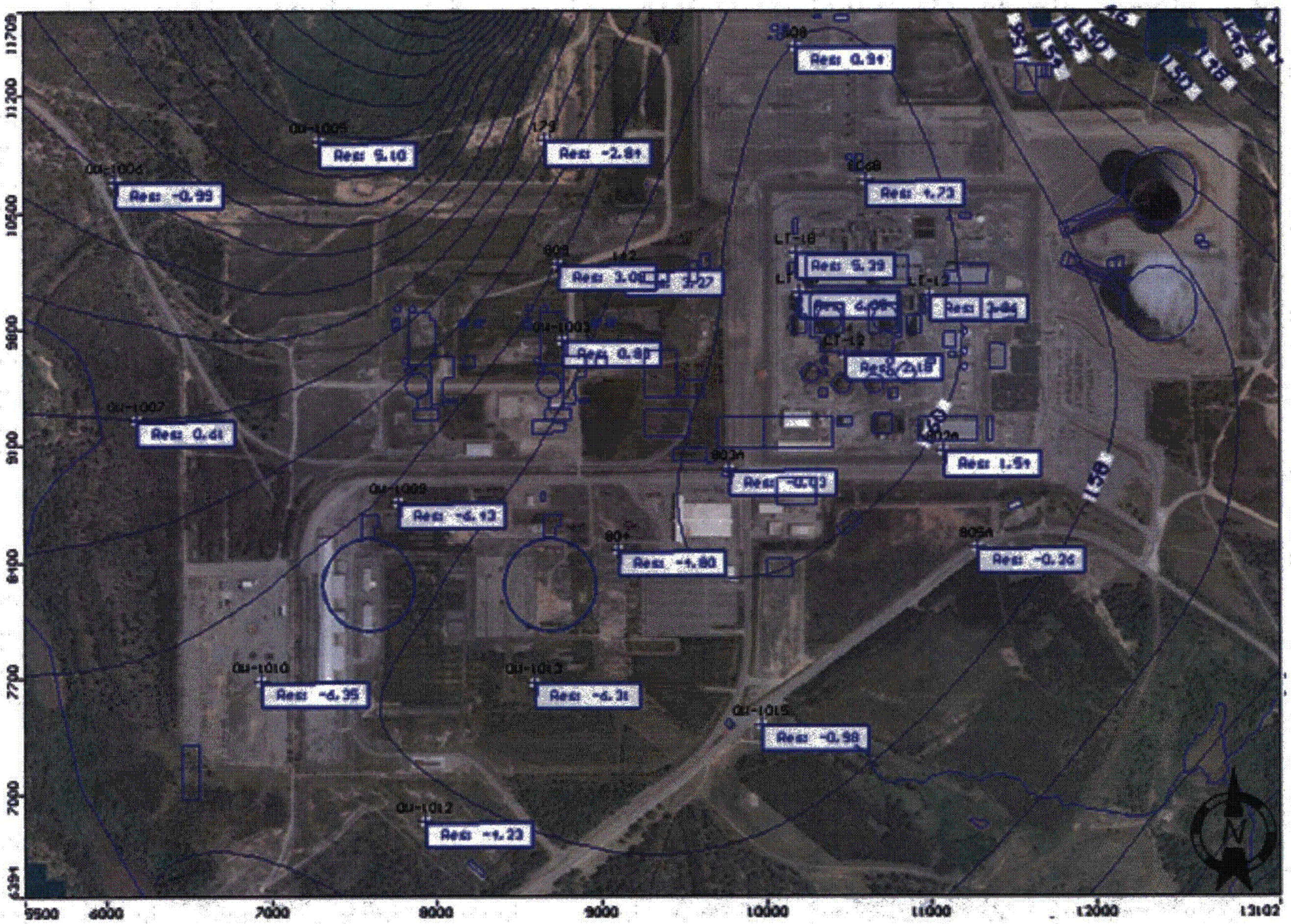


Figure 40: Model 5- Estimated Residuals for Run 504
(K_1=20; K_2=35; K_3=100 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

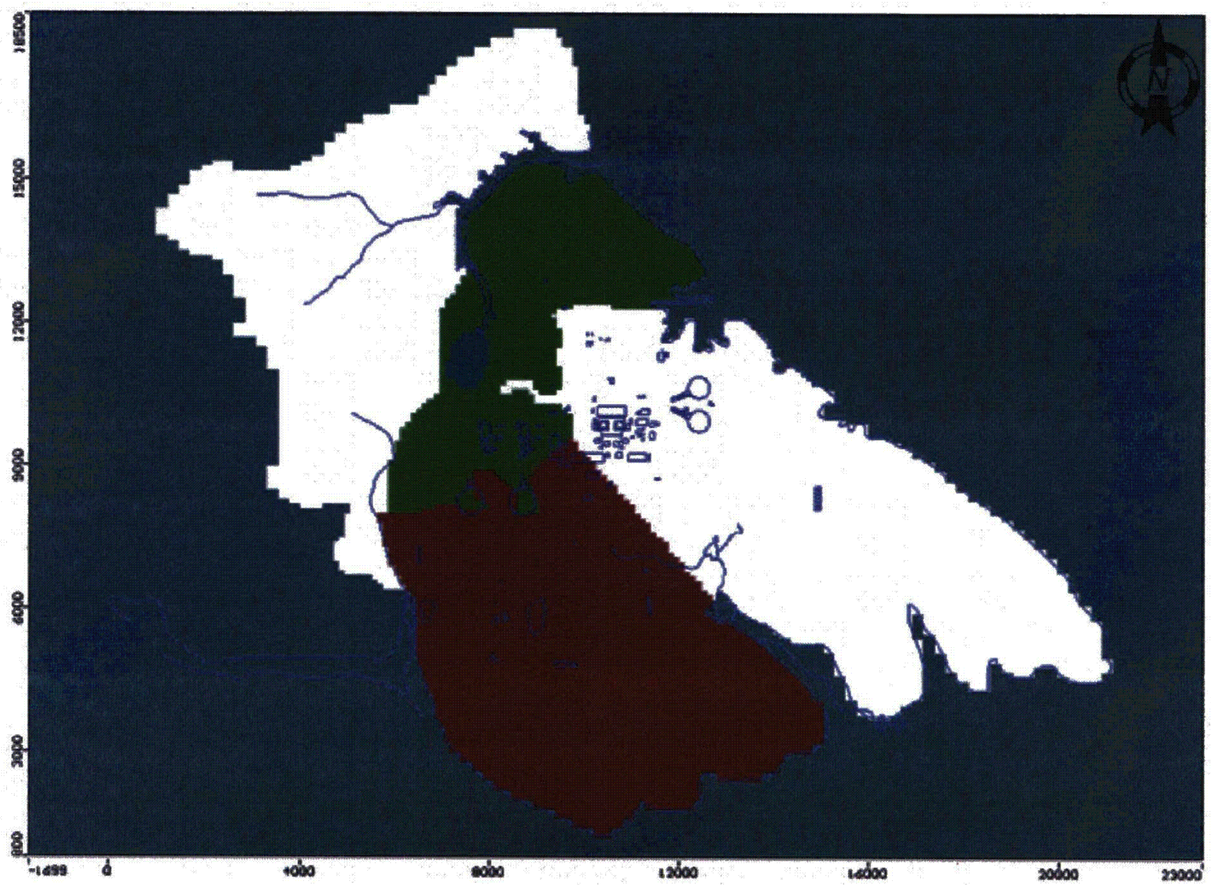


Figure 41: Model 6, Run 612 – Hydraulic Conductivity Zones as for Model 5 and a Low Conductivity Zone in the Southwestern Quarter of the Model (K_1=28; K_2=33; K_3=200; K_4=8 ft/day)

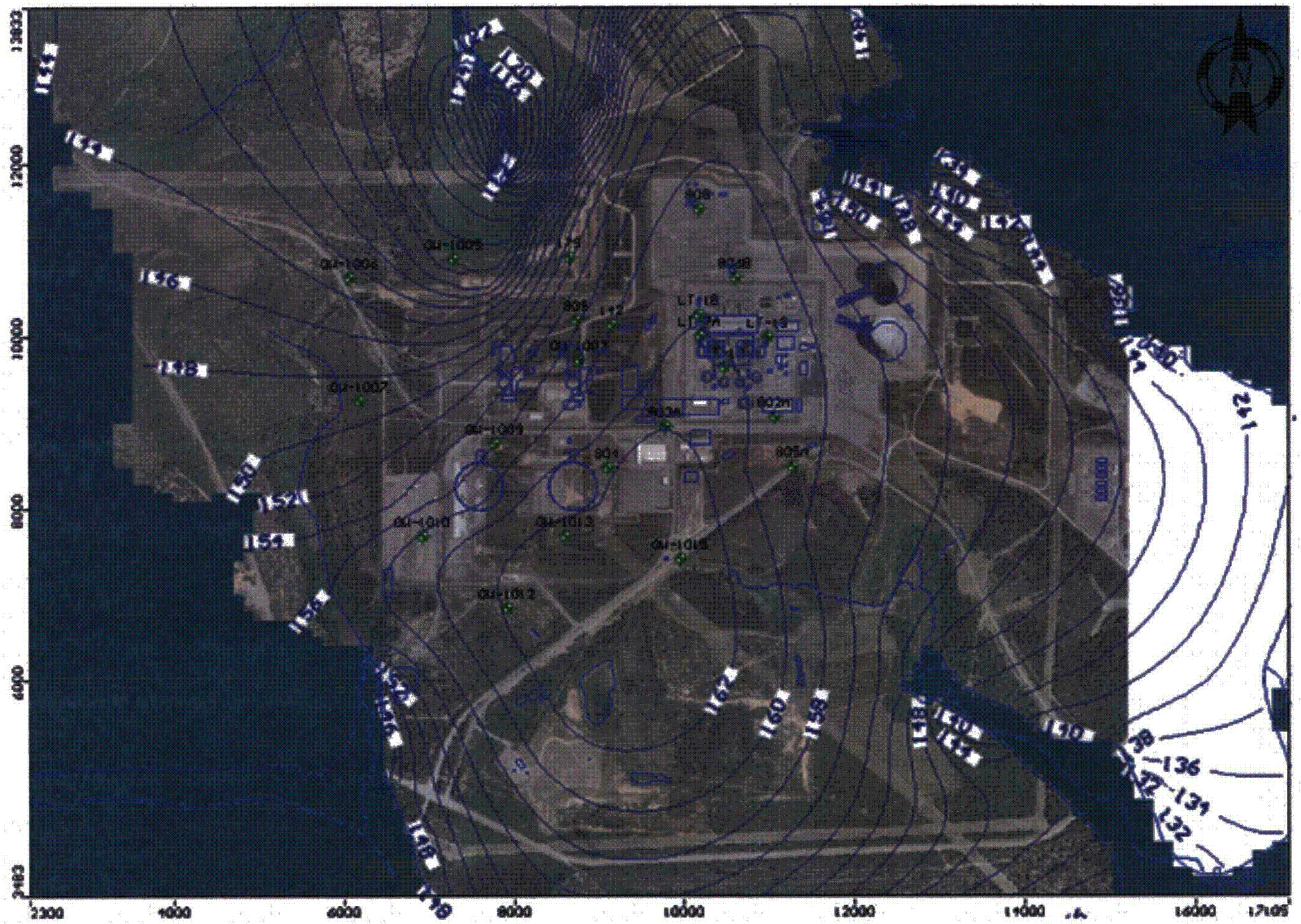


Figure 42: Model 6 - Simulated Water Levels for Run 612
(K_1=28; K_2=33; K_3=200; K_4=8 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

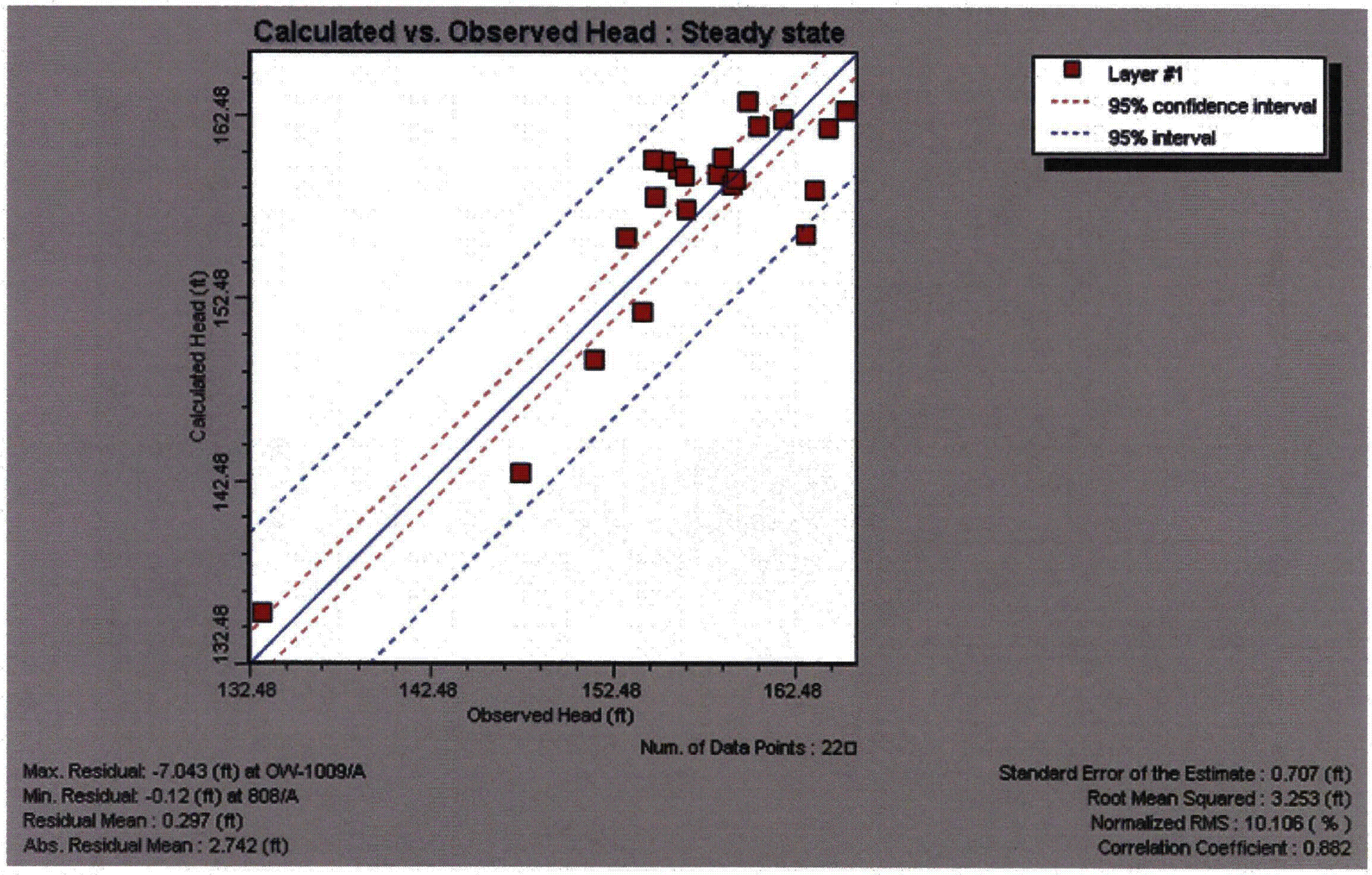


Figure 43: Model 6 - Simulated Vs. Observed Water Levels for Run 612 (K_1=28; K_2=33; K_3=200; K_4=8 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

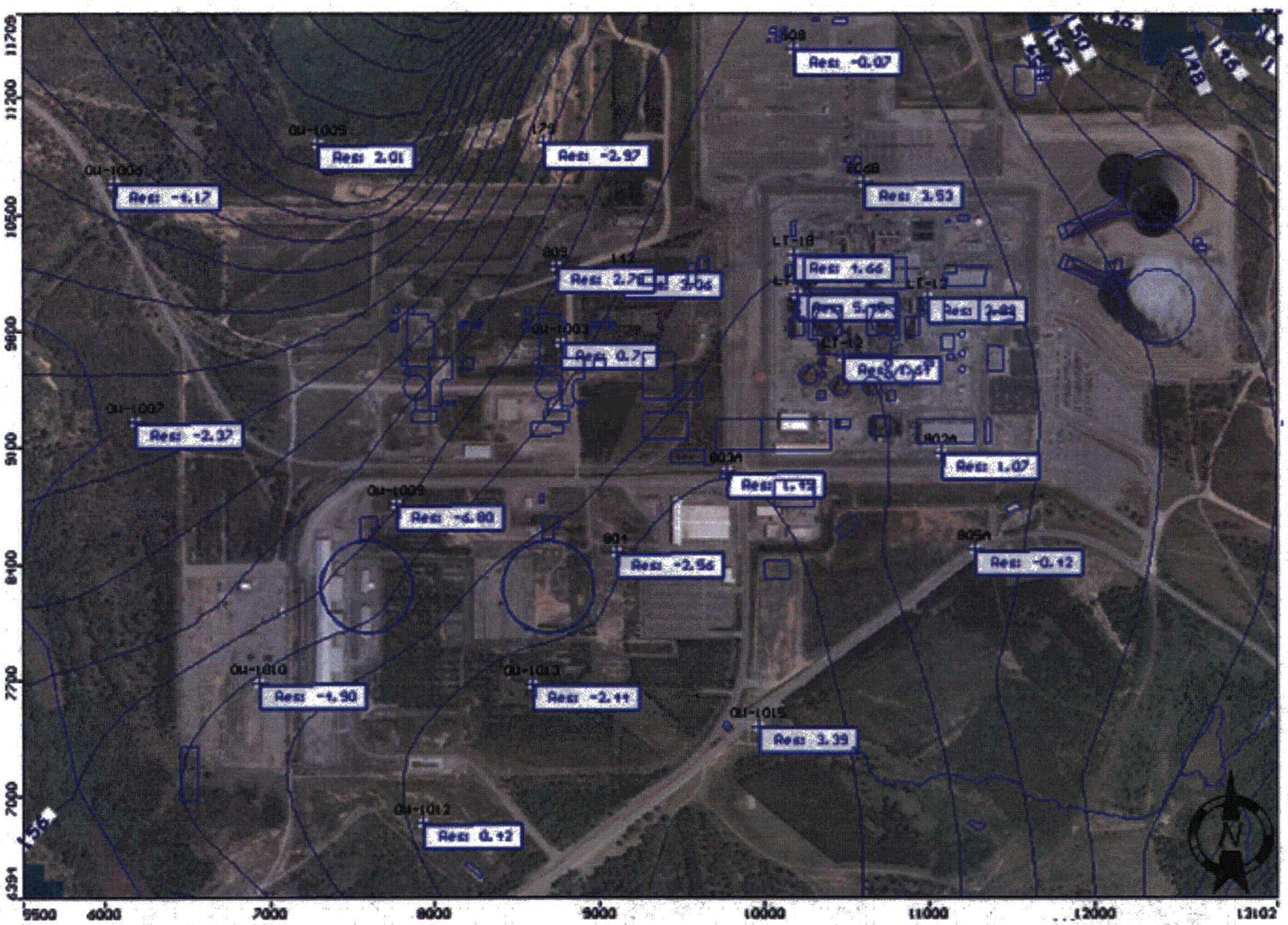


Figure 44: Model 6- Estimated Residuals for Run 612
(K_1=28; K_2=33; K_3=200; K_4=8 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

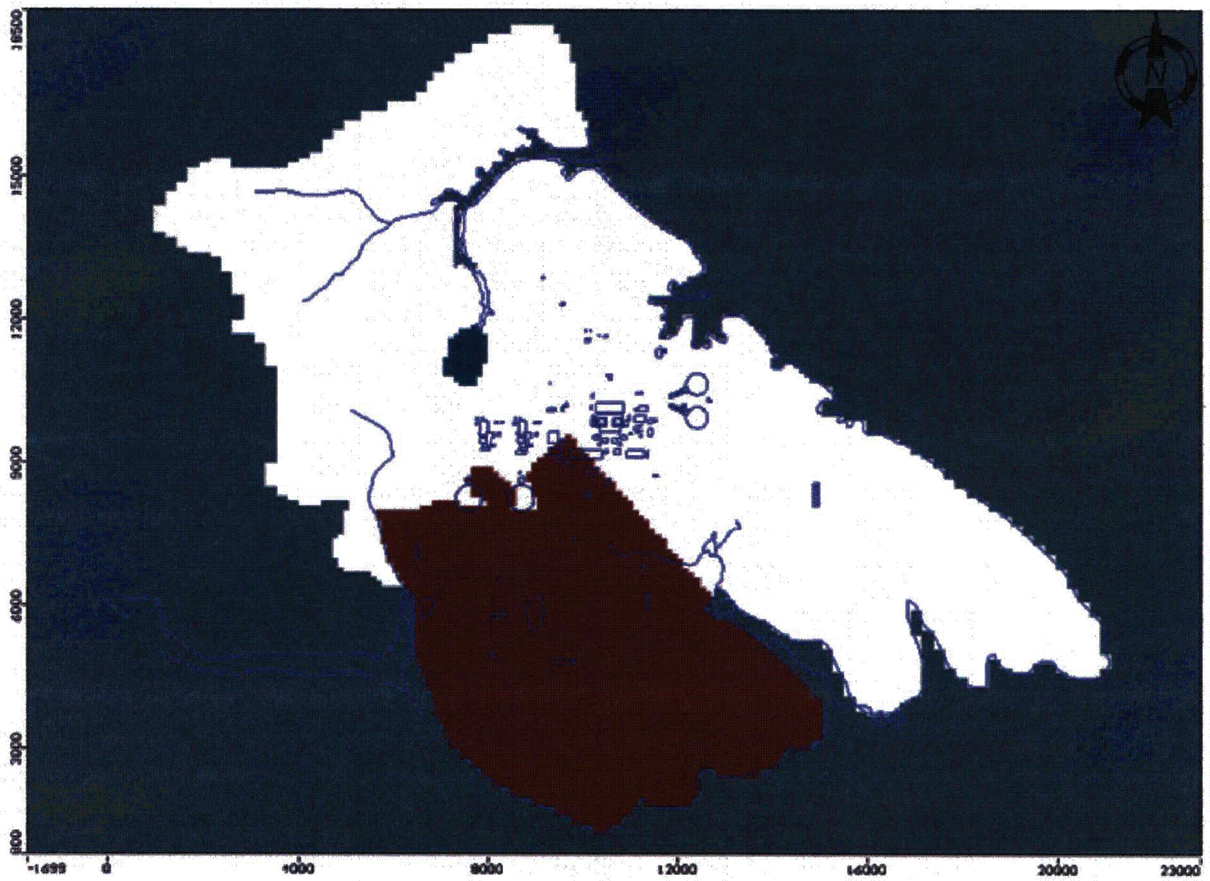


Figure 45: Model 7, Run 708 – Simplified Version of Model 6 (K_1=32; K_2=100; K_3=8 ft/day)

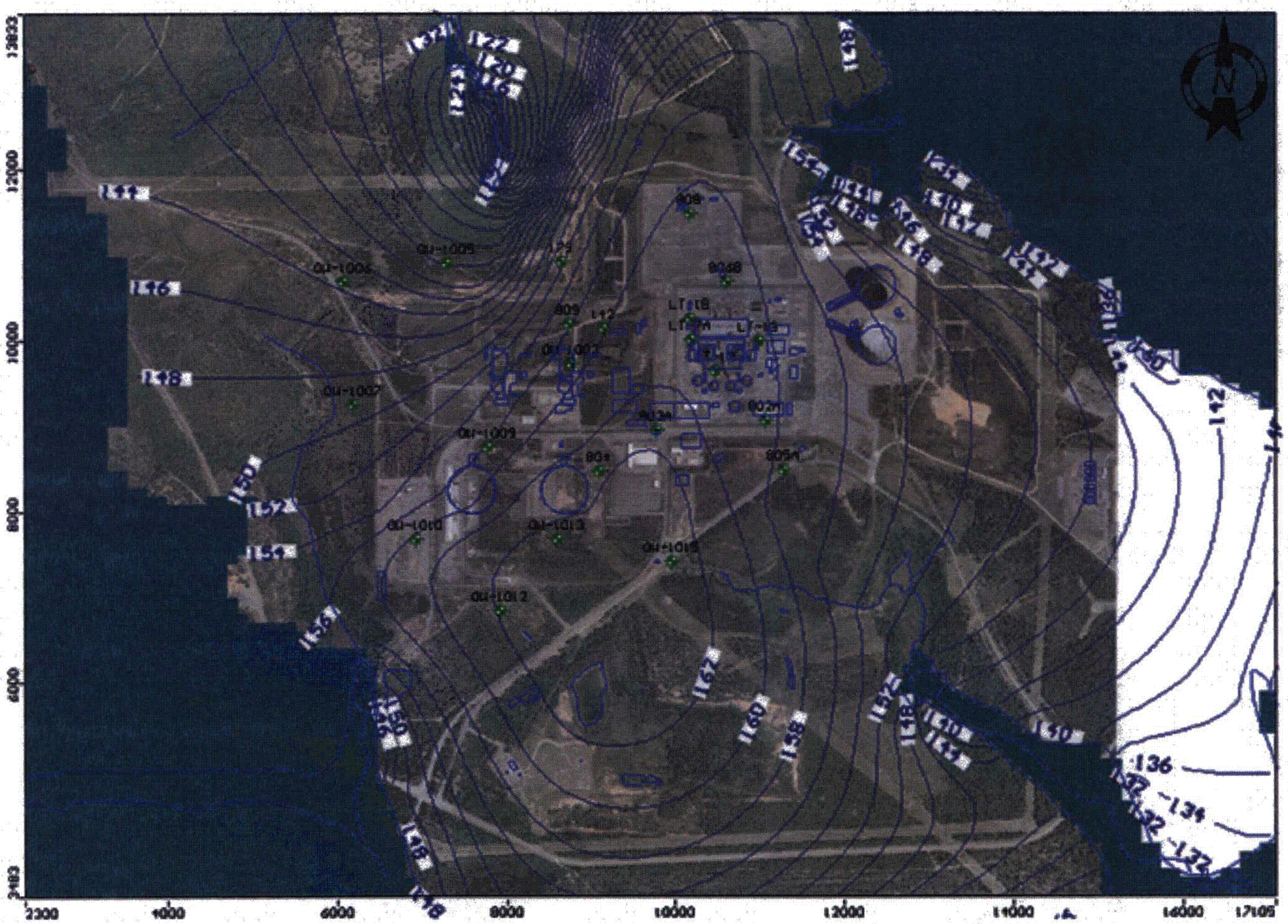


Figure 46: Model 7 - Simulated Water Levels for Run 708
(K_1=32; K_2=100; K_3=8 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

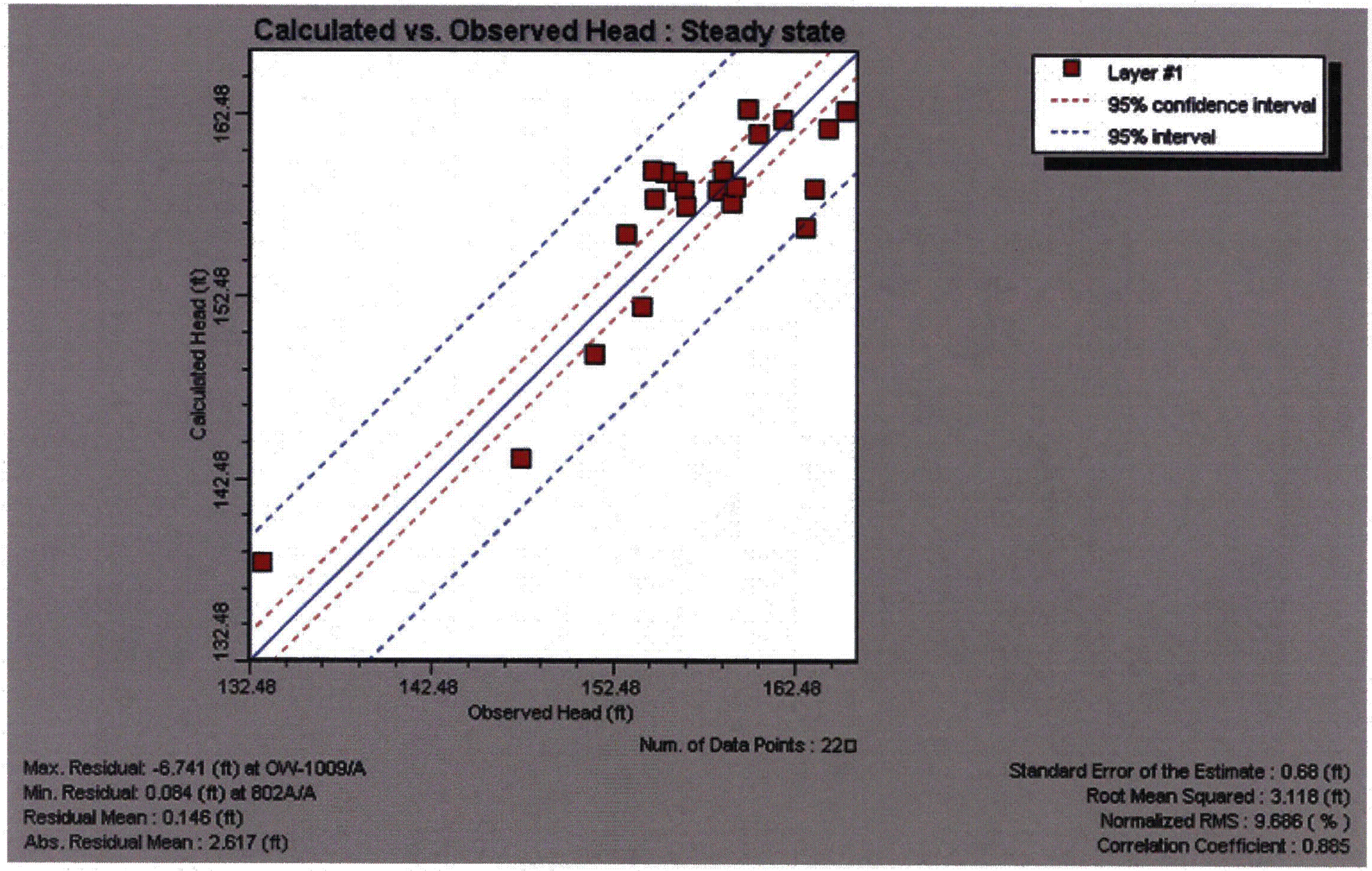


Figure 47: Model 7 - Simulated Vs. Observed Water Levels for Run 708 (K_1=23; K_2=400; K_3=6; ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

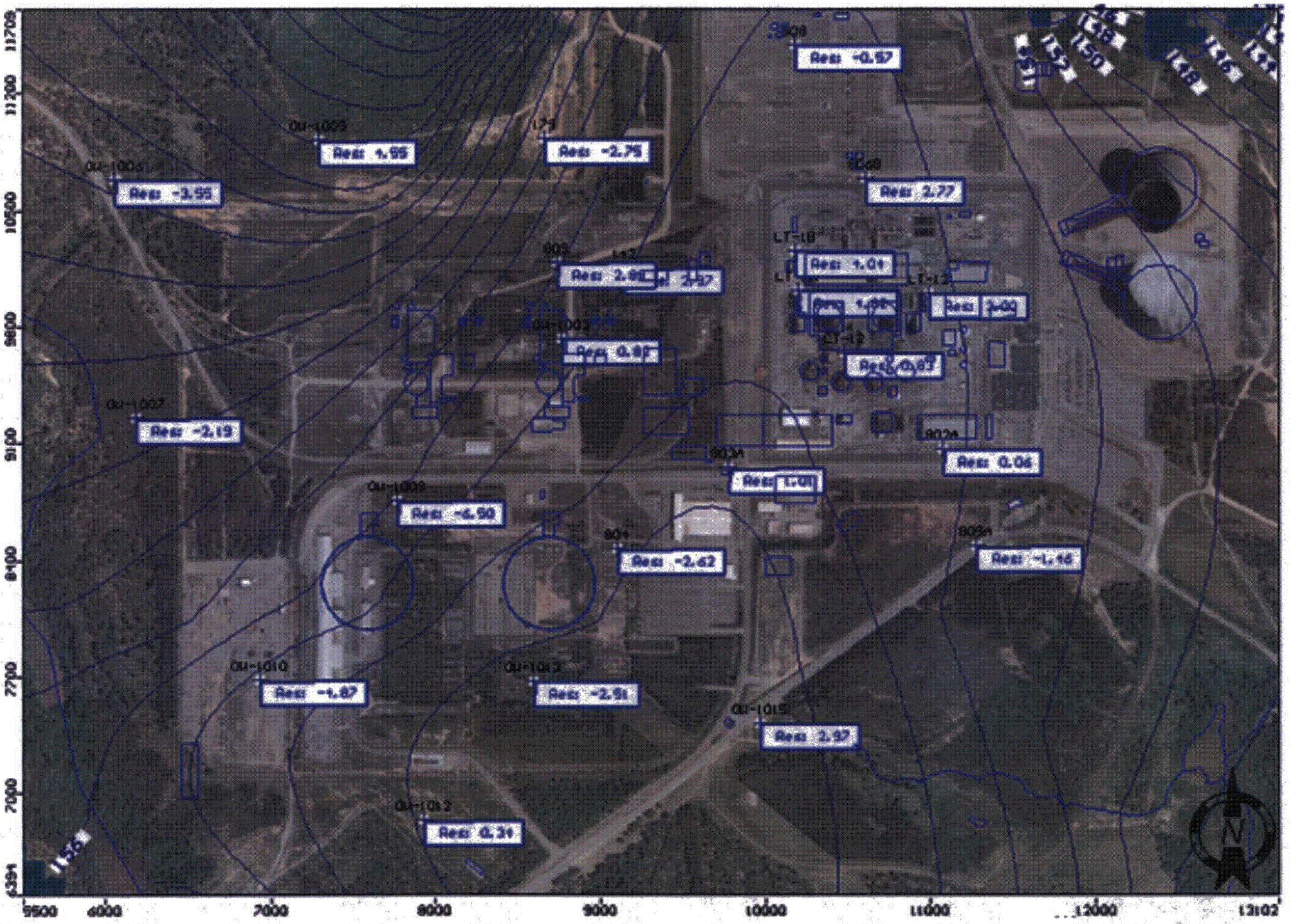


Figure 48: Model 7- Estimated Residuals for Run 708
(K_1=23; K_2=400; K_3=6; ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

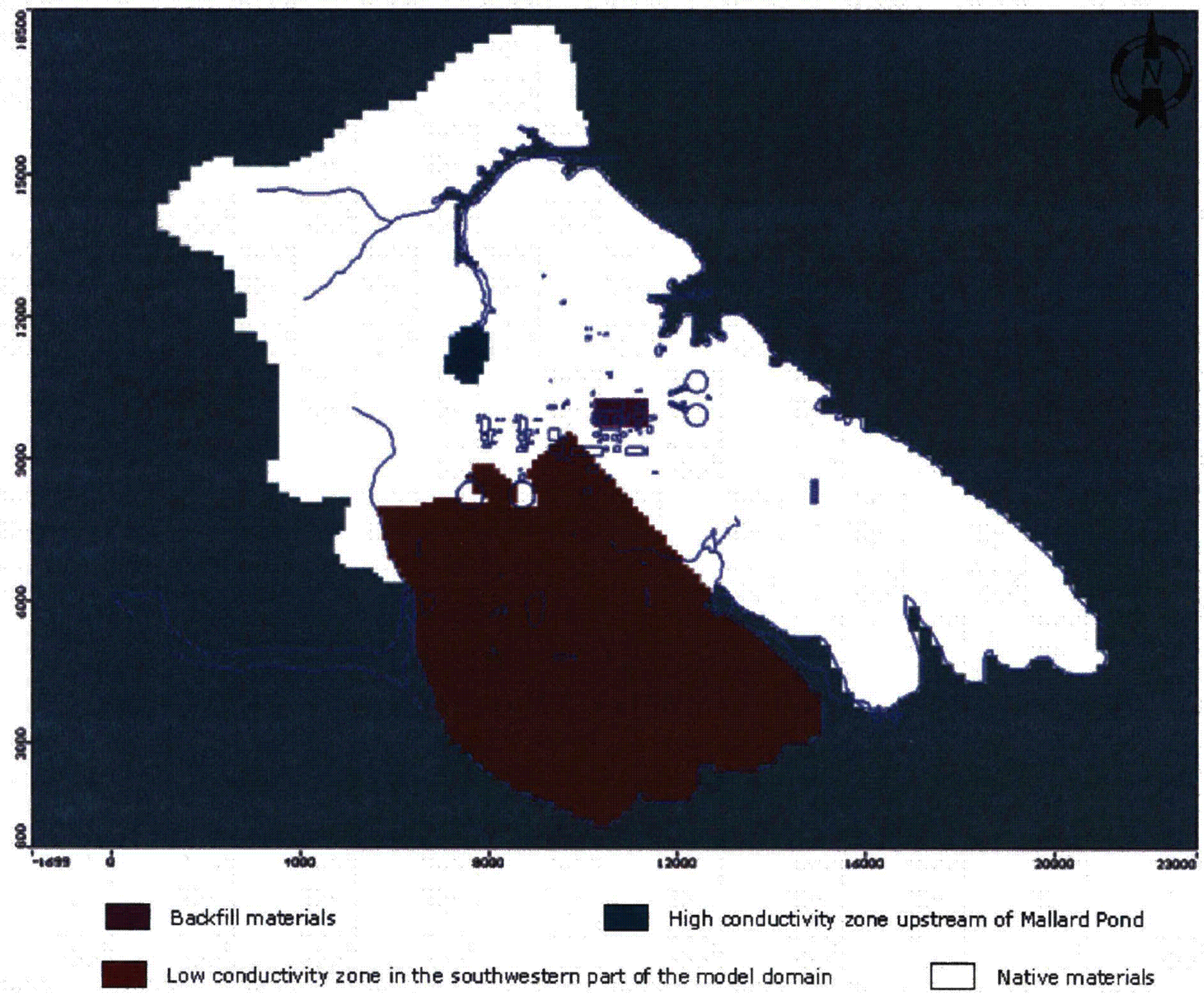


Figure 49: Hydraulic Conductivity Zones Used in Model 7 to Evaluate the Sensitivity of the Model to the Hydraulic Conductivity for the Backfill Material Around Units 1 & 2

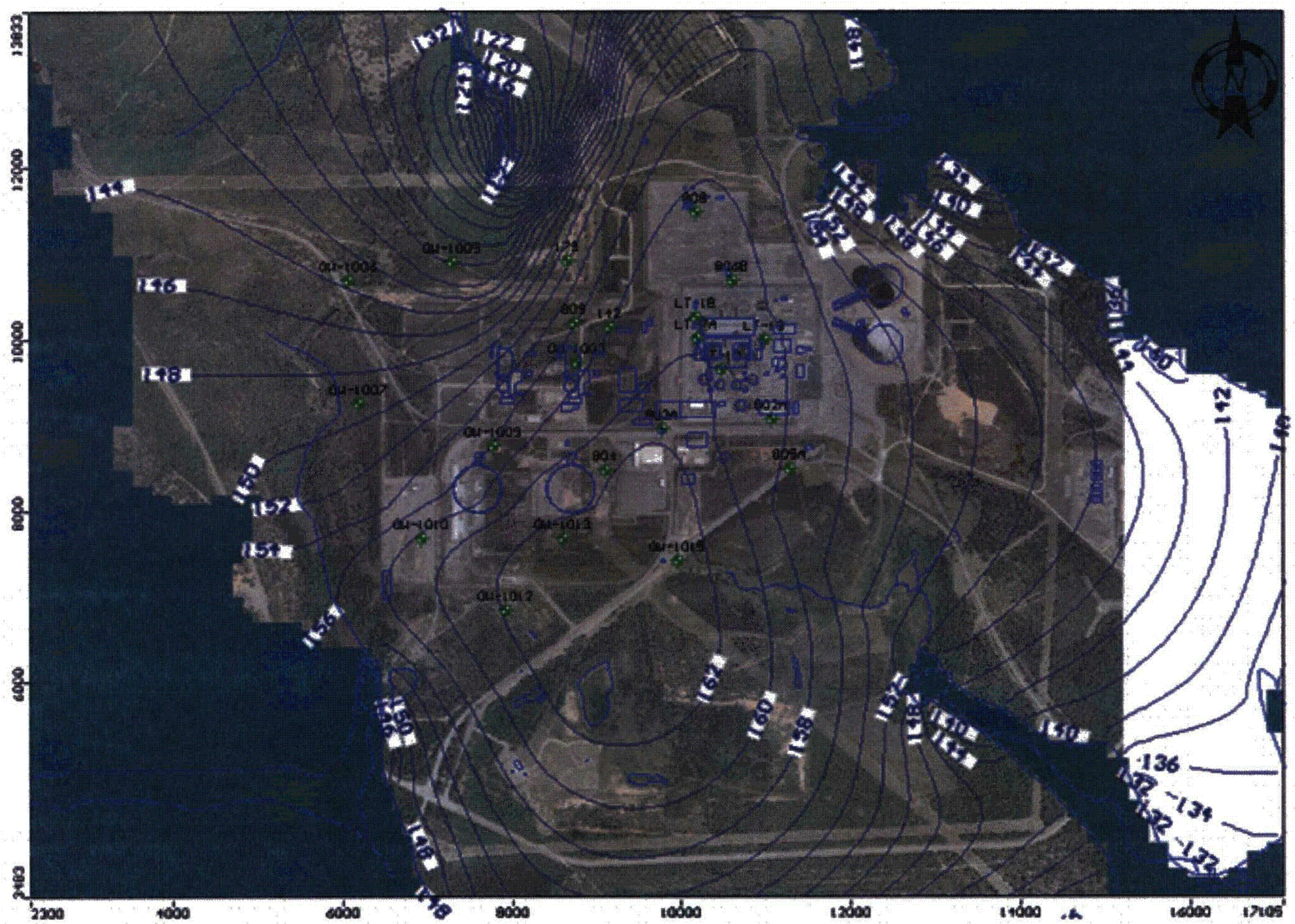


Figure 50: Simulated Water Levels with Model 7 Accounting for the Backfill Material for Units 1 & 2 as a Different Material with Hydraulic Conductivity Equal to 3.3 ft/day

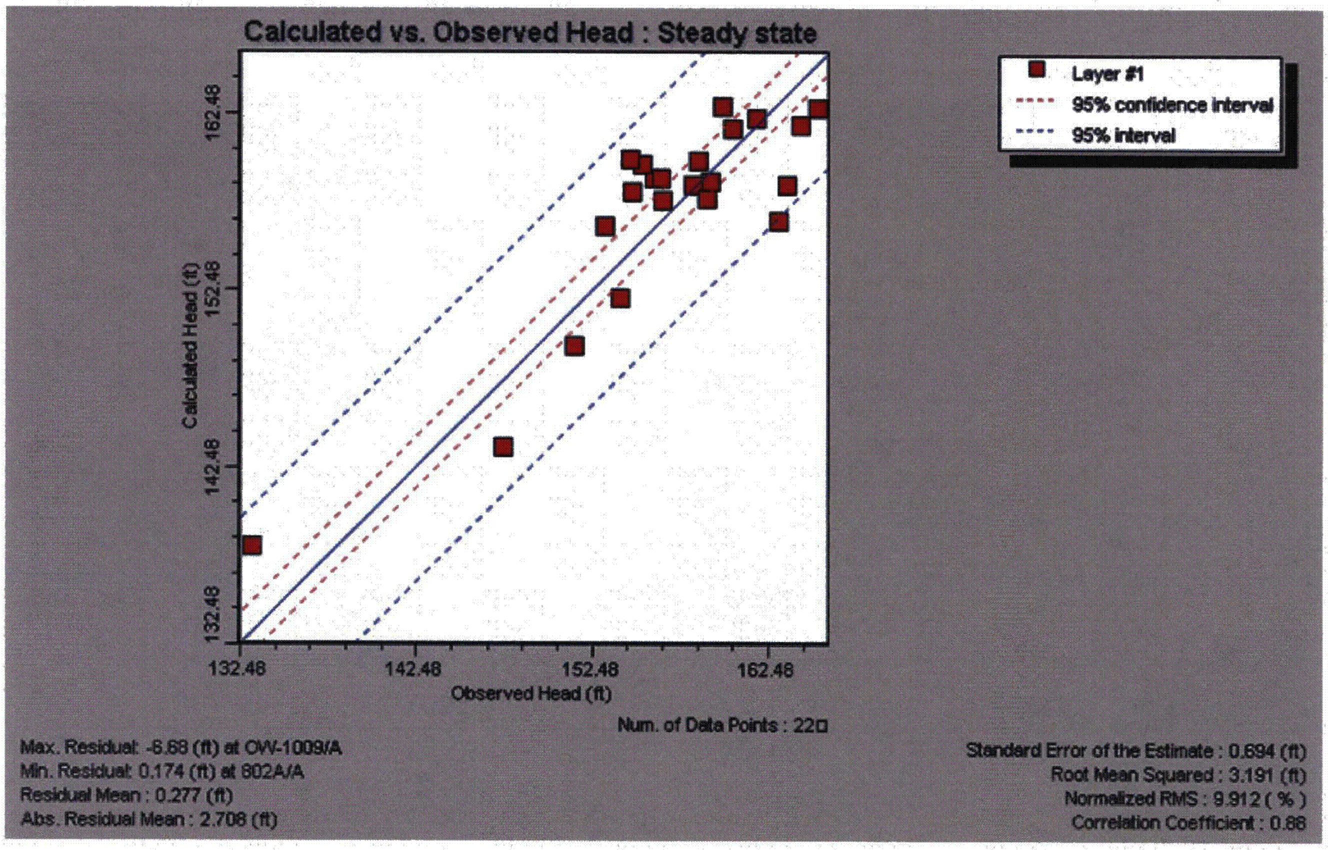


Figure 51: Simulated Versus Observed Water Levels with Model 7 Accounting for the Backfill Material for Units 1 & 2 as a Different Material with Hydraulic Conductivity Equal to 3.3 ft/day

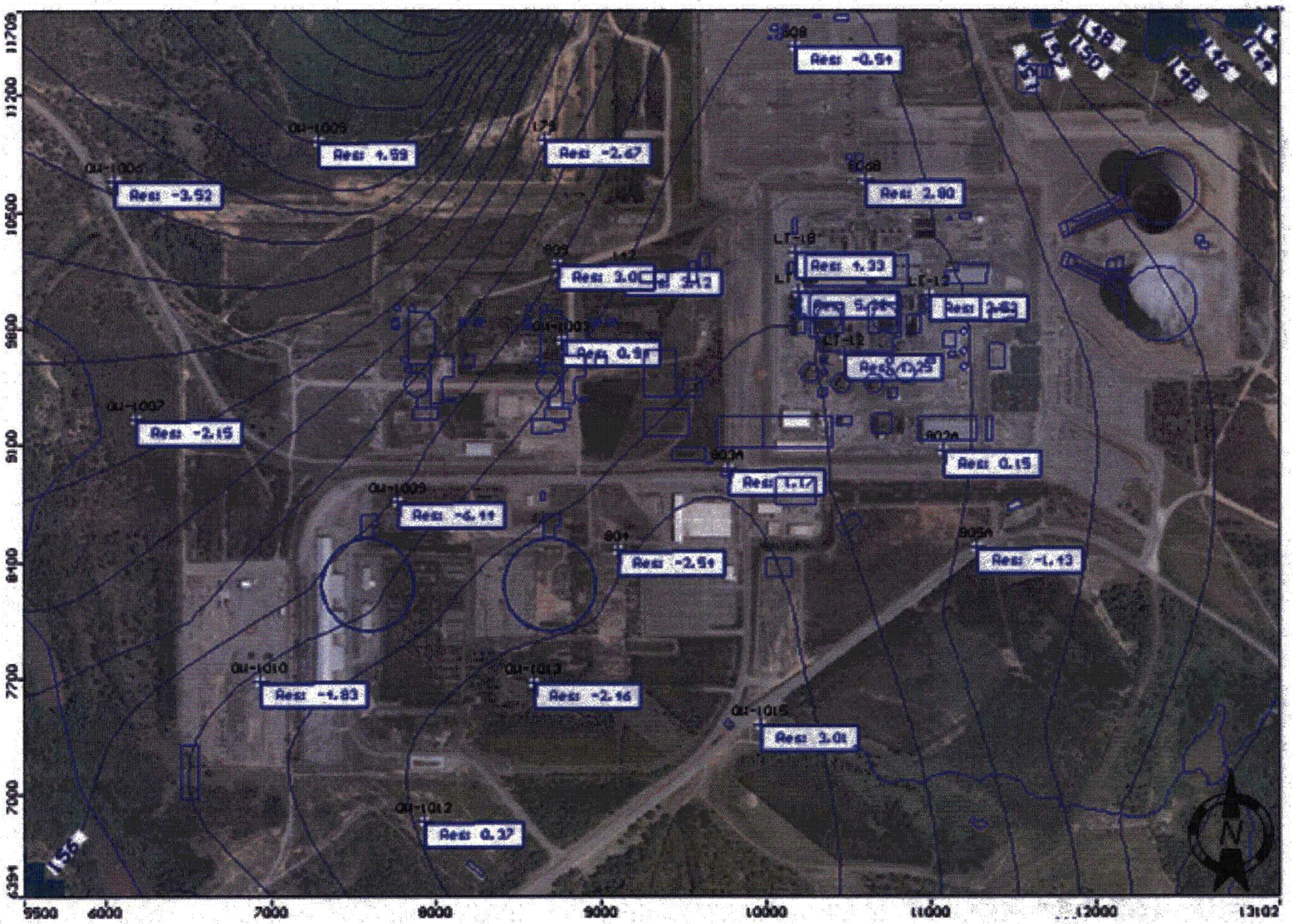


Figure 52: Estimated Residuals with Model 7 Accounting for the Backfill Material for Units 1 & 2 as a Different Material with Hydraulic Conductivity Equal to 3.3 ft/day

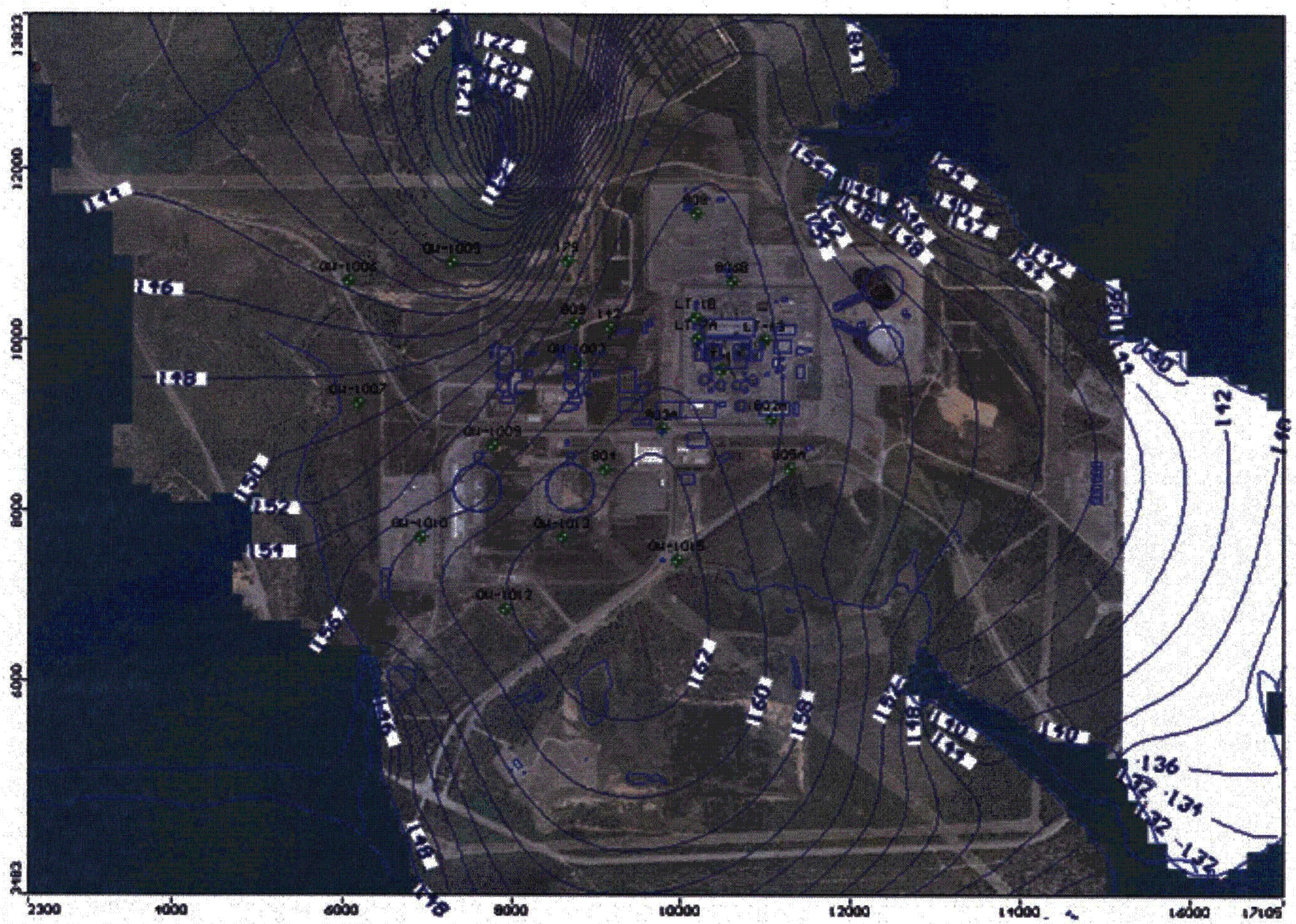


Figure 53: Simulated Water Levels with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 6 in/yr

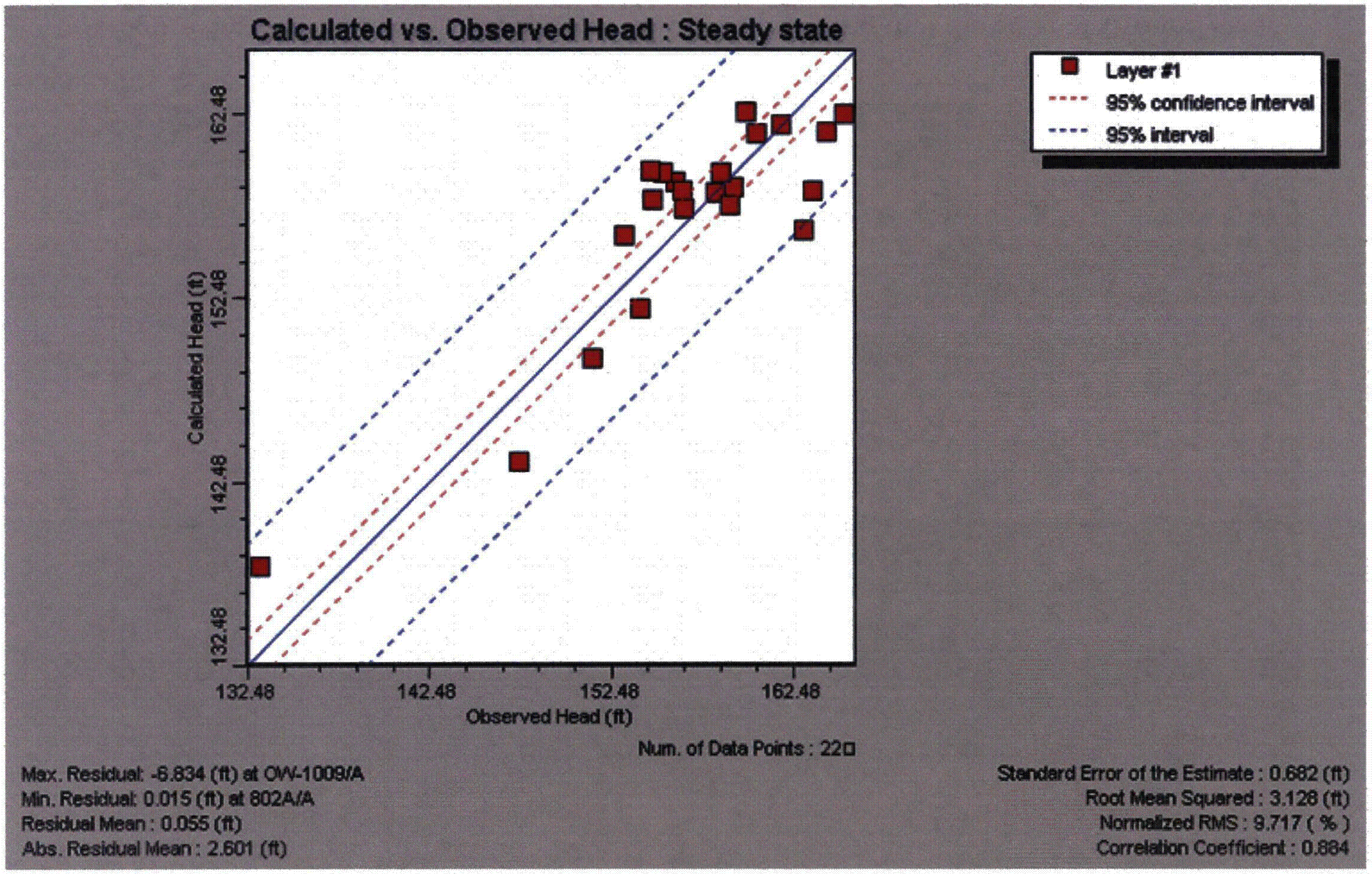


Figure 54: Simulated Versus Observed Water Levels with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 6 in/yr

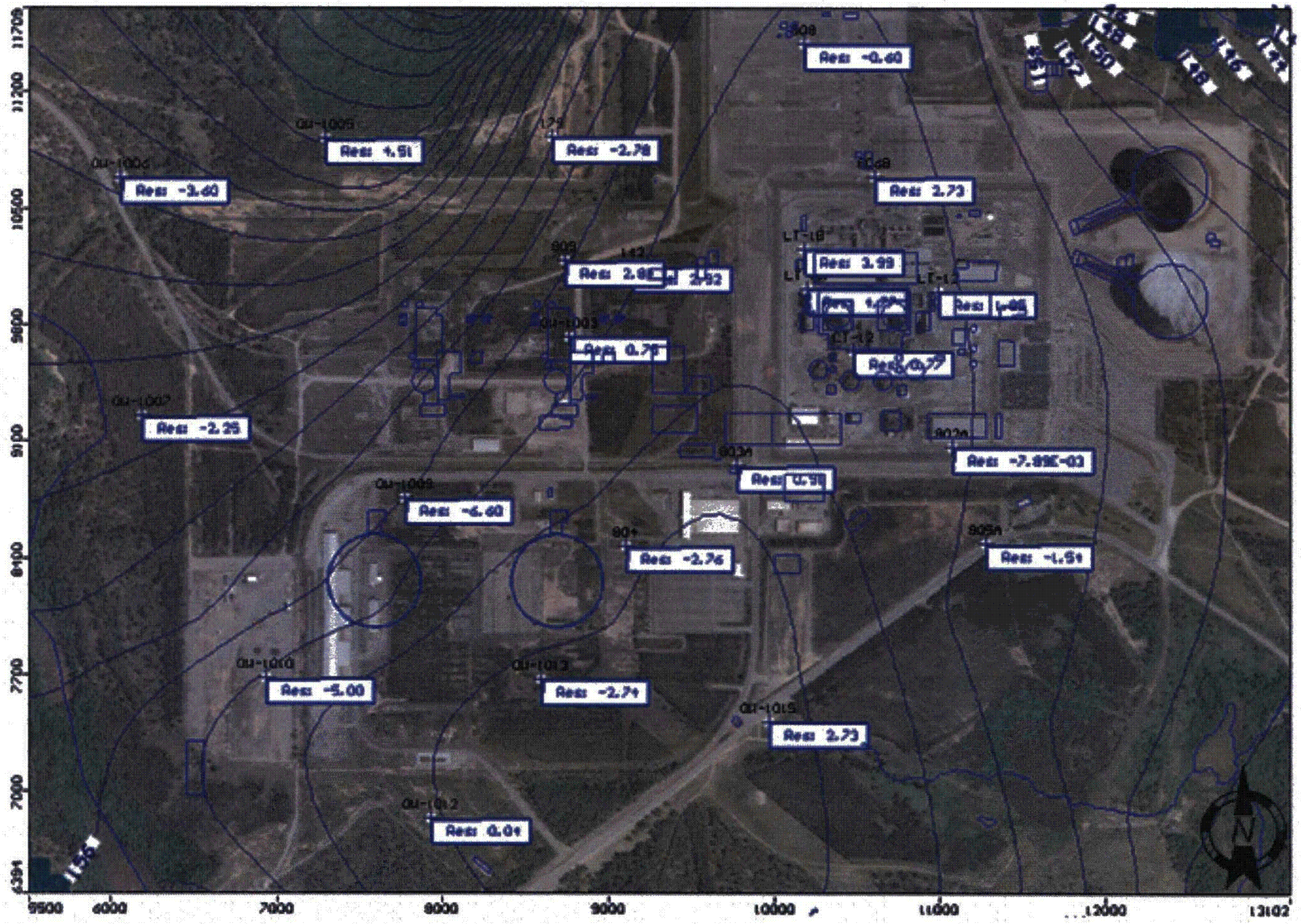


Figure 55: Estimated Residuals with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 6 in/yr

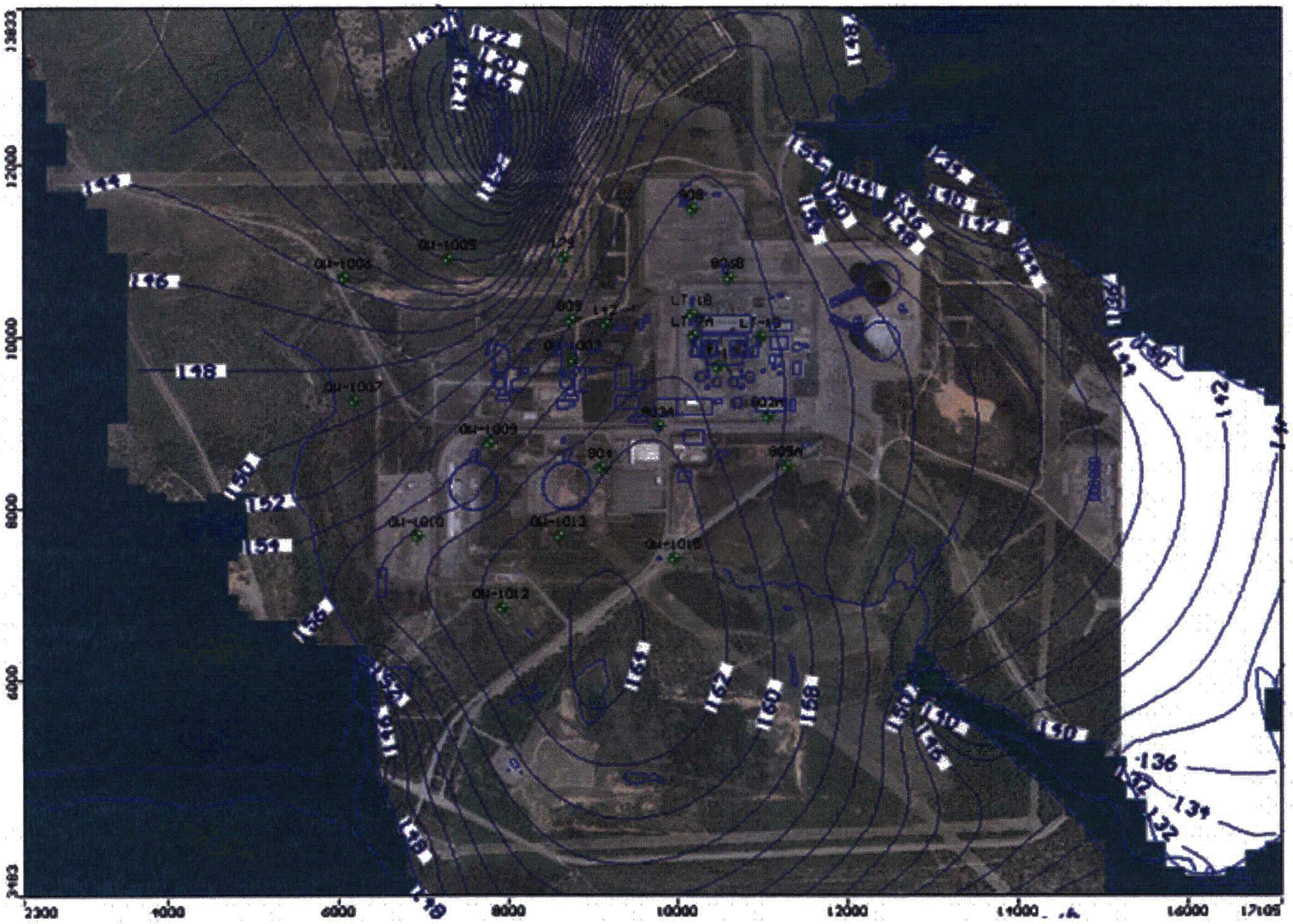


Figure 56: Simulated Water Levels with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 40 in/yr

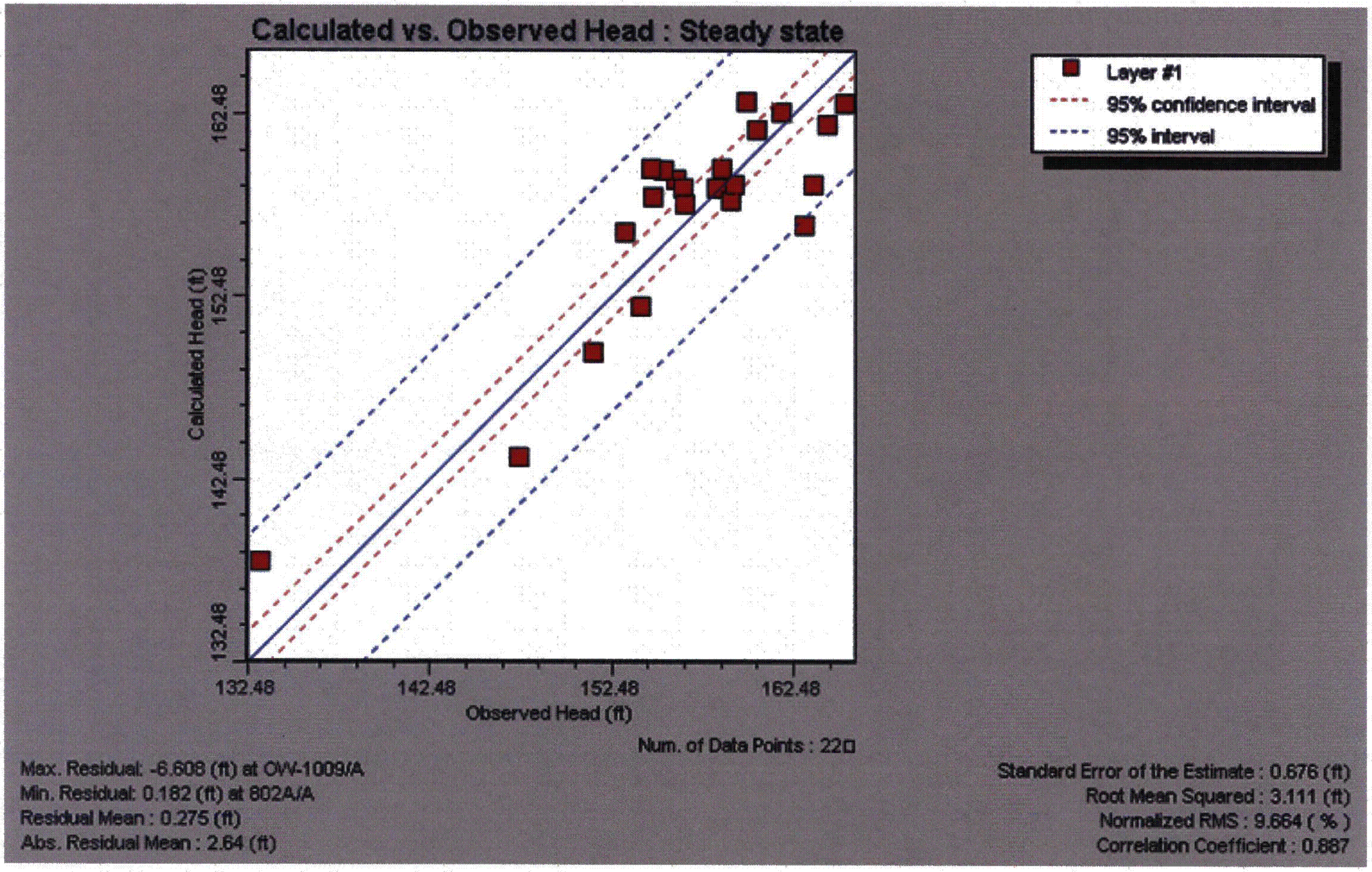


Figure 57: Simulated Versus Observed Water Levels with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 40 in/yr

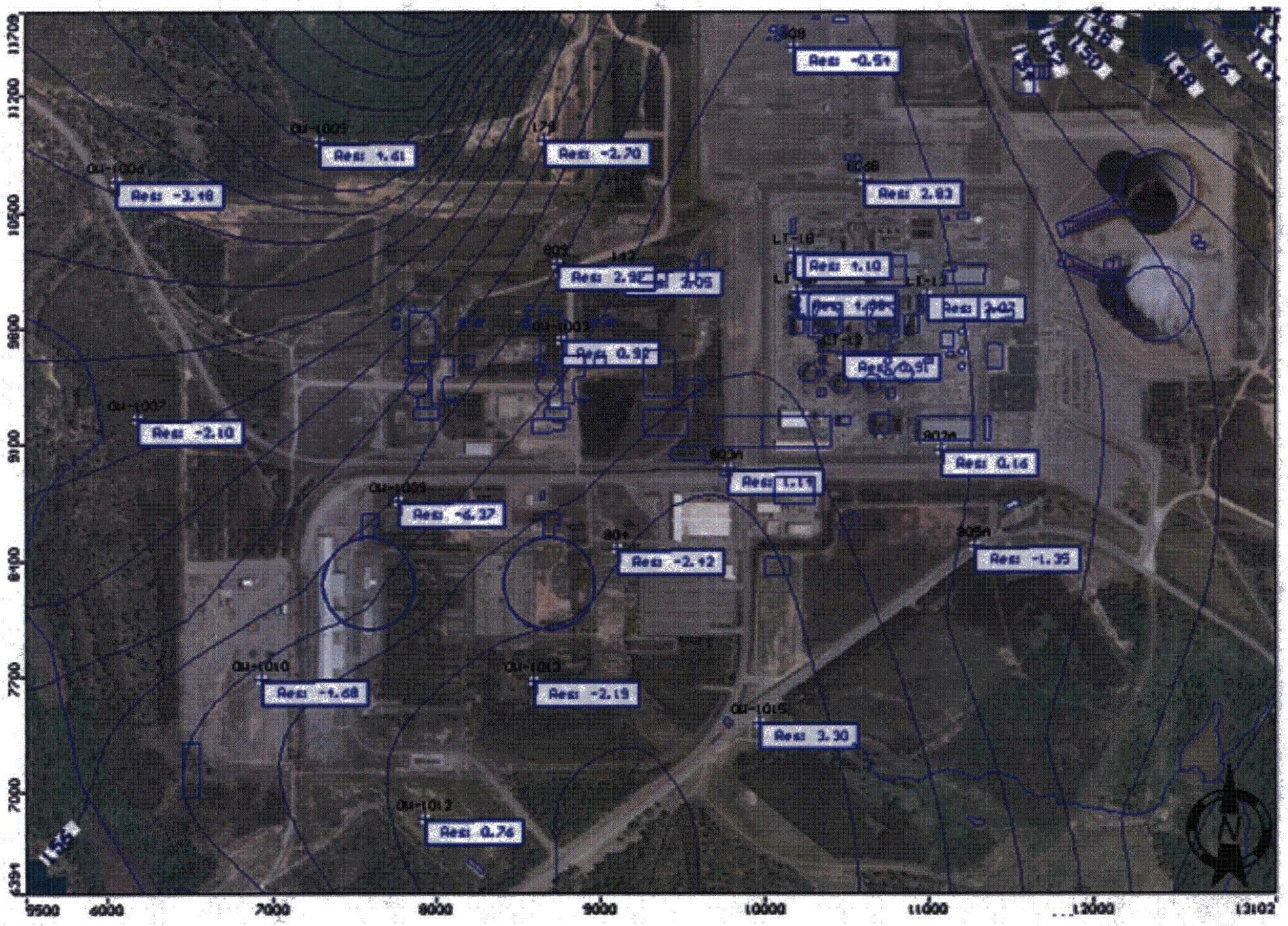


Figure 58: **Estimated Residuals with Model 7 Assuming that the Rate of Groundwater Recharge at the Met Tower Pond is 40 in/yr**

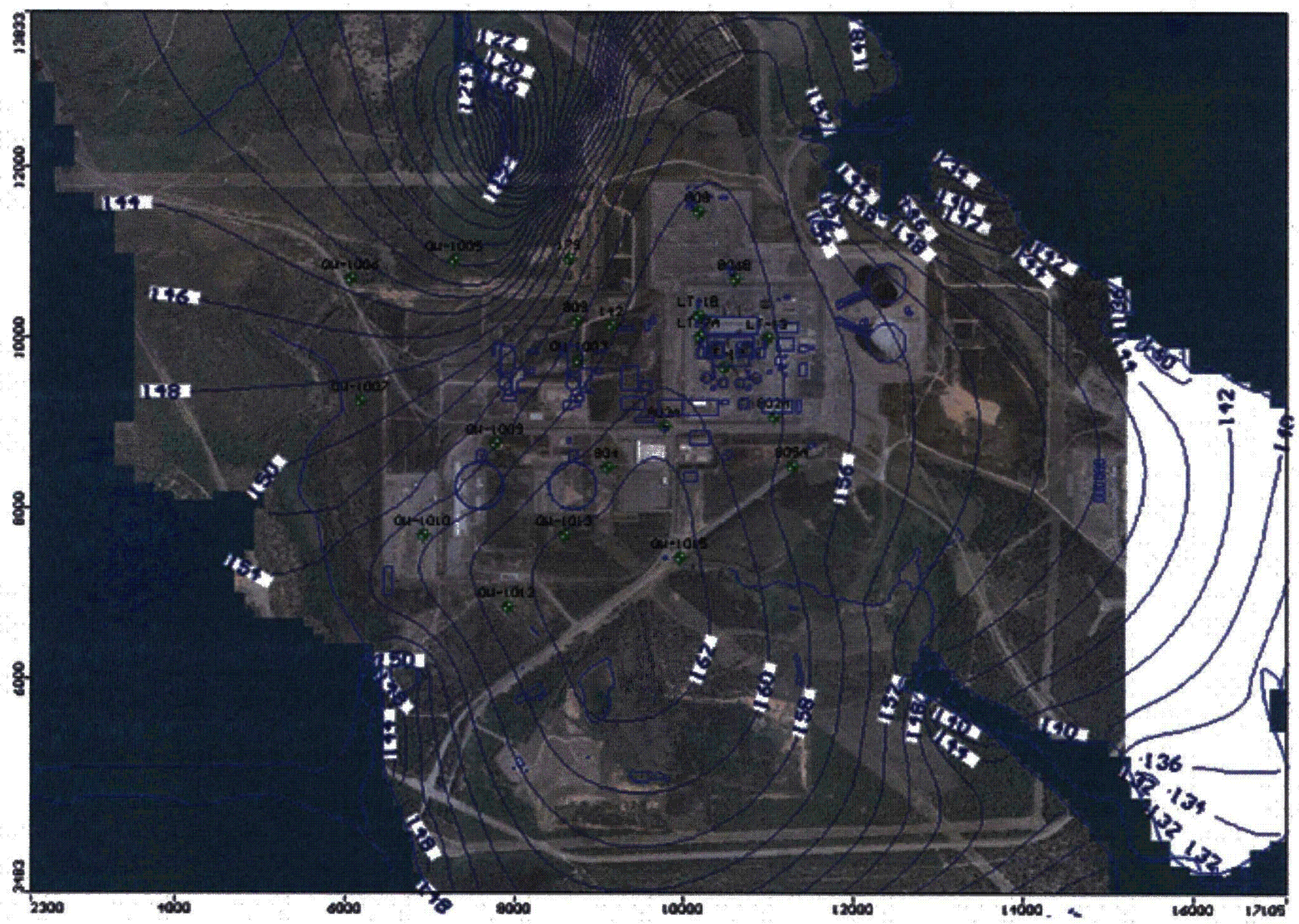


Figure 59: Simulated Water Levels with Model 7 Using a Constant Head Boundary Condition at the Upper Debris Basin 2 (The constant head used was 148.5 ft msl)

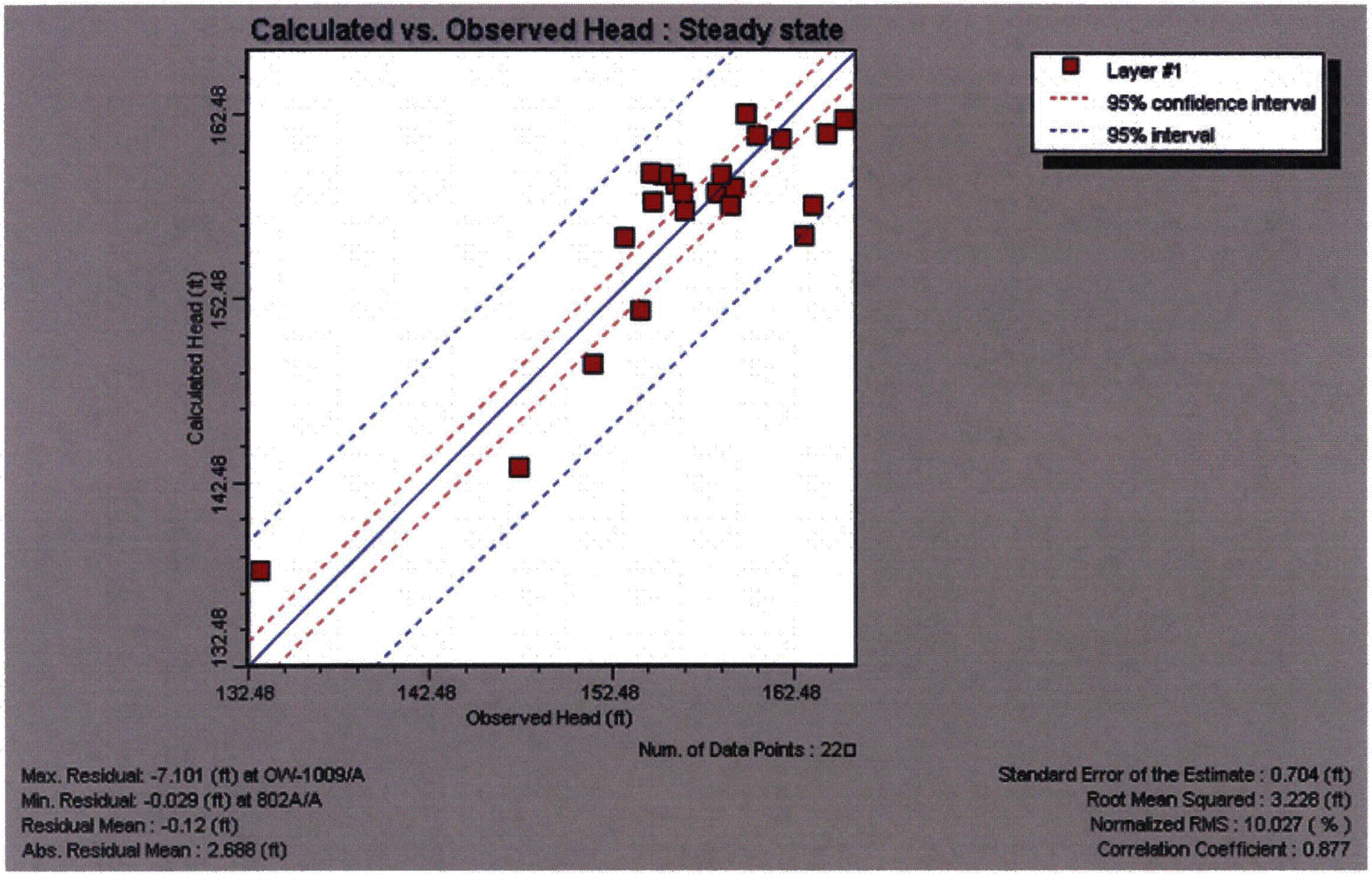


Figure 60: Simulated Versus Observed Water Levels with Model 7 Using a Constant Head Boundary Condition at the Upper Debris Basin 2 (The constant head used was 148.5 ft msl)

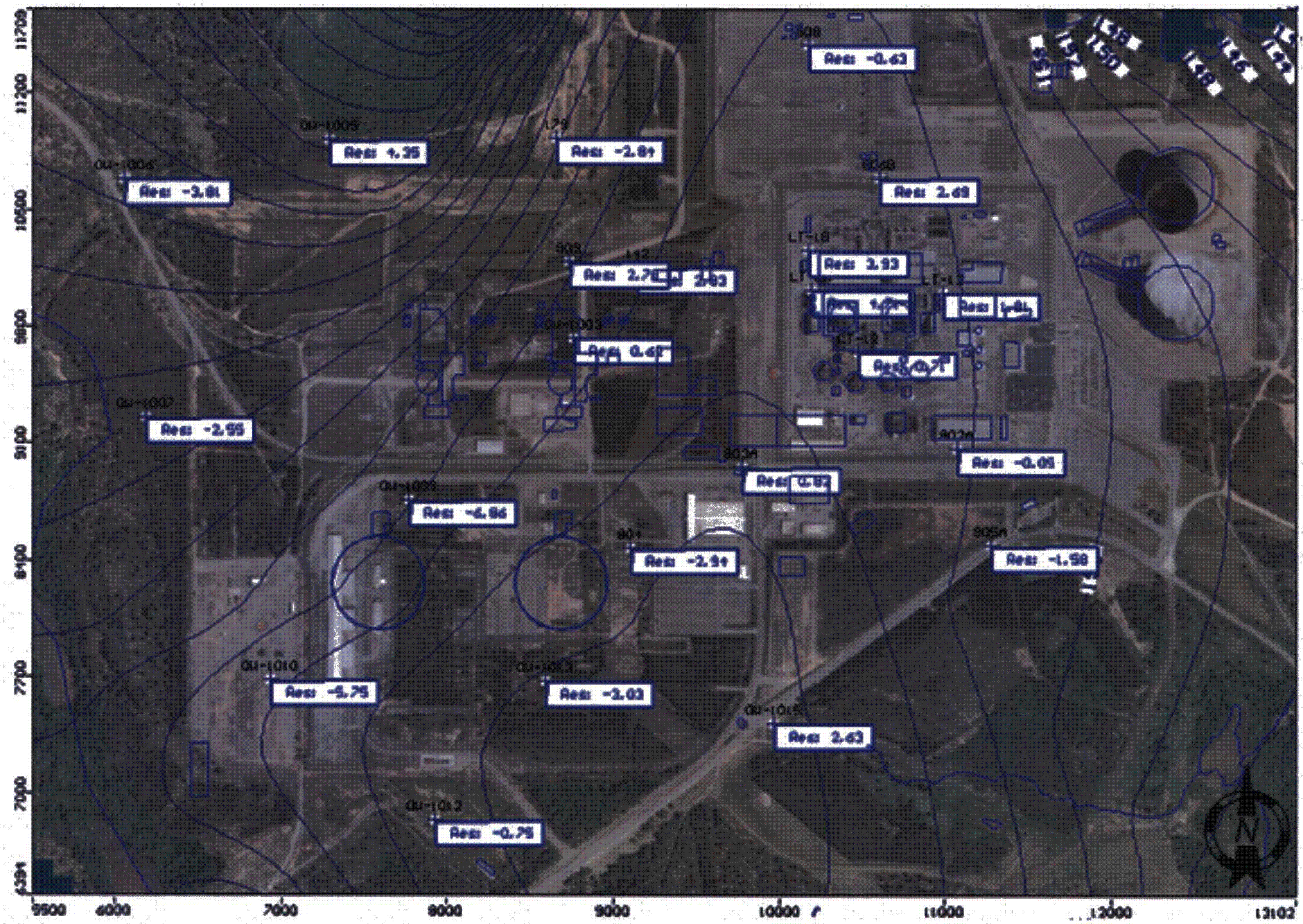


Figure 61: Estimated Residuals with Model 7 Using a Constant Head Boundary Condition at the Upper Debris Basin 2 (The constant head used was 148.5 ft msl)

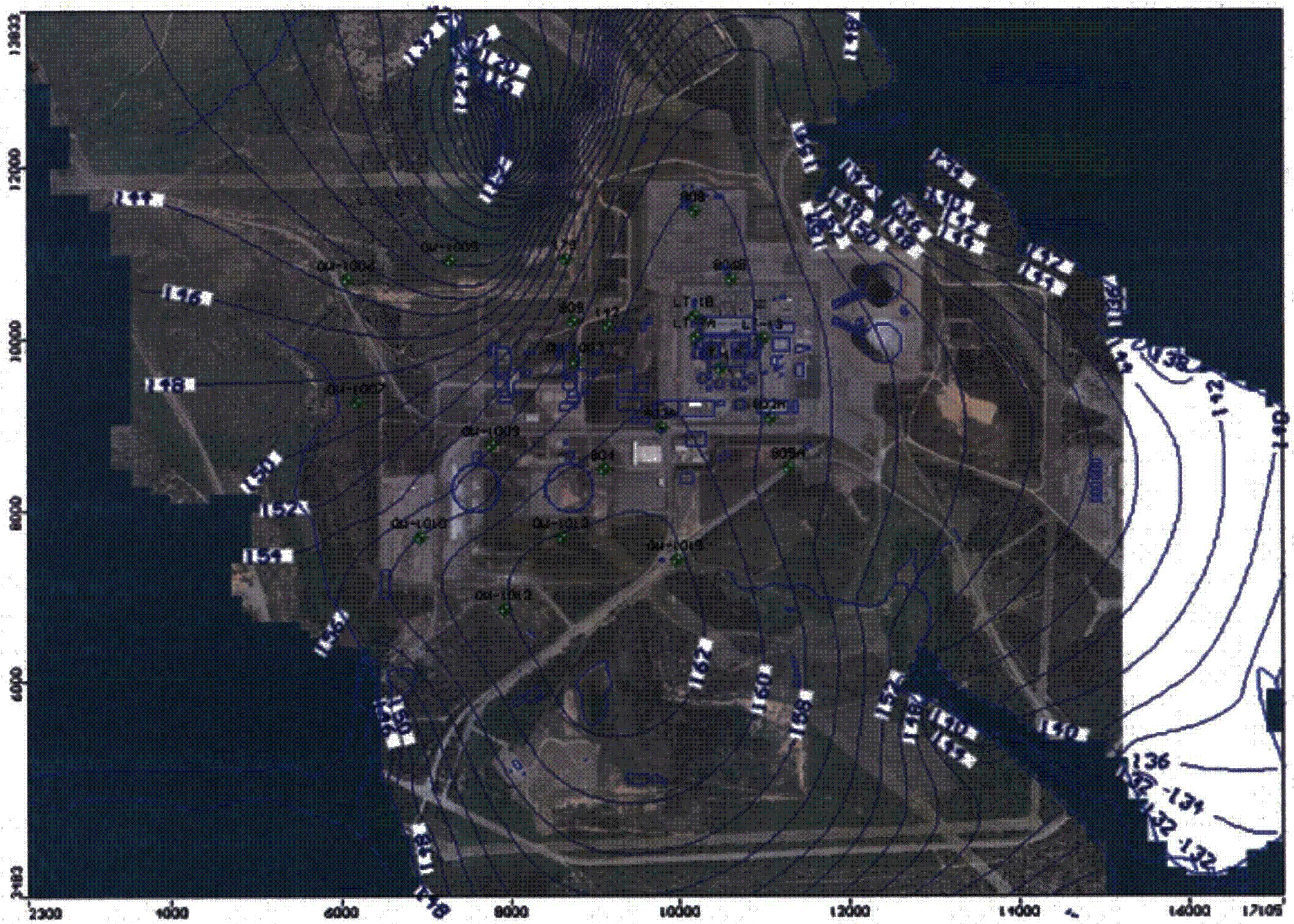


Figure 62: Simulated Water Levels with Model 7 Using Additional Paved Areas Around Units 1 & 2 and 3 & 4

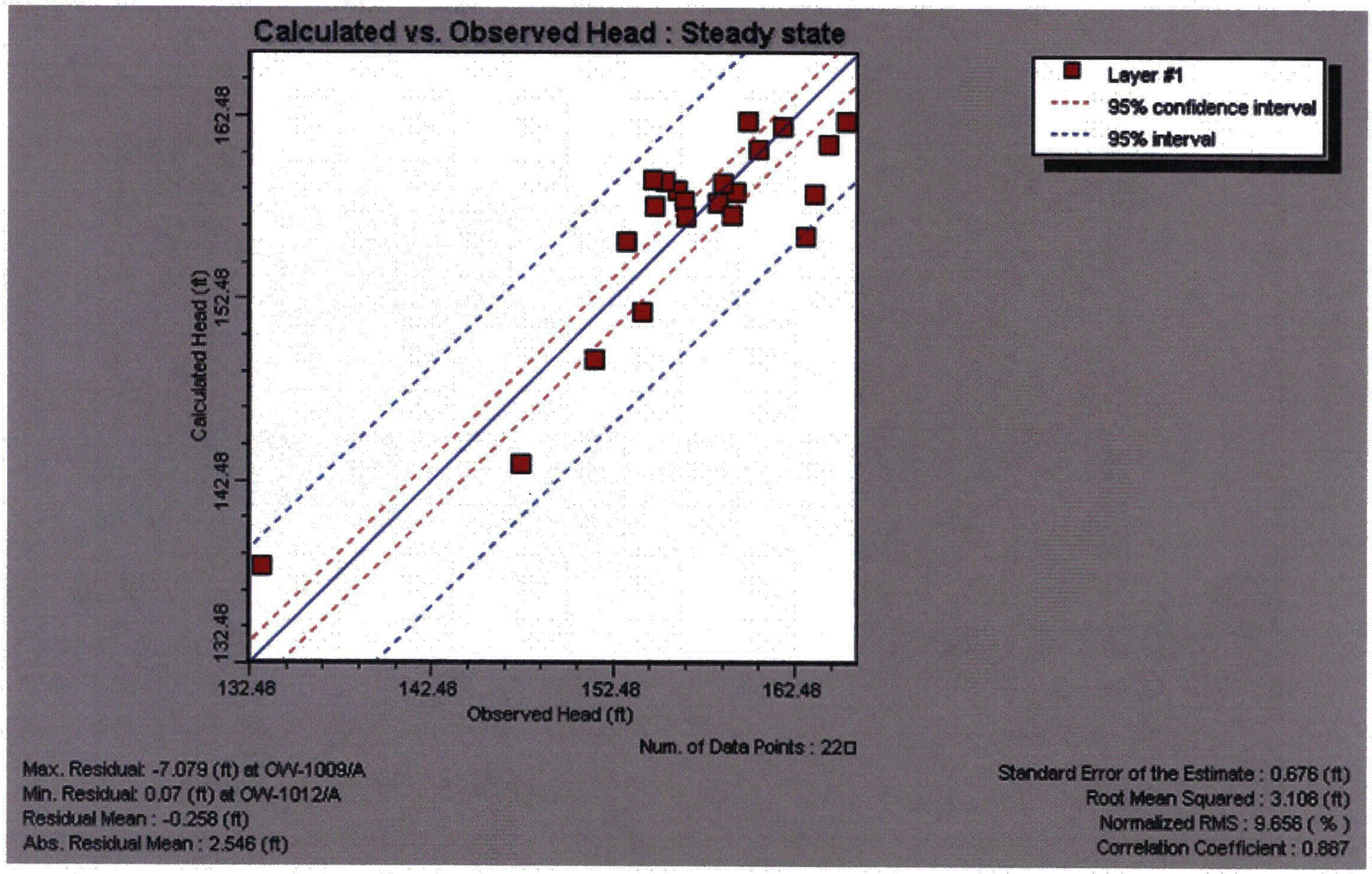


Figure 63: Simulated Versus Observed Water Levels with Model 7 Using Additional Paved Areas Around Units 1 & 2 and 3 & 4

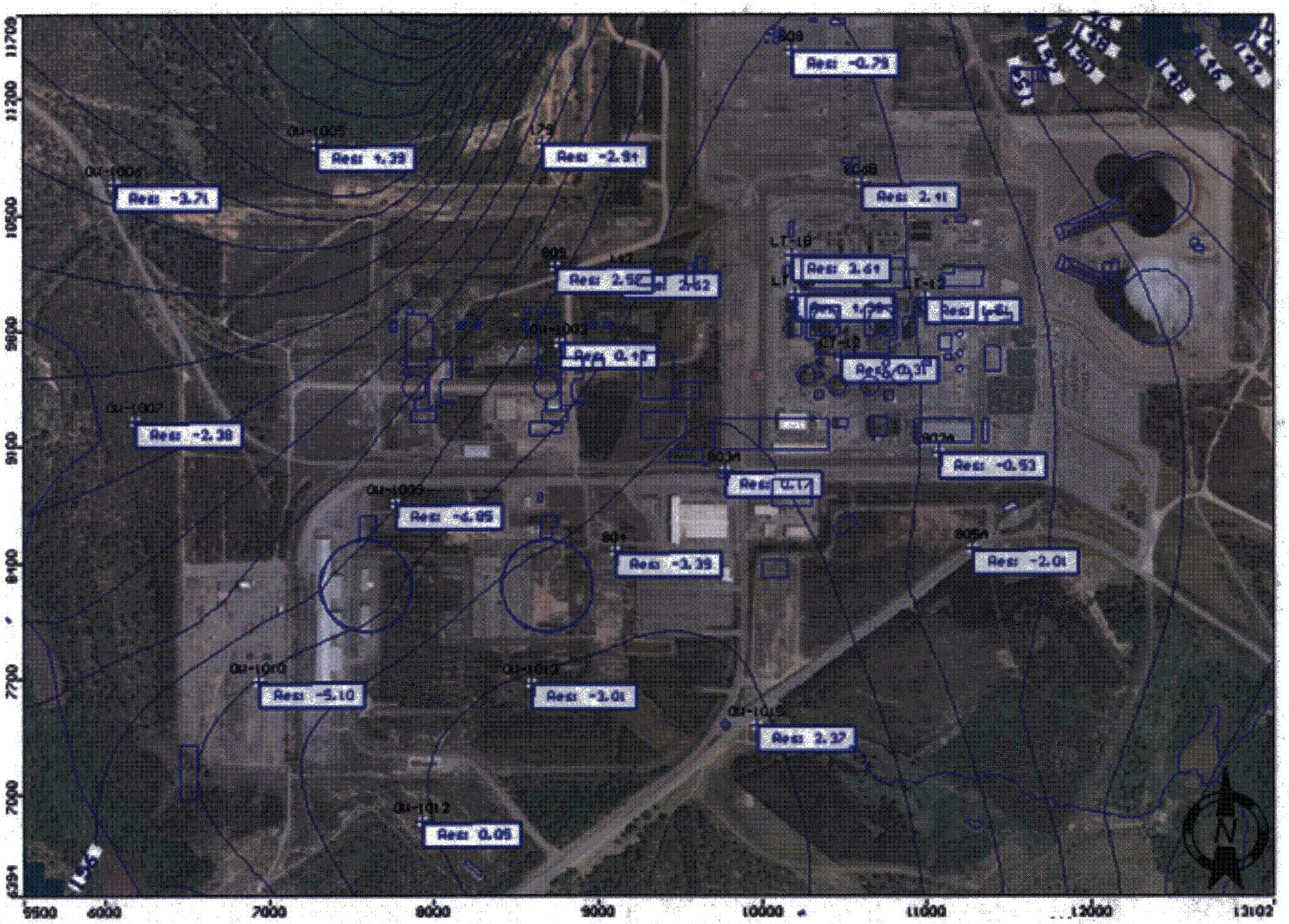
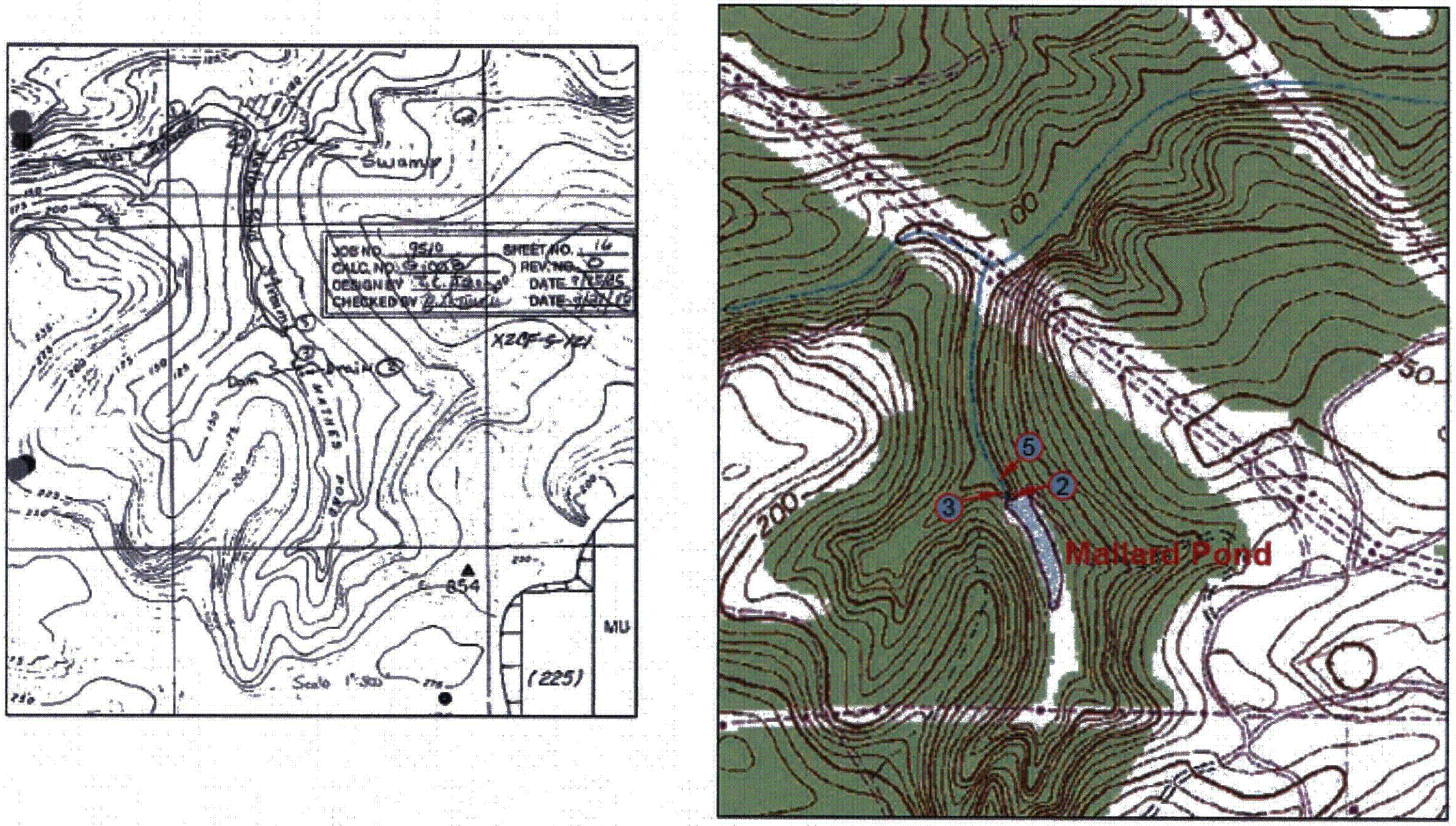


Figure 64: Estimated Residuals with Model 7 Using Additional Paved Areas Around Units 1 & 2 and 3 & 4



(a) Obtained from Ref. 11

(b) Stations from Ref. 11 Superimposed on USGS Map

Figure 65: Location of Stream Flow Measurement Stations at Mallard Pond

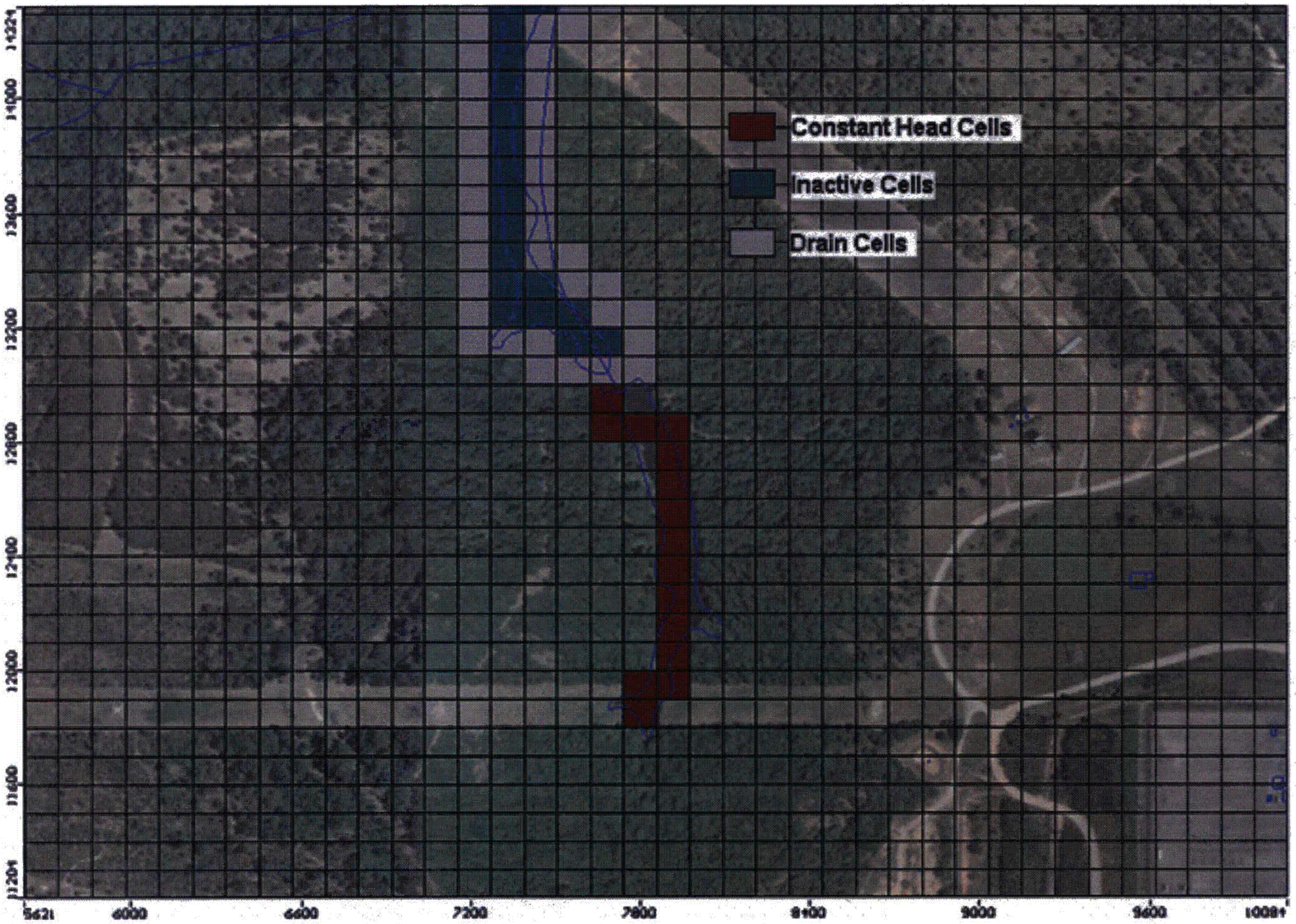


Figure 66: Representation of Mallard Pond and Area in Groundwater Model

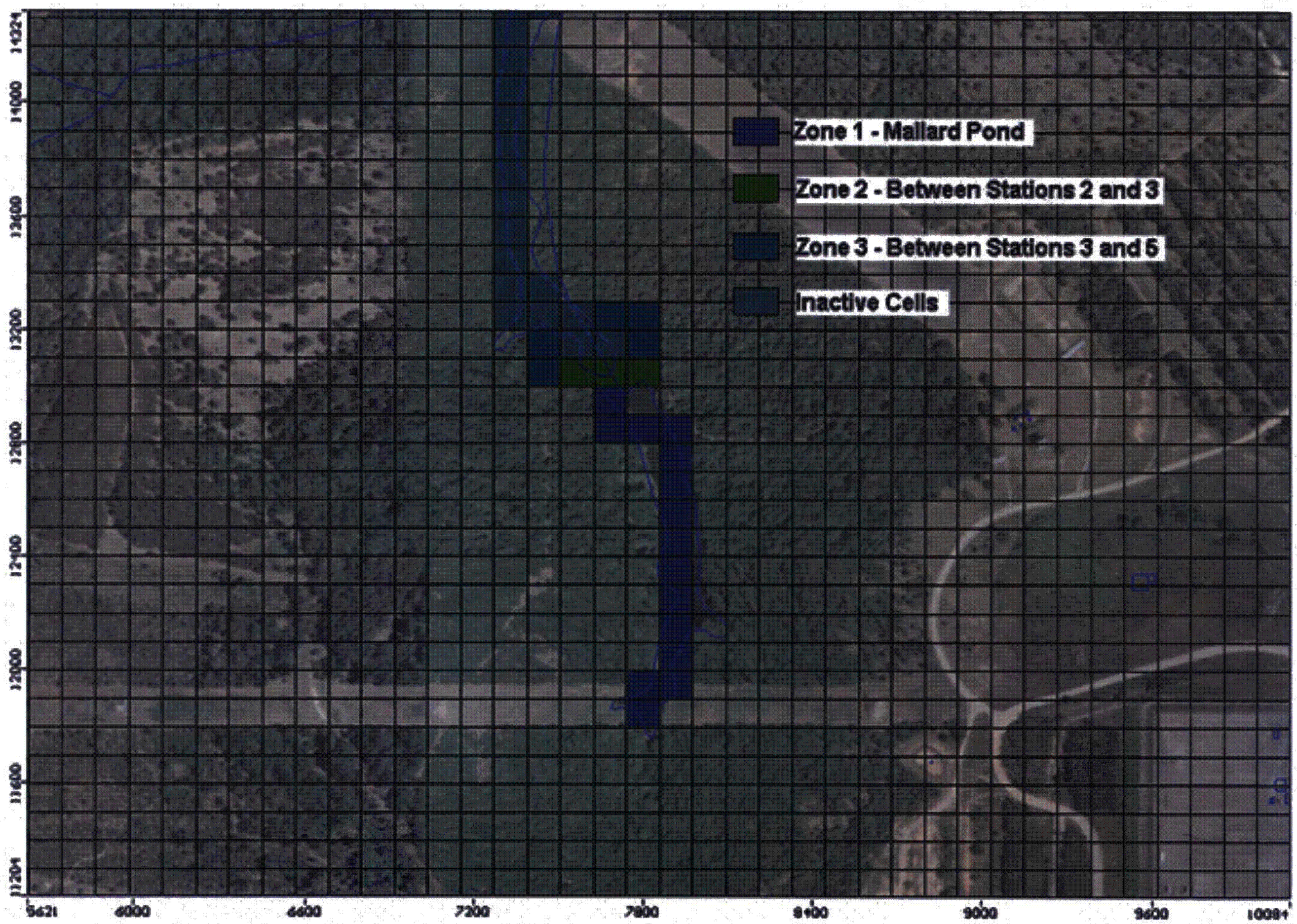


Figure 67: Zone Budget Representation of Mallard Pond and Area in Groundwater Model

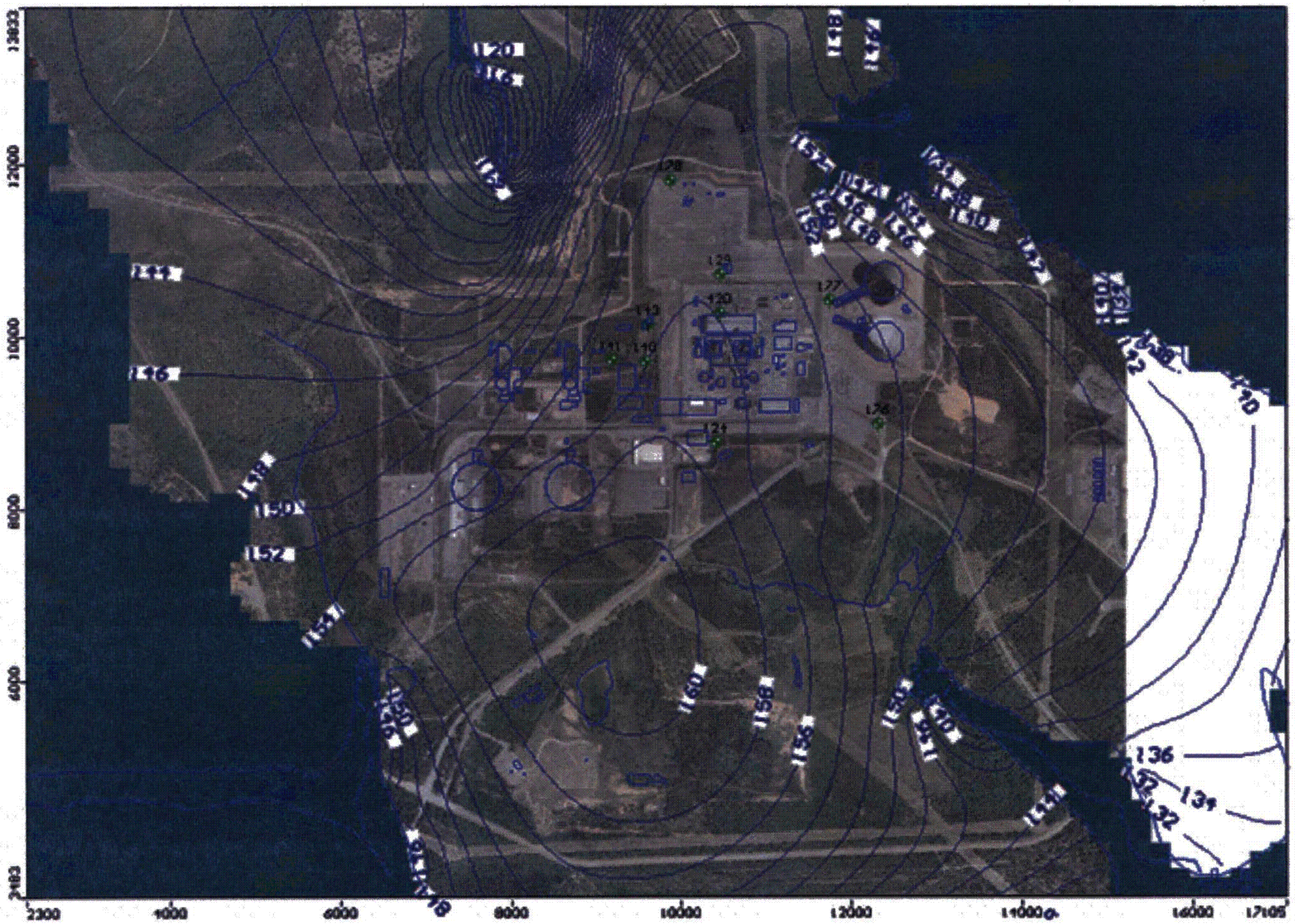


Figure 68: Simulated Water Levels for 1971 Groundwater Model

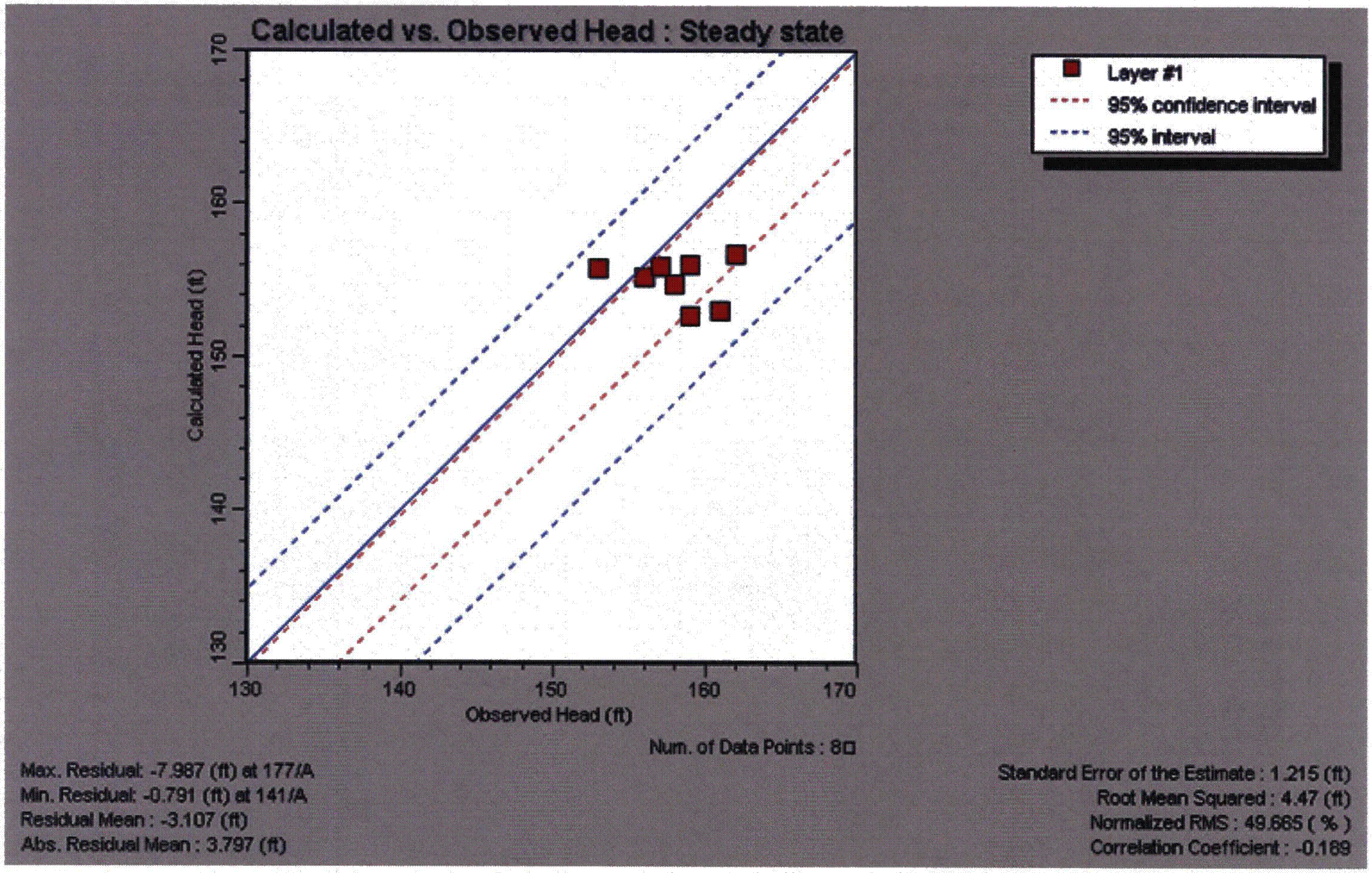


Figure 69: Simulated Vs. Observed Water Levels for 1971 Groundwater Model

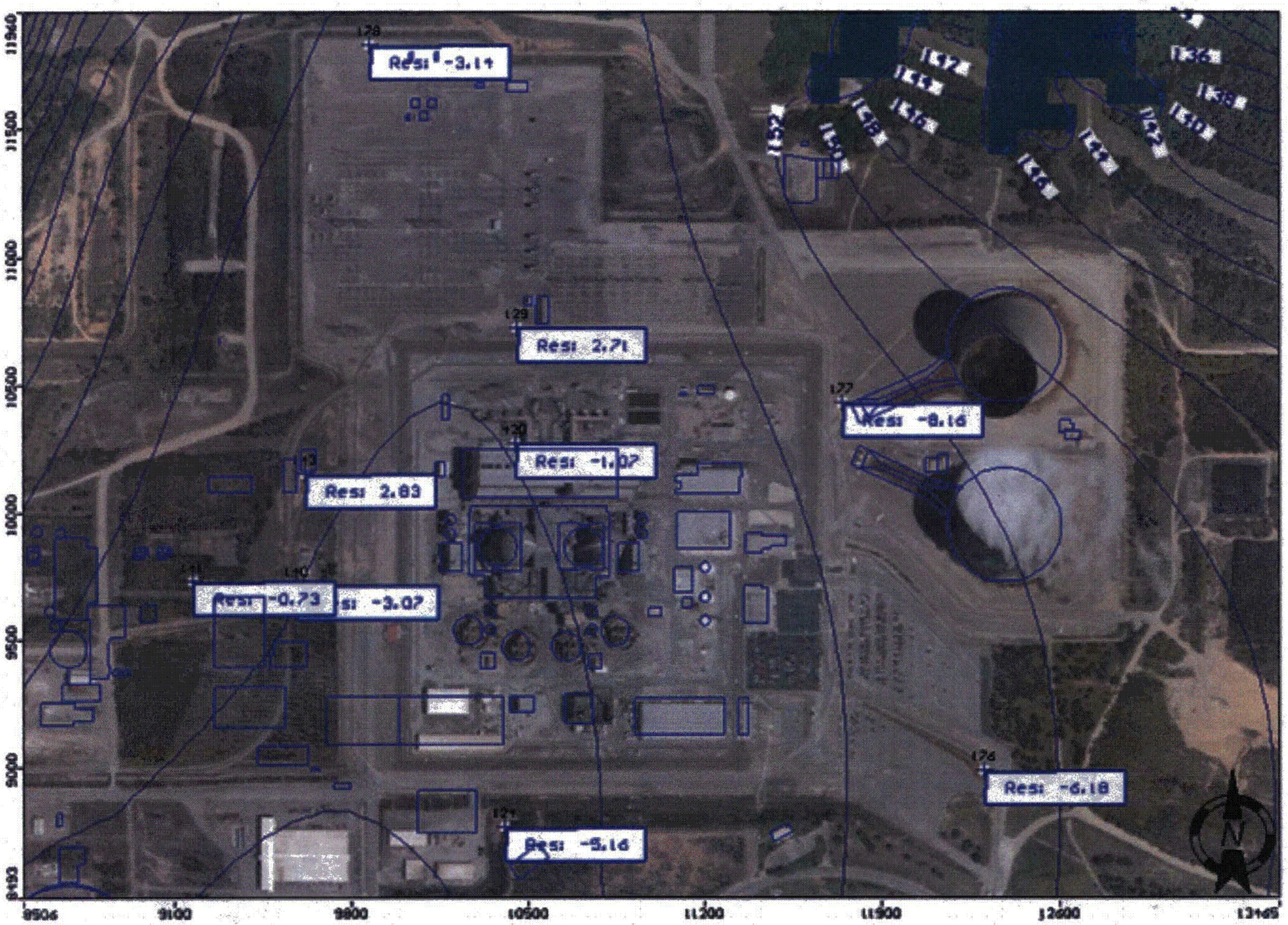


Figure 70: Estimated Residuals for 1971 Groundwater Model

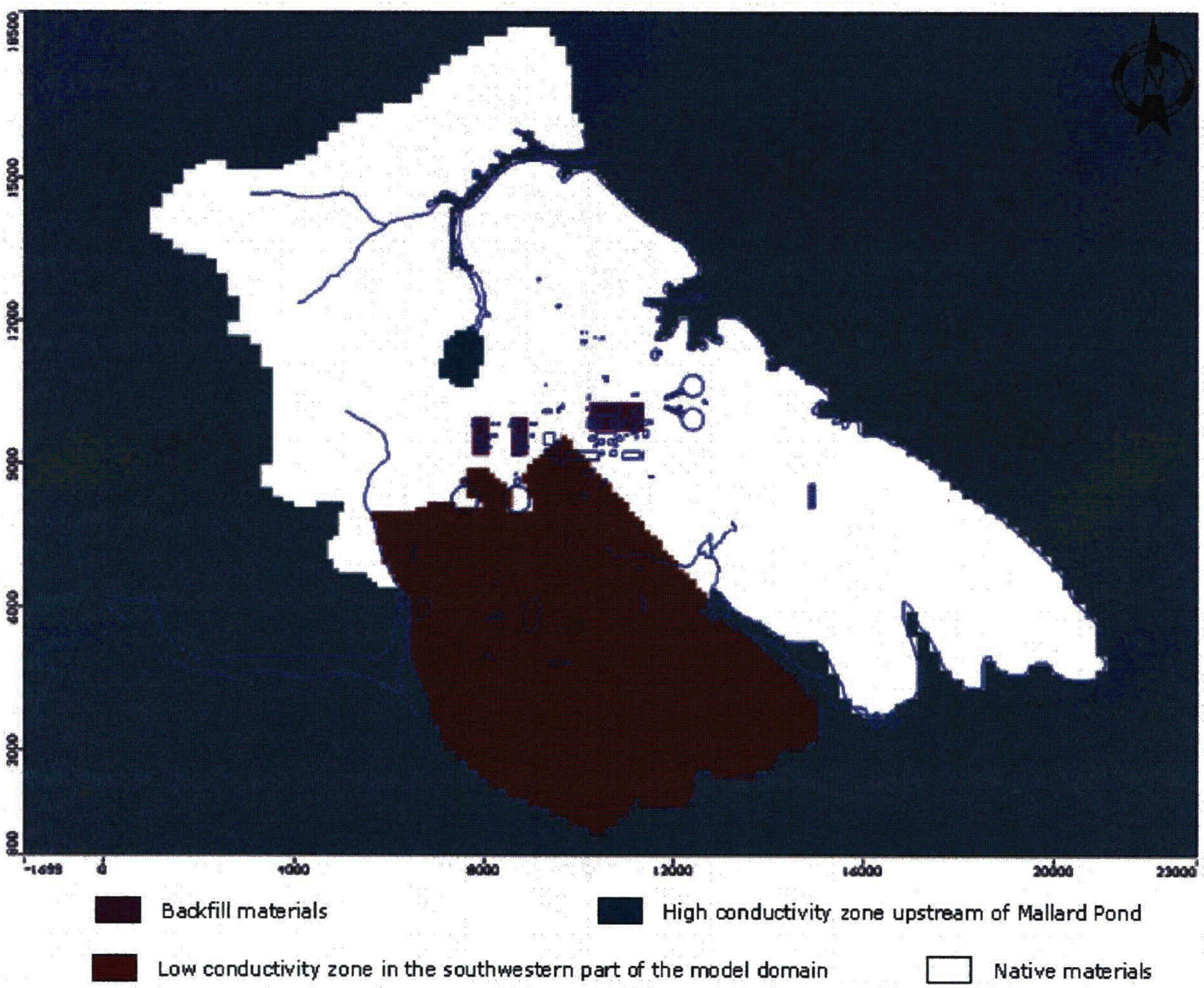


Figure 71: Hydraulic Conductivity Zones Used in Model 7 to Evaluate Post-Construction Conditions

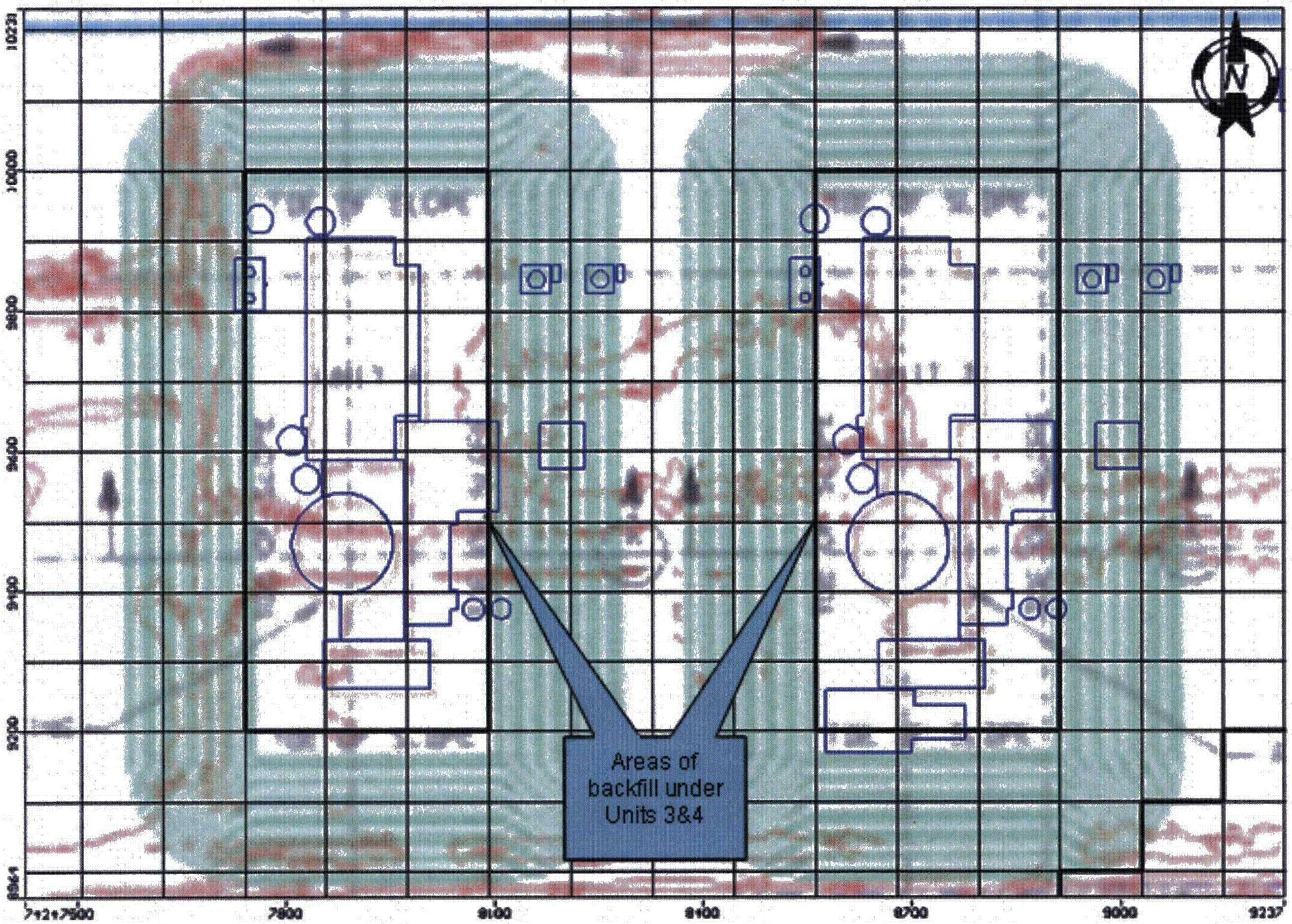
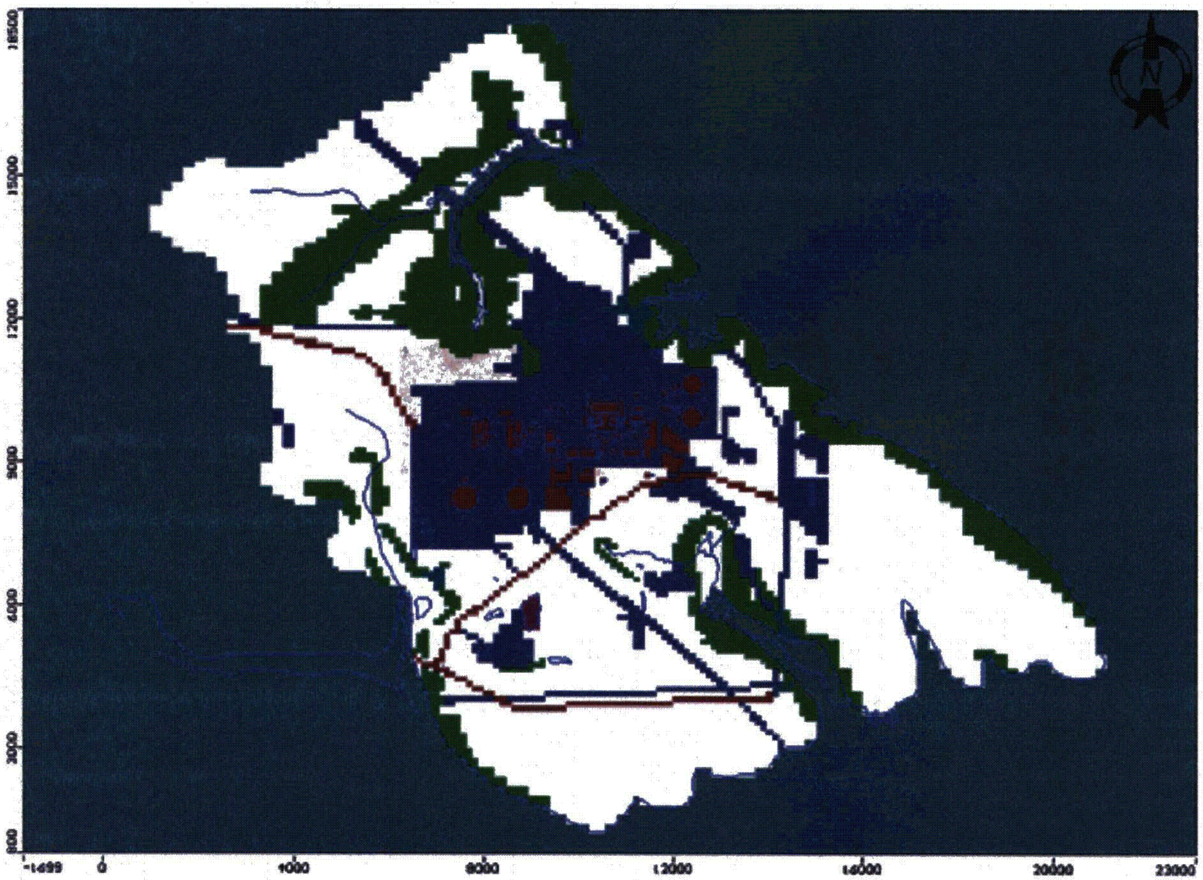


Figure 72: Excavation Plan Overlaid onto Model Grid to Show Areas of Backfill Around Units 3 & 4



Open areas on mild slopes
Open areas on steep slopes
Buildings, paved areas and areas covered with slabs
Forested areas on mild slopes
Forested areas on steep slopes
Met Tower Pond

Figure 73: Recharge Zones Used to Evaluate Post-Construction Conditions

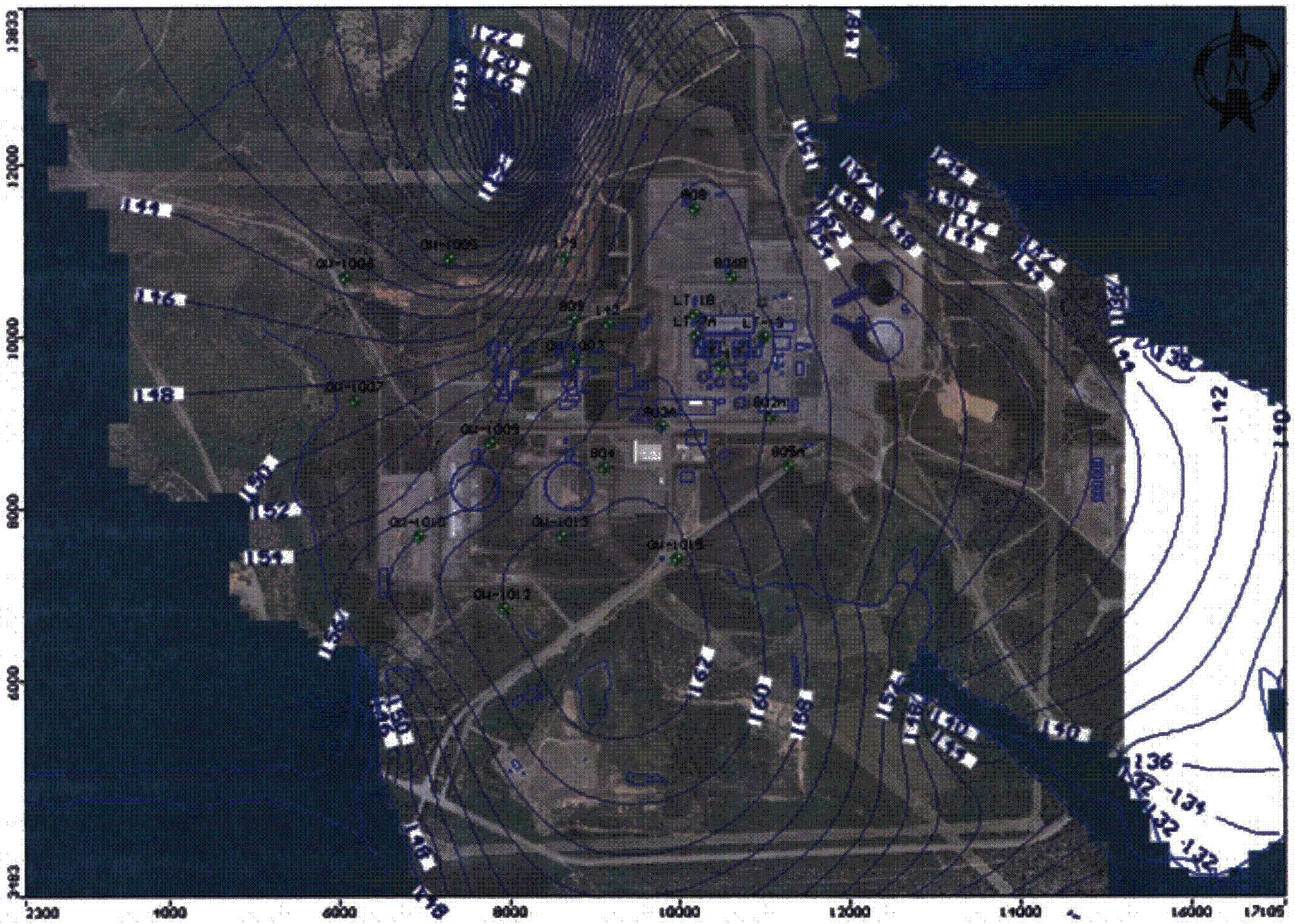


Figure 74: Simulated Water Levels for Post-Construction Conditions Obtained with Model 7 (K_1=32; K_2=100; K_3=8; K_{fill}=3.3 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

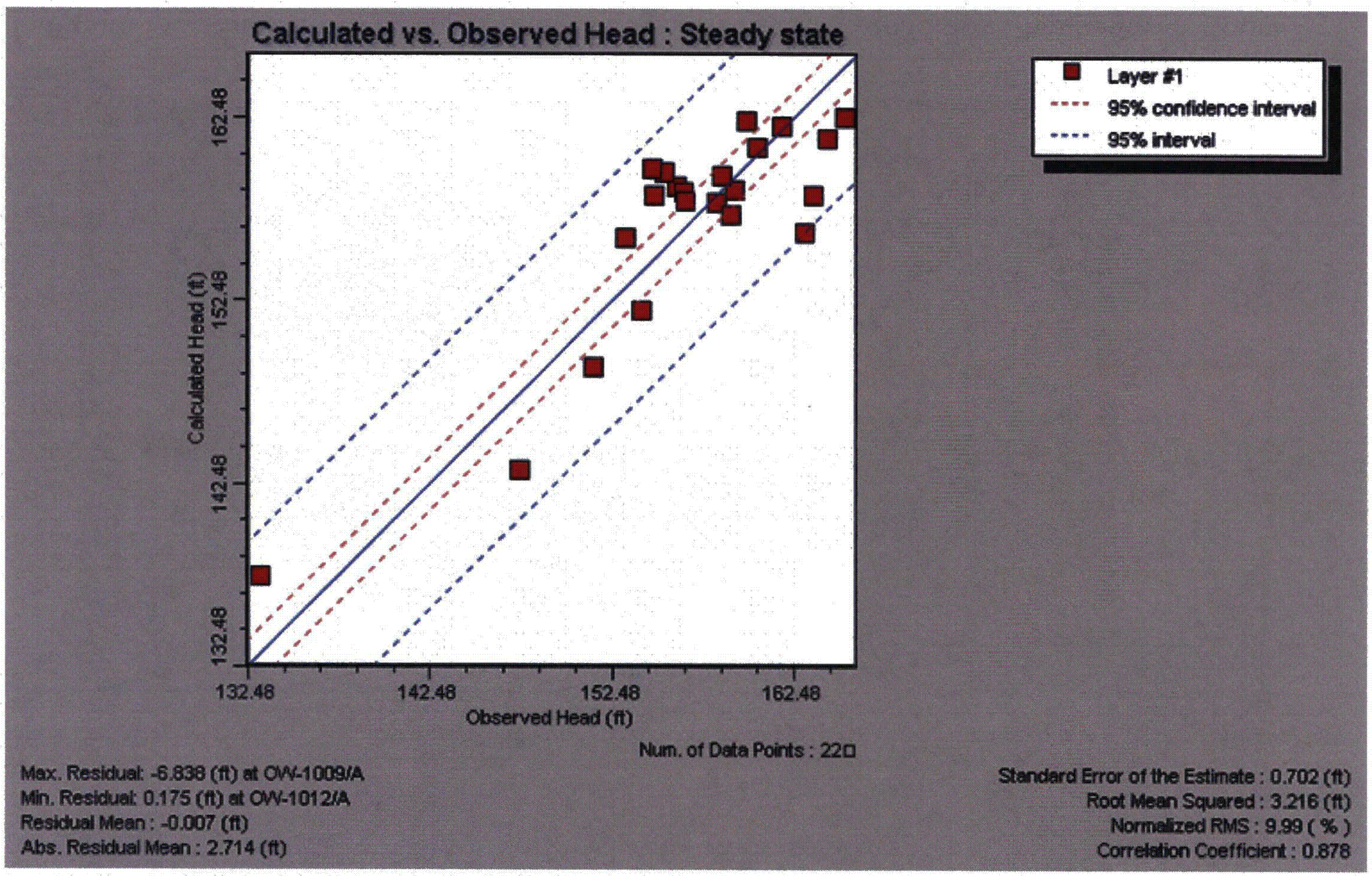


Figure 75: Simulated Water Levels with Model 7 Accounting for the Backfill Material for Units 1 & 2 as a Different Material with Hydraulic Conductivity Equal to 3.3 ft/day

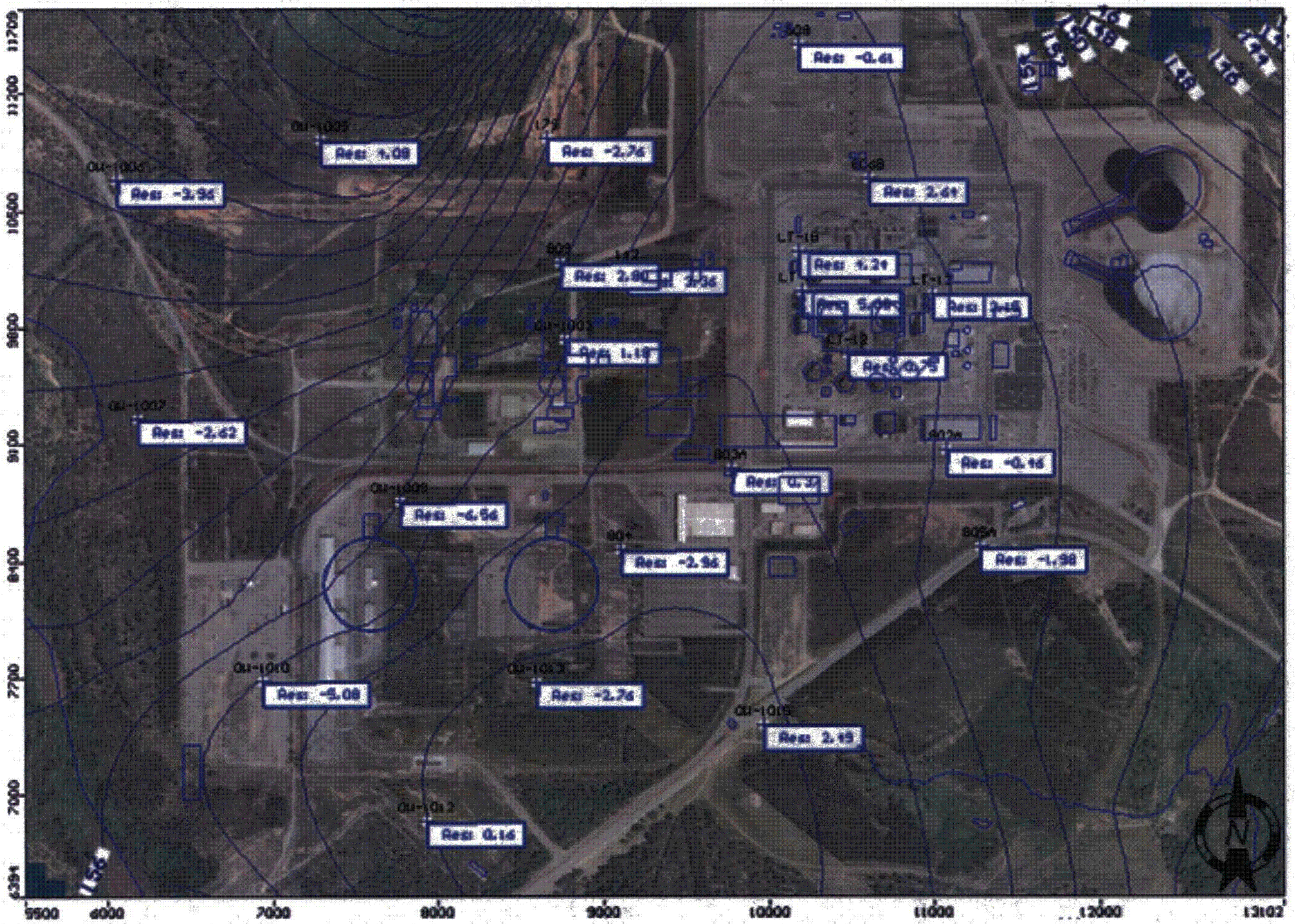


Figure 76: **Simulated Water Levels with Model 7 Accounting for the Backfill Material for Units 1 & 2 as a Different Material with Hydraulic Conductivity Equal to 3.3 ft/day**

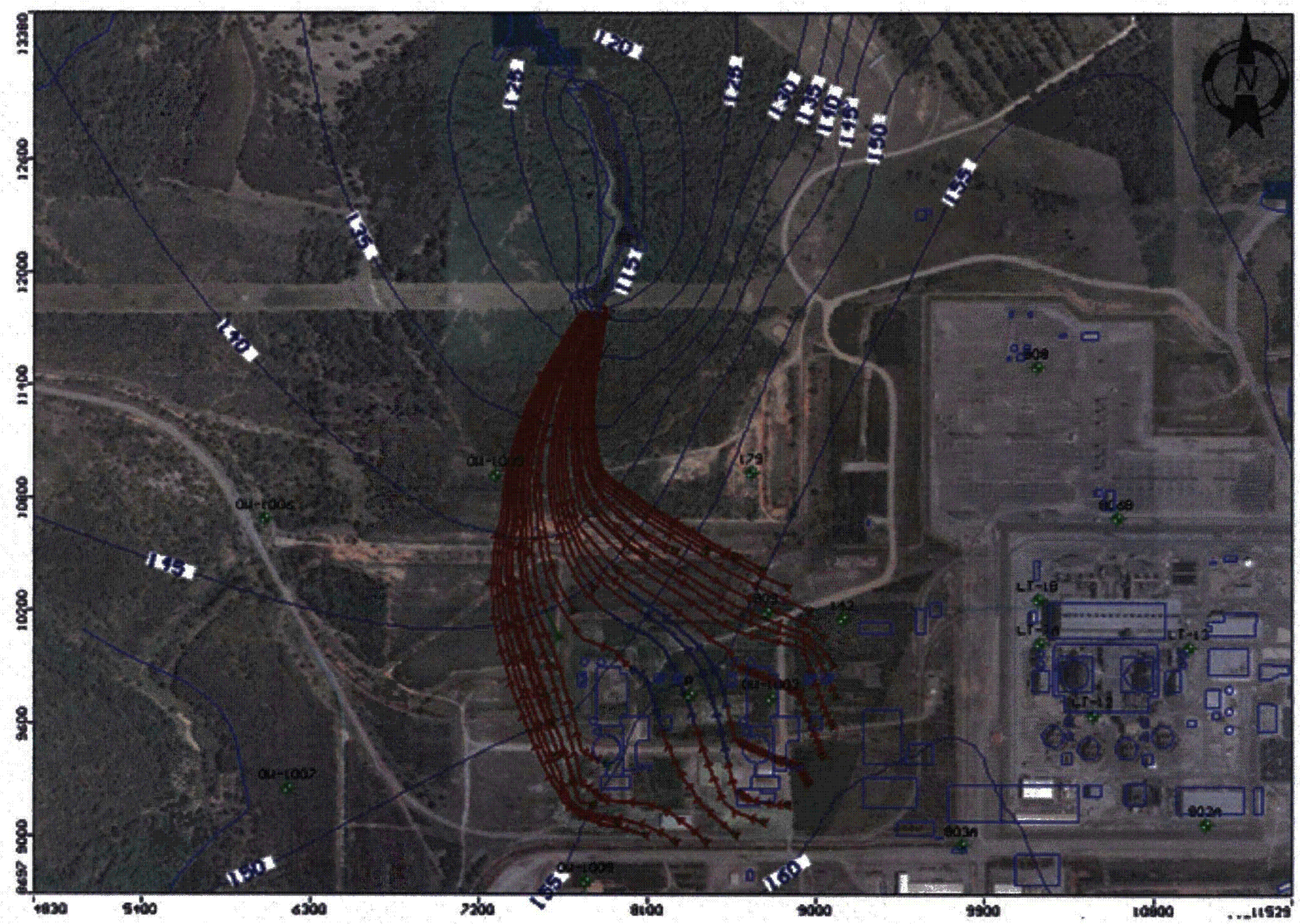


Figure 77: Simulated Water Levels and Particle Tracking for Post-Construction Conditions Obtained with Model 7 (K_1=32; K_2=100; K_3=8; K_{fill}=3.3 ft/day; R_1=10; R_2=6; R_3=6; R_4=4; R_5=0 in/yr)

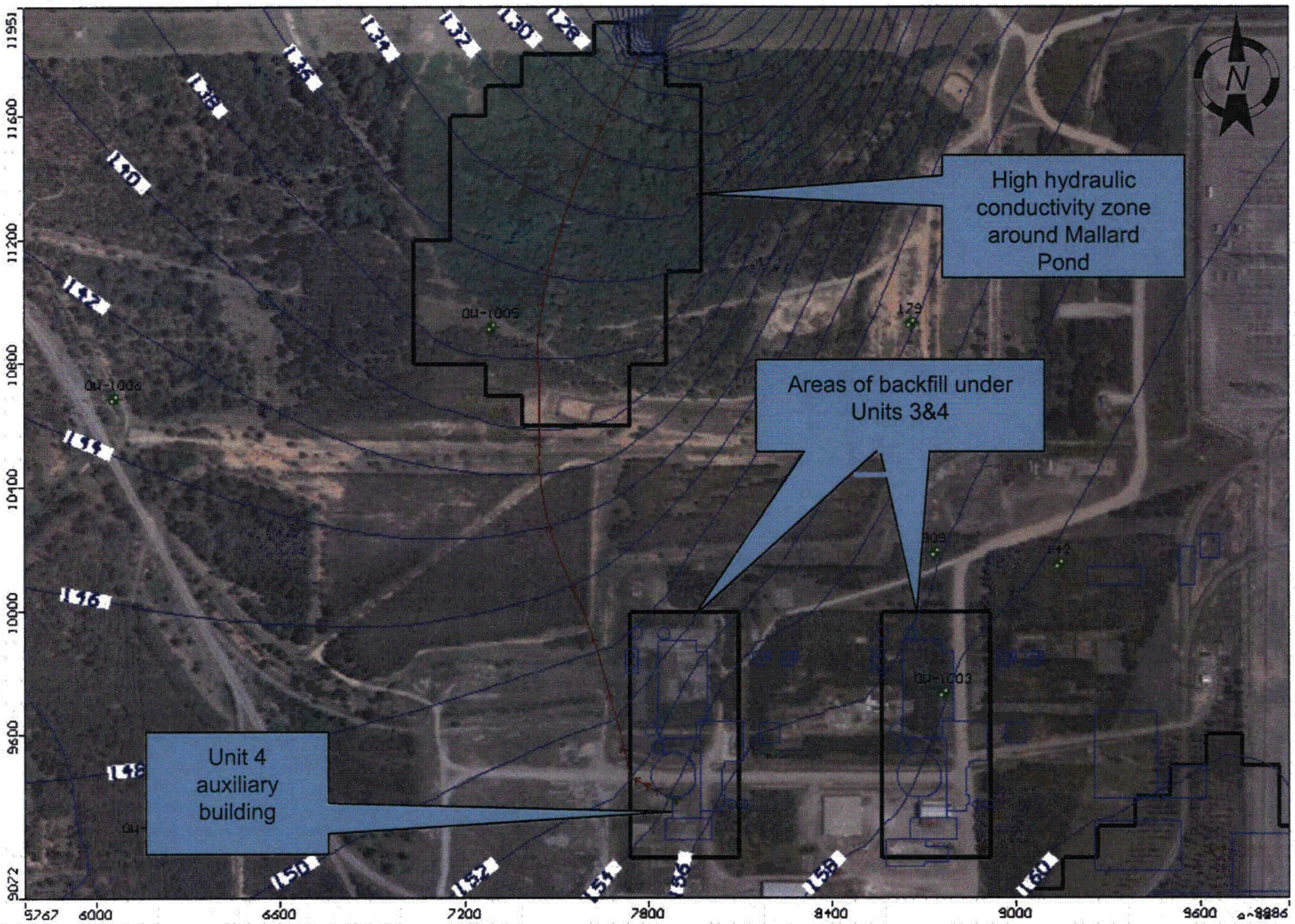


Figure 78: Pathway of Particle Released from Auxiliary Building of Unit 4

ATTACHMENT 1

Relevant Open Items

Open Item 2.4-2 in SSAR 2.4-12

The applicant should provide an improved and complete description of the current and future local hydrological conditions, including alternate conceptual models, to demonstrate that the design bases related to groundwater-induced loadings on subsurface portions of safety-related SSCs would not be exceeded. Alternatively, the applicant can provide design parameters for buoyancy evaluation of the plant structures.

Open Item 2.4-3 in SSAR 2.4-13

The NRC staff found the applicant's analysis in the SSAR to be incomplete; because it did not include consideration for the inevitable change in hydrology, and, hence, the potential changes in flow direction within the Water Table aquifer for some release locations within the protected area (PA). The applicant's analysis provided no assurance that an adequate number of combinations of release locations and feasible pathways had been considered.

Open Item 2.4-4 in SSAR 2.4-13

The NRC staff's review of the release location, migration, attenuation, and dilution of the radioactive liquid effluent inventory was incomplete because, as stated in Open Item 2.4-3, the applicant has not considered a sufficient number of alternate conceptual models to identify potential release points and pathways. Therefore, the applicant needs to specify the nearest point along each potential pathway that may be accessible to the public.

ATTACHMENT 2

NRC's Comments on the Groundwater Model

Date: 21 February 2008

To: Hosung Ahn

From: Charley Kincaid

Subject: Review of South Nuclear Company's submitted groundwater modeling of the Water Table aquifer at the VEGP Site

The following general notes and comments summarize our initial review of the modeling achieved by SNC.

General Notes and Comments:

1. Vogtle Groundwater Model installed and reviewed – per files received January 23 via e-mail message from Chris Cook, NRC. The files consist of three simulation "cases" that are described in Section 2.4.12 of the application plus two simulation variants that are not included in the document. All simulation cases have both "Existing" and "Future" variants. Thus, a total of 10 simulations were received. The cases that are not discussed in Section 2.4.12 were viewed, but not assessed in detail because of the fact that they are not described in the document. Files were generated by Visual Modflow version 4.2.0.151 (Schlumberger Water Services, Waterloo, Ontario, Canada) and were reviewed with version 4.2.0.153.
2. All simulation variants consist of a single layer model with non-uniform lateral grid spacing and a deformed grid in the vertical direction. However, based on the shapefile "map" data set for the top of Blue Bluff Marl (included in some simulation model files, such as Case 1 Existing) and the model data set representing the bottom of the Water Table aquifer, it would appear that the model does not duplicate in good fidelity the primary structural feature of the VEGP Site. It is also noted that an expected subcrop of Blue Bluff Marl above the water table to the north of VEGP Units 1 & 2 is not included in the model configuration.
3. The cases presented would appear to be a sequence of successively improved calibrations or attempts to do so. These might be described as a sequence of calibrations leading to a preferred model. However, the goal is to consider plausible alternative conceptual models that are fundamentally different than a preferred model in some way, but nonetheless consistent with the available data and observations of system behavior. The fundamental differences that should be considered are those that might influence our judgment regarding the safety of the proposed facility, (e.g., that might result in faster transport or transport in a different direction).
4. The saturated conductivity zonation represented in the cases involves a single-layer aquifer and ranges from (1) two zones (i.e., high conductivity for engineered backfill, and lower conductivity elsewhere, to (2) three zones (the third zone being one added in the immediate

vicinity of Mallard Pond), and to (3) a single layer model with the "everywhere else" zone divided in two along a line through the center of the VEGP site from southwest to northeast. Note, the latter case was provided in the files, but not used in the Rev. 3 of the application. The "Future" cases modify the hydraulic conductivity distribution by adding zones for high conductivity backfill material under reactors for Units 3 & 4. The sequence appears to be an attempt to successively improve the calibration and is not a suite of plausible alternative conceptual models.

5. The saturated conductivity assigned to the engineered fill could be conceptualized in at least two ways; (1) assigned saturated conductivity as measured and previously presented in the ER and SSAR because measurement scale and model scale (e.g., cell size) are similar, and (2) scaled saturated hydraulic conductivity to represent the hypothetical scale-up value proposed by SNC.
6. The infiltration zonation is represented in the cases with a single value for the entire model except at the post-construction areas of Units 1 & 2 (including the cooling towers), which are assigned zero recharge. However, no changes to the recharge zonation are implemented in the proposed construction zones of Units 3 & 4. Thus, the "Future" cases fail to examine alteration of recharge after construction of Units 3 & 4. One simulation variant does assign zero infiltration to areas where Units 3 & 4 reactors and cooling towers are proposed to be located, but this simulation variant is not included in the Rev 3 application. None of the alternatives examine the potential for gravel covered and essentially vegetation-free regions having substantially higher recharge than that associated with pre-construction conditions.
7. There is no discussion of model calibration in the Section 2.4.12 of the application, and there is a systematic error in each of the calibrations. All comparisons between field observations and modeled values of groundwater levels on the Mallard Pond drainage side of the model show a higher modeled value than observed value. All comparisons of groundwater levels between field observations and modeled values on the Telfair drainage side of the model show a lower modeled value than observed value. One may assess this calibration error as being conservative with respect to the direction of flow (i.e., if flow goes toward Mallard Pond even when the simulation head results in the direction of Mallard Pond are higher that the observed value, then a more correct calibration would undoubtedly flow in that direction). However, there are two problems with such an assessment. First, this systematic error in calibration is an indication that the model is not correctly conceptualized. Second, the systematic error in calibration means that the hydraulic gradient produced in the simulation is too low, and, hence, any travel time calculations will be substantially incorrect and non-conservative (i.e., the simulated travel time will be longer than the observed gradient would imply.)
8. In the three cases presented, there are model cells that go dry during the simulation. Similarly, there are cells that indicate flooding in some areas. The dry cells are in the vicinity of the expected Blue Bluff Marl outcrop above the water table, which is north of VEGP Units 1 & 2; however, the dry cells do not appear to represent the entire outcrop. Cells that go dry and those that flood are indications that the conceptual model being simulated needs to be reworked. Note also that the appearance of "dry" and "wet" cells within the simulation may indicate a misrepresentation of the structure.
9. The flow balance of the three cases is quite varied, and does not appear to represent solutions to well posed models. For example, the flow balance of Case 1 Future exhibits a

70% discrepancy, that of Case 2 Future exhibits a less than 1% discrepancy, and that of Case 3 Future exhibits a 75% discrepancy. Such information would argue against these cases being plausible alternative conceptual models of the Water Table aquifer. Note that incremental changes in starting and boundary conditions result in widely varied flow balance results, indicating an incorrect model configuration.

10. There are questions about the boundary conditions used to represent the streams in the model. The unnamed stream and Daniels Branch may be appropriately modeled by a "drain" boundary condition provided the applicant has data or knowledge of its ephemeral character. However, two other streams on the Telfair watershed side of the model appear to be spring fed (see the 1971 Water Table aquifer contour map in the FSAR of Units 1 & 2). These streams may be better represented by "river" boundary conditions, especially during a "March" or spring period of the year. Also, the location and topography of the upper reaches of the unnamed stream that feeds the Daniels Branch could be greatly improved based on local topography and would likely lead to improved calibration to nearby field observations.
11. What we want to see in plausible alternative conceptual models are models that do not violate the data, and, given the simplifications they embody, models that are arguably conservative representations of the site. The three cases presented are not plausible alternative conceptual models of the site.
12. Regarding the movement of tracer particles from the proposed VEGP Units 3 & 4, it is important to examine origins anywhere within the entire power block area. Examining start locations only in the immediate vicinity of proposed Units 3 & 4 is not adequate. The ESP assumes reactor facility locations anywhere within the power block area.
13. The model is insufficiently documented (e.g., basis for boundary conditions, calibration, sensitivity, etc.). For example, assuming calibration has been done and needs to be documented, then the accepted procedures followed to complete the calibration need to be described. This would include some quantitative assessment of the results of the calibration.
14. The model fails to consider the transient nature of the system. There needs to be a valid technical rationale for accepting a steady state model. No rationale was provided for using a steady-state model, nor for the selection of March 2006 as the appropriate observed hydraulic heads to use for calibration. Does the seasonal variation in recharge drive this aquifer system to be dynamic or transient over an annual cycle?