PHASE II - FINAL REPORT

For

Additional Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels
(Alcona & Iosco Counties, MI)

Prepared for:

Alcona-Iosco Cedar Lake Association, Inc.
P.O. Box 180
Greenbush, MI 49738

Prepared by:

KIESER & ASSOCIATES, LLC
Environmental Science & Engineering
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

September 18, 2006

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

INTRODUCTION

In July of 2005, KIESER & ASSOCIATES, LLC (K&A) completed a Phase I Study (K&A, 2005) for the Alcona-Iosco Cedar Lake Association, Inc. (AICLA) to provide an initial assessment of the hydrologic conditions influencing Cedar Lake water levels. As a follow-up to the preliminary Phase I efforts, K&A was authorized by the AICLA to further characterize manageable factors influencing lake levels and more formally identify management and/or structural solutions to help maintain lake levels during summer months. As a result, K&A is providing more detailed findings and conclusions within this Phase II Cedar Lake Report. Phase II efforts summarized in this report include:

- Data Collection
- Preliminary Groundwater Modeling
- Results
- Refined Hydraulic Mass Balance
- Lake Management Planning
- Phase III Concept Strategies
- Summary of Findings

This information is supported by figures, tables and references as follows.

DATA COLLECTION

To build upon the Phase I data collection efforts, volunteers from the AICLA provided ongoing collection and record keeping of field-measured data. These data included measurements of groundwater elevation, lake elevation and rainfall from June 2005 through May 2006. AICLA volunteers documented water level measurements from the piezometers every three to four days. Staff gage readings of lake water level were documented every one to two days, and rain gage accumulation data were documented following each rain event and/or once per week. All data were recorded on forms provided by K&A and mailed to the K&A office in Kalamazoo, Michigan each month.

Upon receiving the monthly data sent by the AICLA, K&A entered these records into an electronic database for quality control review, continuous tracking and final analysis. The data were used to generate a series of graphical illustrations that are discussed in detail in the text that follows.

The rain gage and staff gage were again placed at Site #1 during this Phase II monitoring period. Site #1 is located at the home of Mr. Dan Davenport, 4484 E. Cedar Lake Drive along the east side of the lake.

For Phase II, K&A personnel installed six additional shallow groundwater piezometers on September 12 and 13, 2005 to assist with groundwater data collection and modeling efforts. These new piezometer locations (PZ-4s, PZ-5s, PZ-6s, PZ-6s2, PZ-7s and PZ-7s2) are illustrated in Figure 1 at four additional monitoring sites:

Site #4
Mr. and Mrs. John Gurney, 4840 E. Cedar Lake Drive (along the eastern shoreline of the lake)

Site #5
Ms. Marie Goci, 6967 Lakewood Drive (at the southern end of Cedar Lake)

Site #6
Mr. Dave Allen, 7906 W. Cedar Lake Road (along the west shoreline of the lake)

Site #7
Mr. and Mrs. Mike Arsenault, 4975 W. Cedar Lake Road (along the west shoreline of the lake)

These latter two sites received two shallow piezometers (one near the lake and one away from the lake >300ft) to assist with monitoring direction of groundwater flow toward or away from the lake. Summarized information pertaining to the screened depths and top of casing elevations is provided as Table 1. All monitoring data collected by AICLA volunteers is summarized in Attachment A.

Southern Storm Sewers

K&A personnel conducted field reconnaissance of the shallow storm sewer network that exists on the southeast side of Cedar Lake on September 12, 2003 (see Figure 2). On September 13, 2005, K&A personnel visited the Iosco County Drain Commissioner's Office to discuss details these sewers. Mr. Gary Adams was able to locate drawing files illustrating the layout of these sewers servicing the entire area between the southeast corner of the lake and Lake Huron. A total of five stormsewer outfalls were noted to discharge into Lake Huron. A schematic diagram illustrating the approximate locations of these sewers is provided in Figure 3.

PRELIMINARY GROUNDWATER MODELING

K&A utilized a US Environmental Protection Agency (EPA) computer program entitled the Wellhead Analytic Element Model (WhAEM 2000) to simulate groundwater geohydrology in the vicinity of Cedar Lake. This program offers modeling of steady-state pumping wells, including the influence of hydrological boundaries, such as rivers, recharge, and no-flow contacts, by using the analytic element method. It is a database program with groundwater modeling capabilities. The program requires the use of specific regional aquifer information such as base elevation, aquifer thickness, hydraulic conductivity and porosity. After all site-specific data are defined and entered into the database a visual groundwater flow solution can be generated. The output is displayed on a computer generated groundwater contour map of equal piezometric head.

Site-Specific Model Features

Numerous site-specific model inputs were incorporated into the WhEAM model for Cedar Lake. A Geological Survey Digital Line Graph (DLG) base map was

downloaded and used to define the project area. Model inputs included data that were observed or measured by both K&A personnel and AICLA representatives during the past two years. Such data included hydraulic conductivity, porosity, average annual precipitation, monitor well elevation data, lake elevation data, creek elevation data and pumping rates on major groundwater withdrawals. A summary of the detailed data inputs used in this preliminary Cedar Lake model is provided in Attachment B.

Alcona and Iosco Regional Aquifer Data

Regional groundwater aquifer data were obtained from the searchable database provided by the Michigan Groundwater Mapping Project. The project (funded by the State of Michigan through cooperative agreement with the U.S. Geological Survey (USGS) and the MSU Institute of Water Research) offers available groundwater inventory data and GIS map viewing capabilities. Copies of the Alcona and Iosco County data summaries are provided in Attachment C.

Model Calibration and Testing

Adjustments were made to the input data to fit boundary conditions and site-specific data with actual observed groundwater and lake level elevation data collected by AICLA volunteers. A best-fit calibration of the model was conducted to relate the actual head-specified groundwater data measured from each piezometer for both September 2005 and May 2006 data. Conservative estimates were used for the Lakewood Shores (LWS) Golf Course pumping well input parameters. For example, this well was assumed to be installed in the upper forty feet of the shallow groundwater aquifer, and installed with a diameter of one foot. Other pertinent assumptions are listed in the model attributes and settings summary in Attachment B.

Hypothesis testing of the model included the following scenarios:

- Pumping vs. no pumping of LWS golf course irrigation well (using their reported use quantities)
- Pumping 3x the reported use quantity vs. pumping 10x reported use quantity
- Average annual precipitation rates vs. 7-yr minimum precipitation rate vs. 7-yr maximum precipitation rate

Model Contour Maps

Groundwater piezometric contour maps for the several different model scenarios described above in the testing section are provided in Attachment D. The following scenarios are depicted using May 2006 observed groundwater elevation and stream flow estimates:

Figure D-1: average annual precipitation and reported groundwater pumping from the golf course. Comments: very little observed change from calibration conditions of actual groundwater elevations.

Figure D-2: average annual precipitation and no groundwater pumping from the golf course. Comments: very little observed change from calibration conditions of actual groundwater elevations.

Figure D-3: average annual precipitation and 3 times reported groundwater pumping from the golf course. Comments: subtle changes are observed from calibration conditions of actual groundwater elevations.

Figure D-4: average annual precipitation and 10 times reported groundwater pumping from the golf course. Comments: subtle changes are observed from calibration conditions of actual groundwater elevations. Upper aquifer cannot support this pumping rate; the well is pumped dry with no apparent affect on nearby groundwater contours.

Figure D-5: minimum observed precipitation value (past seven years) and reported groundwater pumping from the golf course. Comments: notable changes are observed to impact regional groundwater elevations. Precipitation is the model input parameter with the greatest sensitivity.

Figure D-6: maximum observed precipitation value (past seven years) and reported groundwater pumping from the golf course. Comments: notable changes are observed to impact regional groundwater elevations. Precipitation is the model input parameter with the greatest sensitivity.

Model Results

Overall, preliminary groundwater modeling with the EPA WhAEM software reveals that the golf course irrigation does not significantly impact gradients (rate of groundwater movement) on the southwest side of Cedar Lake. Groundwater flow in that area is largely governed by the presence of Phelan Creek. Furthermore, groundwater modeling reveals that precipitation is the model input parameter with the greatest sensitivity to change.

RESULTS

Groundwater Flow Direction

Figures 4 through 11 depict observed Cedar Lake water level data with respect to each of the seven groundwater monitoring sites. All sites, except 2, 6 and 7, exhibit groundwater elevations below adjacent lake elevations confirming that drainage is moving away from the lake. Sites 2 and 7 are the only sites where shallow adjacent groundwater is observed year-round above lake elevations thus providing continuous recharge into the lake. Site 6 is very near the groundwater divide where it may still also be providing recharge to the lake, but perhaps not year-round. Continued monitoring at this site will provide further confirmation. Figure 11 depicts all seven groundwater monitoring sites on one graph. This figure further illustrates that Site 2 groundwater is well above lake elevation (providing recharge), and Sites 4 and 5 are well below the lake elevation (as southern storm sewers artificially lower the groundwater). Results from Phase II are consistent with those from Phase I.

Southern Storm Sewers

September 12, 2005, field observations confirmed that these shallow storm sewers were exhibiting characteristics similar to subsurface tile drains, since dry weather low-flows were documented. These observed dry weather flows were understood to be

associated with the storm sewer structures intercepting and redirecting groundwater. Measured dry weather flow in one of these sewers was 0.06 cubic feet per second.

King's Corner Road Culvert

Additional field reconnaissance of the storm sewer culvert beneath King's Corner Road revealed that this drainage culvert actually directs water from the northern Cedar Swamp to the south toward Phelan Creek. Original observations and field notes collected by K&A during the Phase I study suggested that flows were directed from the south to the north. This Phase II finding reveals that the road culvert has impacted the quantity of recharge to Cedar Lake during the late winter and early spring while the cedar swamp provides runoff into Cedar Lake.

Sherman, "Jones" and Phelan Creeks

Surface water flow was measured by K&A personnel on September 13, 2006 in Phelan Creek just south of the Lakewood Shores Golf Course property. The dry weather flow measured in Phelan Creek was 0.61 cubic feet per second.

Surface water flows were also measured by K&A personnel on April 10, 2006 during the later winter, early spring runoff period of the year when Sherman and "Jones" Creeks discharge into Cedar Lake. These surface water flows were measured as 4.4 cubic feet per second and 1.19 cubic feet per second, respectively. Based on local observations that these two creeks discharge from mid March through May (approx. 70 days) the contributions from Sherman Creek and "Jones" Creek (from April 2006 measurements) would amount to roughly 199 million gallons and 53 million gallons, respectively.

2004 and 2005 Lake Levels

Figure 12 presents both rain gage and staff gage data. The 2004 data collected during Phase I monitoring revealed that summer lake levels dropped 2.2 feet. Phase II monitoring data reveal that lake levels dropped 1.1 feet from June through September 2005. The observed 2005 lake level drop during the summer months was approximately 50% of the drop observed for 2004. This observation triggered further inquiry into the possible causes or related factors which may influence lake levels and perhaps provide further insight into potential lake management considerations as follows.

Precipitation, Evaporation and Lake Levels

A review of recent available rainfall records from the Harrisville NOAA weather station (#203628) reveals that from 1998 through 2004, the annual average total was 27.56 inches per year. Figure 13 depicts these annual totals. The annual precipitation totals for 2004 and 2005 only differed by 0.74 inches. However, when these same data were analyzed for the summer months each year (June through September), a different image emerges. Figure 14 illustrates that the summer totals were much less stable from year to year. The most significant example occurred during 2004 and 2005. Figure 14 reveals that the summer 2005 precipitation total (15.16 inches; nearly 4 inches above the eight-year average) was nearly twice the amount that was recorded for the 2004 summer months (7.61 inches; 4 inches below the observed eight-year average). Figure 15

illustrates average summer precipitation over the past eight years according to each individual month. K&A conducted further analyses of these data to explore the apparent correlation between precipitation, evaporation and lake levels during the summer months in 2004 and 2005.

Figure 16 illustrates a regression analysis between precipitation and evaporation monthly totals recorded from June through September 2004. These data exhibit a strong linear correlation (R^2 value = 0.9782) between the monthly totals of precipitation and evaporation. These data also reveal that even if the monthly precipitation total were zero, the monthly evaporation total would likely still be greater than three inches. In summary, since precipitation can be highly variable from one summer to another, it exhibits a greater potential to influence lake levels than evaporation (which holds more steady).

Further analyses conducted between observed monthly precipitation totals and monthly lake level drop totals suggest that a similar strong correlation exists between these two monitored parameters. Since Cedar Lake is currently a "losing" lake (i.e., external losses overshadow the inputs within the watershed, Figure 17), there will always be an observed summer lake level drop. Figure 18 depicts the apparent exponential relationship between monthly precipitation totals and monthly lake level drop. Due to the external losses, and the observed data correlation in Figures 16 and 18, the local monthly precipitation total appears to exert the single greatest influence on Cedar Lake water levels. When monthly precipitation totals are greater than approximately 3.3 inches, the lake level drop is quite subtle (i.e., the rate of loss per month). On the other hand, a significant lake level drop (rate of loss per month) is predicted by this relationship when monthly precipitation totals are less than approximately 1.8 inches. For example, when monthly precipitation totals are below approximately 1.8 inches, each external influence such as Phelan Creek, southern storm sewers, lawn water withdrawals, loss to groundwater toward Lake Huron and evaporation imparts a greater total affect on observed lake water loss. During such dry conditions, the rate of loss within Cedar Lake may range from 0.12 to 0.48 inches per day (0.84 to 3.36 inches per week).

REFINED HYDRAULIC MASS BALANCE

As part of the Phase I study for Cedar Lake, a preliminary hydraulic mass balance was presented based on the available monitoring data at that time. Since additional data have been gathered and evaluated during Phase II efforts, modifications regarding this hydraulic mass balance are appropriate.

Figure 19 presents the revised Phase I mass balance prepared by K&A based on the observed 2004 conditions and known impacts. Individual losses and estimated percentages of each loss have been revised to reflect the new 2005 findings discussed in the previous text sections. Revisions are as follows:

- Evaporation and precipitation estimates were previously considered to not cause any net effect on an annual basis, and therefore not included in the preliminary Phase I mass balance. However, due to observed summer

influences, illustrated in Figures 16 and 18, these two estimates have been included in the revised 2004 mass balance (Figure 19). The 2004 summer precipitation is estimated to reflect 53.3% of the net gains into Cedar Lake. The 2004 summer evaporation is estimated to represent 15% of the individual losses.

- Southwest Cedar Lake losses to groundwater were previously combined with assumed losses to the Lakewood Shores Golf Resort pumping well. Due to the observed, negligible impacts from any nearby golf course pumping well and measured dry weather flows in Phelan Creek, this estimate has now been reduced from 19% to 4%.
- The northeast groundwater losses toward Lake Huron were previously estimated to be 52%. Based on measured groundwater gradients and local/regional aquifer data, this estimated loss has been reduced to 33.1% of the total losses.
- The most notable change to the hydraulic mass balance was for the southern storm sewers in the Lakewood Shores residential areas along the southeast portion of Cedar Lake within Iosco County. Since these sewers were confirmed to flow during dry weather, they appear to behave similar to subsurface tile drains. The estimated summer water loss to these storm sewers was previously 10% and is now revised to reflect 39.1% of the 2004 losses.

A similar hydraulic mass balance conceptual illustration of the summer 2005 recreational season is provided in Figure 20. The most notable difference between the 2004 and 2005 mass balance estimates is the apparent precipitation influence on water loss. In 2004, the lake level dropped approximately 2.2 feet (805 million gallons) with 7.6 inches of recorded rainfall. However in 2005, the lake level dropped approximately 1.1 feet (402 million gallons) with nearly 15.2 inches of recorded rainfall.

Land Use and Creek Flows

Although reduced surface water flows from the two observed creeks in the northwest recharge area of Cedar Lake, Sherman Creek and "Jones" Creek, flowing from late winter through late spring, appear to be important sources of water volume during periods of intermittent flow. These two creeks originate in the large wetlands/cedar swamp complex in the drainage area northwest of Cedar Lake.

Recent fisheries data from the Michigan Department of Natural Resources (DNR) collected from Cedar Lake in 2000 suggest a diverse fishery including black crappie, bluegill, pumpkinseed, largemouth bass, northern pike, rock bass, smallmouth bass, tiger musky walleye and yellow perch. Information provided by nearby, long-time residents and local agency officials suggest that both Sherman Creek and "Jones" Creek once discharged to Cedar Lake much longer into the summer months before becoming dry. Early spring spawning runs of pike were also observed annually, so much so that fish were frequently observed in inundated roadside ditches adjacent to these streams. Recent AICLA observations in spring 2006 confirmed the presence of spawning pike in Sherman Creek west of West Cedar Lake Road. According to township officials, drainage modifications by county road commissions in the 1980s appear to have substantially

lowered the groundwater table in the nearby drainage areas of these creeks such that flows are now limited to select times of the year (primarily late March through May). Since these hydrologic modifications, there have not been reports of significant pike spawning runs as were once commonly noted.

Changes in land use within a watershed can impart a significant influence on the drainage patterns, quality and quantity of runoff generated. Figures 21 and 22 represent historic 1800 and recent 2001 land use maps (respectively) for the areas surrounding Cedar Lake. The historic 1800 land use image depicts the majority of the surrounding areas to be approximately 54% swamp/marsh. The recent 2001 land use image depicts similar lowland/wetland areas to be only 28%.

Perhaps the most recent changes near the corner of King's Corner Road illustrate just how quickly development activities can take place. Figures 23 and 24 present field reconnaissance photos from August 2004 and April 2006 (respectively) of the area immediately north of King's Corner Road and west of W. Cedar Lake Rd. As previously stated in this report, the county road culvert beneath King's Corner Road directs surface drainage from the cedar swamp area on the north side of the road toward the Phelan Creek drainage area on the south side of the road. The aforementioned drainage would otherwise be directed to Cedar Lake via Sherman Creek or infiltrated and enter Cedar Lake more slowly via groundwater recharge. Figure 24 illustrates how this area (formerly the headwaters of Sherman Creek) was recently cleared of nearly all the mature vegetation in hopes of future development. Such change in land use reflects a very real and striking example of the pressure that has been, and continues to be, placed on the limited area of recharge located northwest of Cedar Lake. Furthermore, such change in land use demonstrates the importance of, and the need for, a comprehensive watershed management planning process to restore and/or protect Cedar Lake recharge resources.

LAKE MANAGEMENT PLANNING

MDEQ Planning Grant Application

In March of 2006, K&A provided assistance to the AICLA with the preparation of an MDEQ Planning Grant Application for Cedar Lake. Based on variety of historic and recent studies, the following water quality and resource concerns were identified within the grant application submitted to MDEQ:

- Evidence of worsening seasonal lake level declines,
- Loss of tributary flows and spawning habitat due to roadway construction and culvert placement,
- Long-term impacts of septic system loads,
- Concentration of in-lake and added pollutants with significant seasonal loss of lake volume,
- Exotic plant growth invasions (e.g., Eurasian milfoil),
- Reduced recreational value with shrinking water depths,
- Increased disturbance and resuspension of anaerobic sediments,
- Reduced functional aquatic habitat in shoreline areas,

- Previous development activities that resulted in groundwater diversions away from the lake,
- Significant development pressures on the limited area of recharge to the northwest of the lake, and
- The lack of a scientific understanding and cohesive plan to address water resource needs and opportunities.

It is this final issue that has sparked a new interest and related efforts to pursue the development of a watershed management plan (WMP).

Project Partners

Efforts to form a project Steering Committee were initiated by the AICLA in early fall of 2005 to discuss watershed management planning efforts. Steering Committee participants have formally met twice since then and have expressed interest in becoming more involved in ongoing watershed planning efforts. These partners include:

- Greenbush Township
- Alcona Conservation District
- Iosco County Drain Commissioner
- Charter Township of Oscoda
- Iosco Conservation District
- Lakewood Shores Property Owner's Association, Inc.
- Alcona County Road Commission
- Alcona County Board of Commissioners
- Alcona-Iosco Cedar Lake Association, Inc. (AICLA)
- Kieser & Associates, LLC
- Stevan Sendel, Fisheries Biologist (DNR, Grayling)

There is a broad-based representation of the local townships, county agencies and state interests. Many of those noted above serve on the current lake board that addresses nuisance weed management on Cedar Lake. Township and county representatives have assessment and planning authority, both of which have been recognized by these agencies as necessary to restore and/or protect Cedar Lake resources.

The Steering Committee will continue to meet on a quarterly basis to begin discussions regarding current water level study efforts and next steps to formulate policy, ordinances and other strategies to protect and restore Cedar Lake resources through a WMP process. These meetings are viewed as a critical means to comprehensively understand and address the range of needs for such desires. Steering committee participants have broadly recognized the benefits of developing and implementing a WMP for Cedar Lake. Several issues have drawn the acute attention of these stakeholders, prompting the recognition of and immediate need for effective management. For example, Greenbush Township, with significant reliance on the tax base associated with Cedar Lake, views these water quality and water level issues as an immediate call to action.

Diversion of groundwater away from Cedar Lake is largely impacting this shallow lake through reduced shoreline aquatic habitat, concentrating in-lake and limited external pollutant loads, eliminating high quality ephemeral streams and impeding recreational uses. A unique opportunity exists to meld inextricably linked issues of water quality and quantity in a local setting that is highly manageable. A Cedar Lake Watershed Management Plan would address one of the pressing issues for the 21st century in the Great Lakes Basin, i.e., increased water demand/water withdrawals and the resulting impact on water resources.

Elements of an approvable Watershed Management Plan include:

- Steering Committee (Stakeholder) process
- Background information collection & evaluation
- Drainage basin characterization
- Identification of critical areas/needs
- Prioritization of concerns
- Identification of improvement/restoration options
- Information dissemination & communication
- Public education/participation
- Watershed Management Plan Development
- Reporting

Possible goals and objectives might include:

1. Protect remaining natural features of the watershed through planning, education and zoning.
2. Protect groundwater recharge via planning, zoning, and wetland protection/restoration.
3. Maintain biologically/recreationally appropriate lake levels.
4. Enhance recreational uses of the lake by reducing and managing sediment accumulations.
5. Improve fisheries by: a) determining data gaps; b) identifying natural habitat needs; c) evaluating stocking options; and, d) restoring stream spawning habitat.
6. Develop a sustainable and ongoing educational program for lake management education.

PHASE III CONCEPT STRATEGIES

Cedar Swamp/King's Corner

Most of the conceptual strategies presented herein can be contemplated within the context of the watershed management planning process. Emphasis should be placed on discussions regarding current water level study efforts and next steps to formulate policy, ordinances and other strategies to protect and restore Cedar Lake resources through a comprehensive collaborative Steering Committee process that includes as many local

stakeholders as possible. Initial strategies to be explored future options for the Cedar Lake recharge area might include the following:

1. Groundwater/wetland protection policies for recharge (WMP)
2. Explore interest in land swap opportunities with the State (WMP)
3. Eliminate King's Corner culvert – extended retention in swamp (WMP)
4. Sherman Cr. restoration - extended flow period/volume (WMP)
5. "Jones" Cr. modification - extended flow period/volume (WMP)
6. Possible Phelan Cr. surface water low-flow diversion below golf course (Iosco County Drain Commissioner)

Costs to develop and refine the scientific understanding and cohesive plan to address interrelated water resource needs and opportunities may range from $50,000 to $70,000. Funding for such expenses might come from state planning grants or local fund-raising efforts. Costs related to the implementation of creek restoration and/or modification concepts might range from $50,000 to $150,000. State implementation grant funds or perhaps township tax assessments might provide assistance in these regards. Such restoration activities could greatly impact the need for potential further augmentation.

Lake Level Augmentation

The concept of lake level augmentation for Cedar Lake during the summer months provides a great deal of practical validity to assist with maintaining biologically/recreationally appropriate lake levels. Based on the Phase II observed relationships between observed lake elevation drop and monthly precipitation during the summer recreational season, some preliminary concepts emerge for future consideration.

Figure 25 presents a simple comparison of observed lake elevation drop (as measured by AICLA volunteers using an in-lake staff gage) and calculated elevation drop (as data within Figure 18 provide a means of calculating elevation drop using measured monthly precipitation values). Management tools such as this example might offer decision-making assistance regarding augmentation needs.

Another example of a decision-making management tool is provided in Figure 26. This illustration links Cedar Lake observed monthly precipitation and lake elevation drop data with estimated augmentation volumes required to offset lake elevation drop. On the left side of the graph, the precipitation and recharge into the lake are less adequate to keep up with the many losses which influence Cedar Lake. During these conditions, estimated higher augmentation volumes are needed to compensate for the rate of water loss. As precipitation and recharge increase toward the right side of the graph, estimated augmentation volumes are lower due to the greater amount of precipitation and recharge which better counterbalance the rate of water loss.

Conceptual strategies related to the exploration and feasibility of lake level augmentation might include the following:

1. Lake Level Augmentation Feasibility (*Phase III* – Lake Assoc.)
   - Source (GW, surface water) - Location
   - Amount/timing - Impacts assessment
   - Preliminary engineering - Costing (construction/O&M)
   - Legalities/responsibilities

   If deemed feasible, then…

   - Final engineering - Permitting
   - Bidding - Installation & operation

Potential costs associated with implementation of an augmentation strategy for Cedar Lake are estimated to range from $150,000 - $265,000 and might include:

a) Feasibility study of augmentation wells with limited a hydrogeological investigation and test wells (if needed) ~$30,000 - $80,000.
b) Final Engineering & Permitting ~$25,000
c) Construction of up to two wells ~$60,000 - $80,000.
d) Pumps (for local Sherman Creek and "Jones" Creek headwater discharge and no pipes to lake): ~$30,000 - $70,000.
e) Annual O&M ~$5,000 - $10,000.

SUMMARY OF FINDINGS

- Since surficial recharge flows to Cedar Lake are limited to late March through May, local precipitation during the June through September summer months greatly influences the rate of water loss from the lake.
- Storm sewers in Iosco County (on the southeast side of Cedar Lake) have a greater impact on water loss than originally estimated in the Phase I study. Groundwater loss to these sewers is estimated to amount to approximately 39% to 44% of the total water loss. (Groundwater elevations and lake level elevations are observed to decrease from north to south.)
- Lakewood Shores Golf Course groundwater irrigation pumping exerts limited (if any) impact on the water loss from the southwest side of Cedar Lake. (Phelan Creek exerts the predominant impact on groundwater flow in this area.)
- The King's Corner road culvert diverts surface water from the northern cedar swamp area toward the south into the Phelan Creek drainage area. A portion of surface flows that would presumably be routed into Cedar Lake, via Sherman Creek, are instead directed toward Van Etten Lake.
- Previous and current development pressures on the Cedar Lake recharge area to the west-northwest have resulted in surface and groundwater diversions away from the lake. Emphasis should be placed on strategies to protect and restore Cedar Lake resources through a comprehensive collaborative Steering Committee process that includes as many local stakeholders as possible.
- A strong relationship exists within the measured data to between monthly precipitation and monthly lake level water loss from June through September. These data suggest that long-term management of lake levels might be

possible by monitoring precipitation and providing supplemental recharge into the lake with an augmentation of restored surface flows and/or deep groundwater withdrawal.

REFERENCES

KIESER & ASSOCIATES, LLC. *Phase I Final Report for the Preliminary Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels.* Prepared for Alcona-Iosco Cedar Lake Association, Inc. July 15, 2005.

The Michigan Groundwater Mapping Project. U.S. Geological Survey (USGS) and the MSU Institute of Water Research. http://gwmap.rsgis.msu.edu/start.htm

Site #1
Dan/Gloria Davenport
4484 E. Cedar Lake Dr.
739-8463

Site #2
Ray/Jan Mackmin
3481 W. Cedar Lake Rd.
739-7374

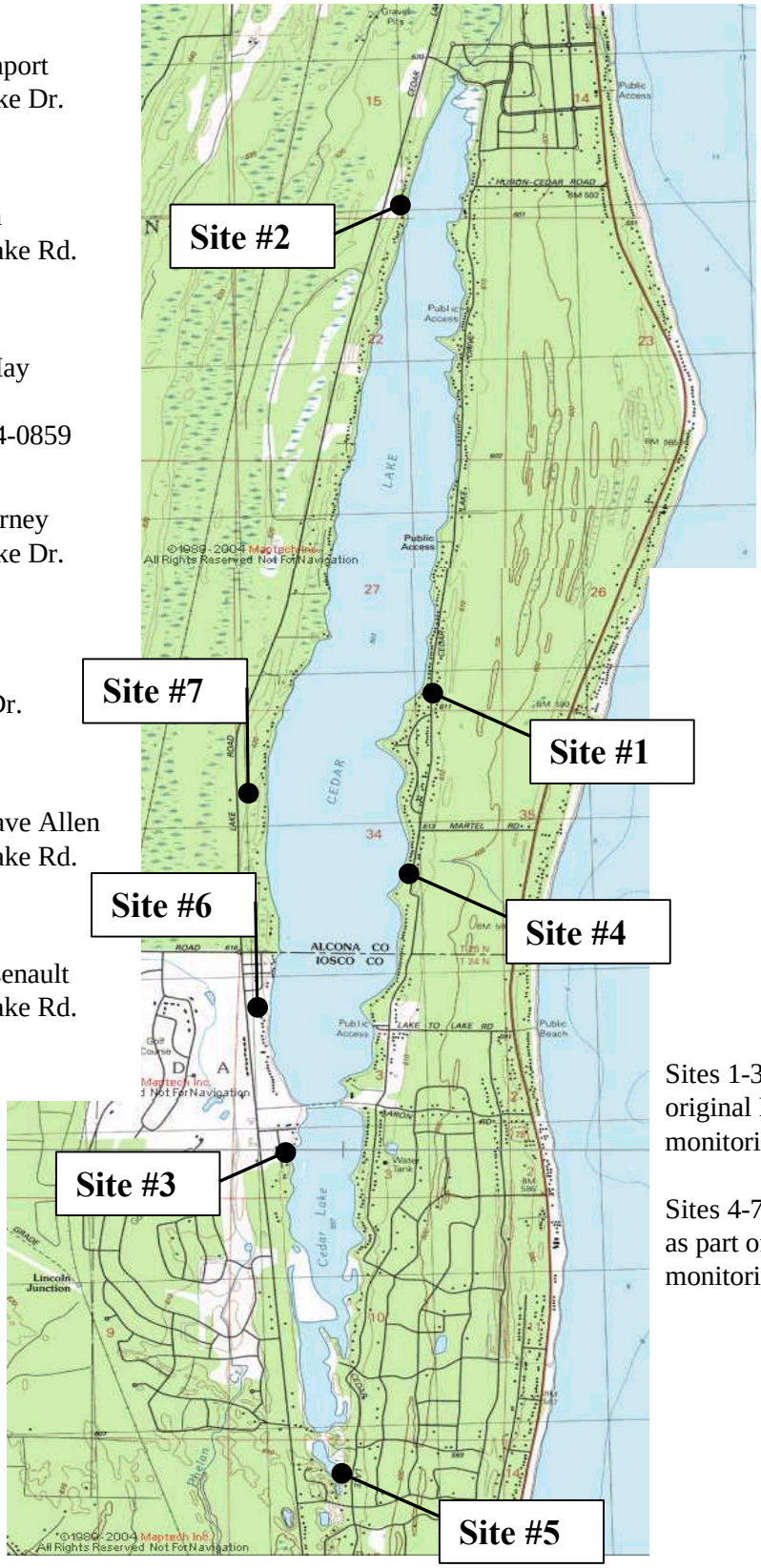
Site #3
William/Donna May
7588 Teal
739-5766/734-464-0859

Site #4
John/Evaughn Gurney
4840 E. Cedar Lake Dr.
739-3914

Site #5
Marie Goci
6967 Lakewood Dr.
739-7247

Site #6
Carolyn Byron/Dave Allen
7906 W. Cedar Lake Rd.
739-3472

Site #7
Mike/Jennifer Arsenault
4795 W. Cedar Lake Rd.
739-7544
248-844-9294



Sites 1-3 were original Phase I monitoring locations.

Sites 4-7 were added as part of Phase II monitoring efforts.

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Sitemap of seven groundwater monitoring sites located around the perimeter of Cedar Lake.

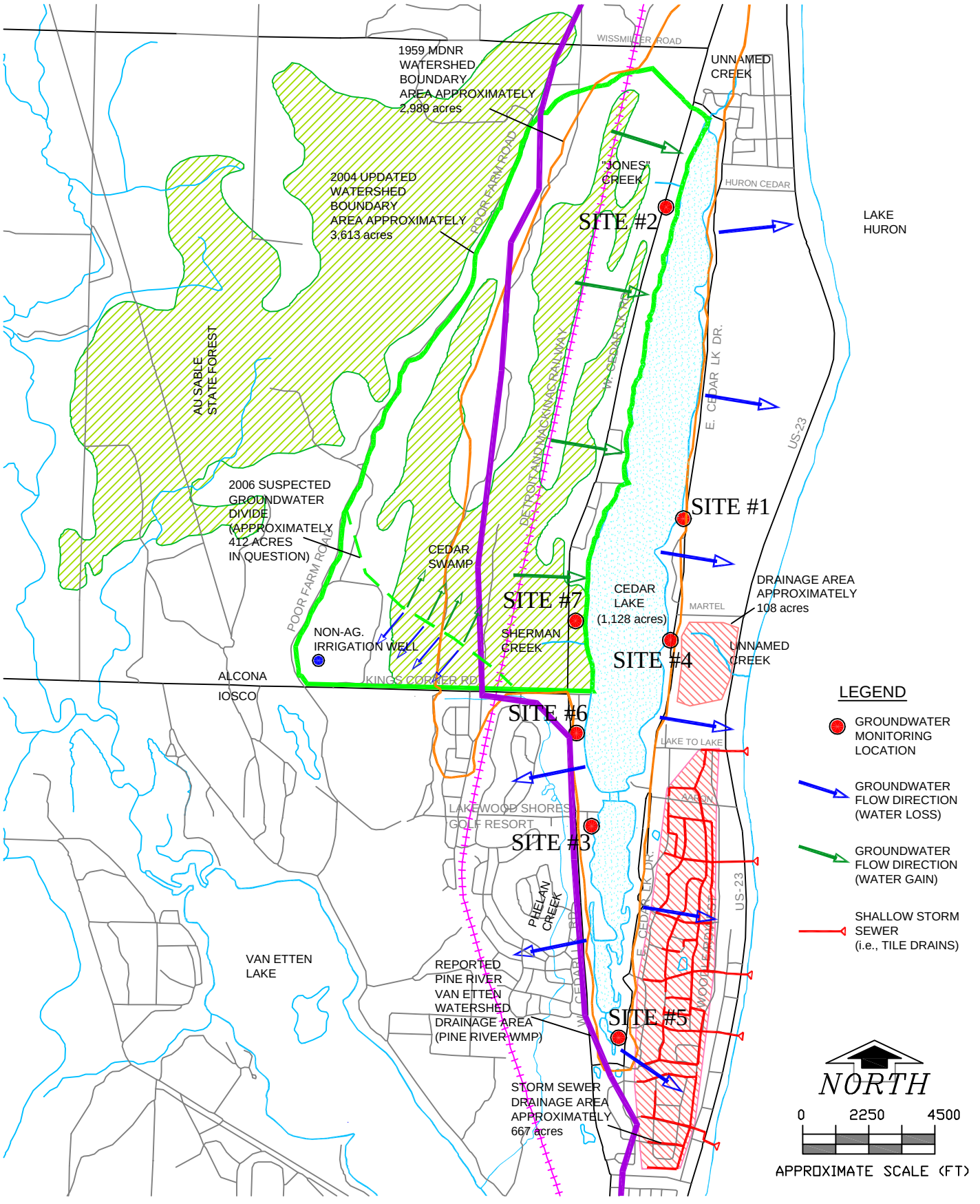
FIGURE 1

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Field reconnaissance photos of storm sewers located southeast of Cedar Lake, September 12 and 13, 2005.

FIGURE
2

DRAWN BY: KBB CHECKED BY: MSK REVISED:

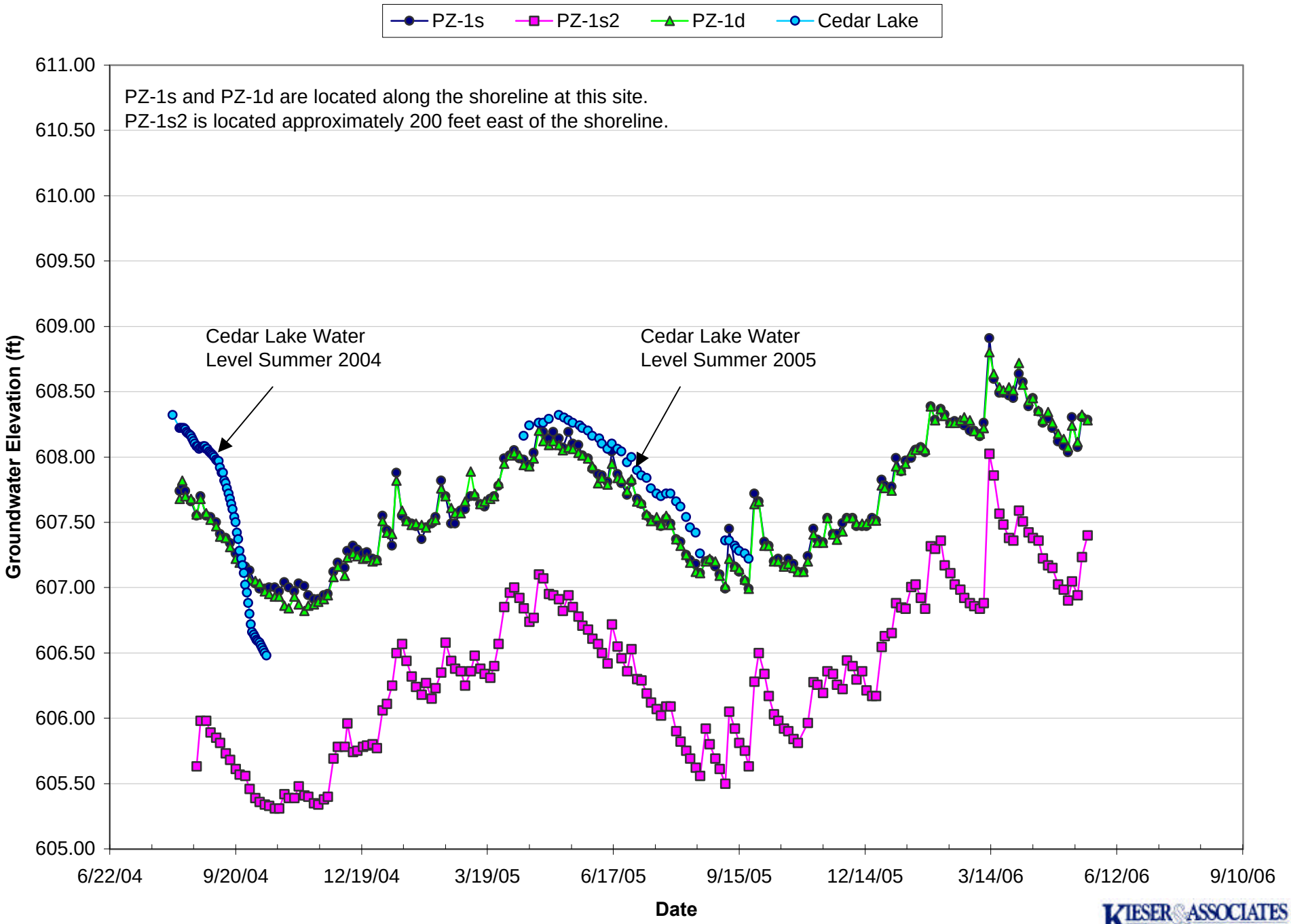


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. MICHIGAN AVE., SUITE. 300, KALAMAZOO, MI 49007
Phone: (269) 344-7117 Fax: (269) 344-2493

SITEMAP OF EXISTING FEATURES AND MONITORING LOCATIONS SURROUNDING CEDAR LAKE.

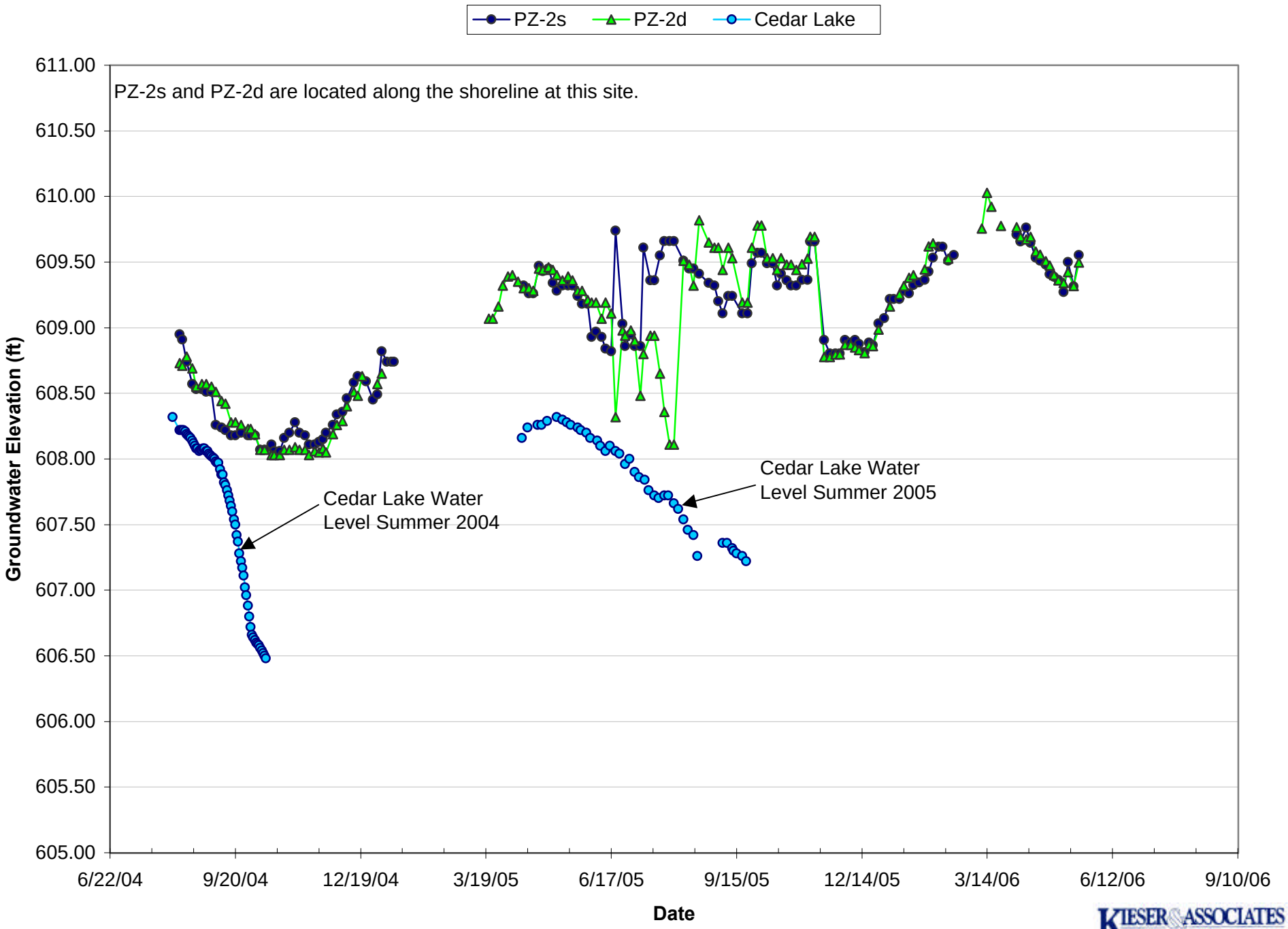
FIGURE 3

Figure 4. Cedar Lake Groundwater Elevations at Site #1
(east side of lake)



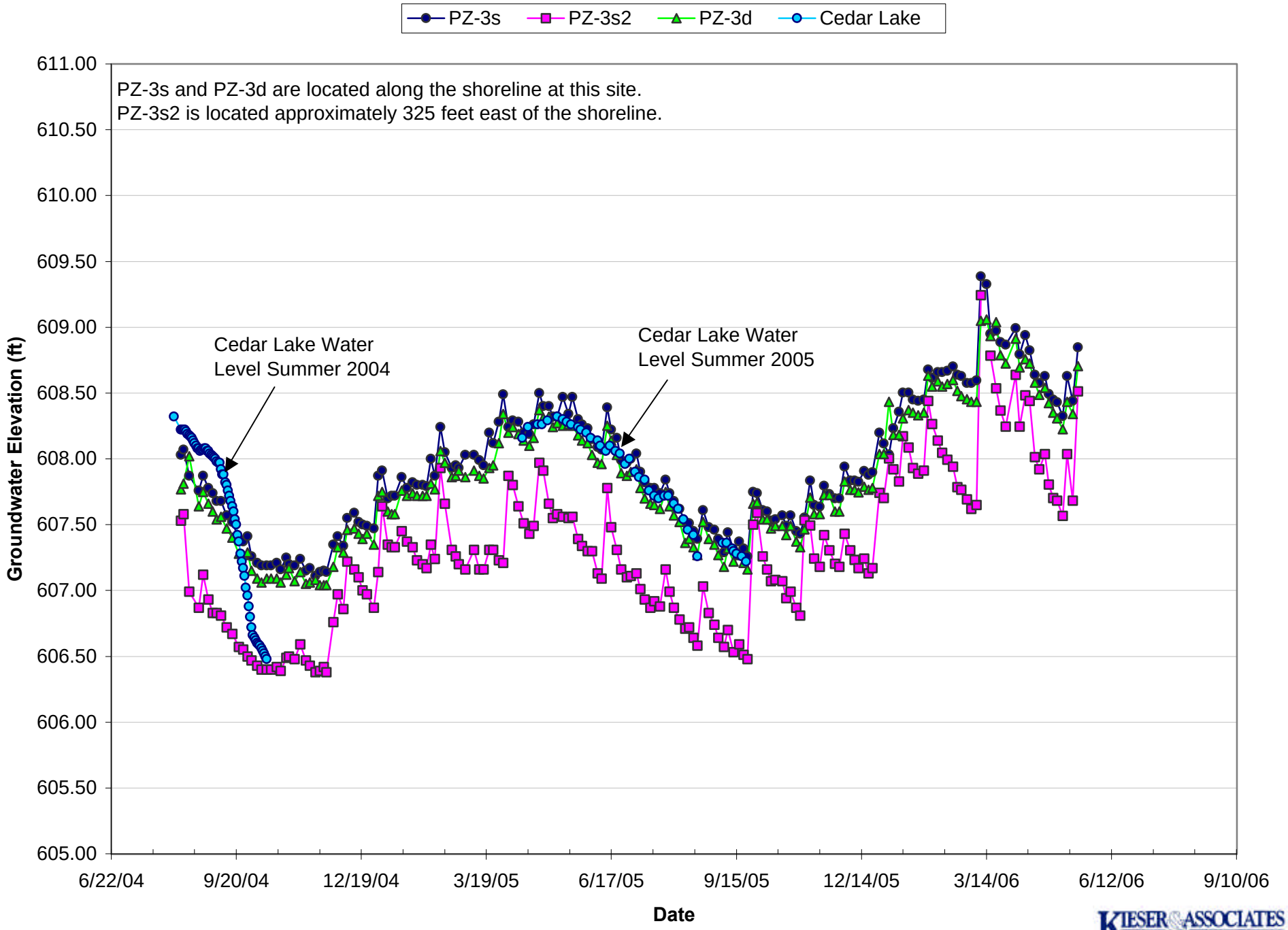
KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 5. Cedar Lake Groundwater Elevations at Site #2
(northwest side of lake)



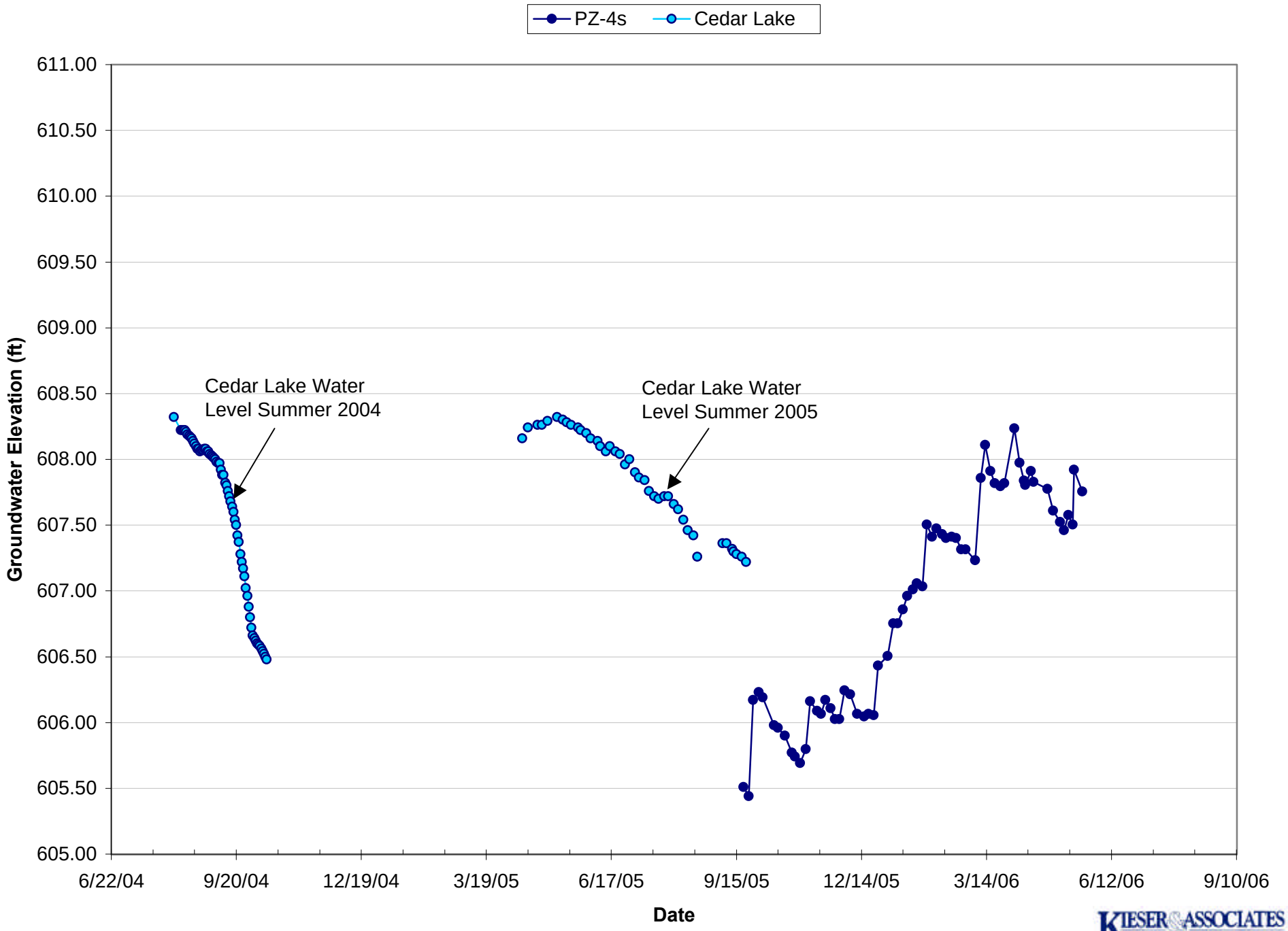
KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 6. Cedar Lake Groundwater Elevations at Site #3
(southwest side of lake)



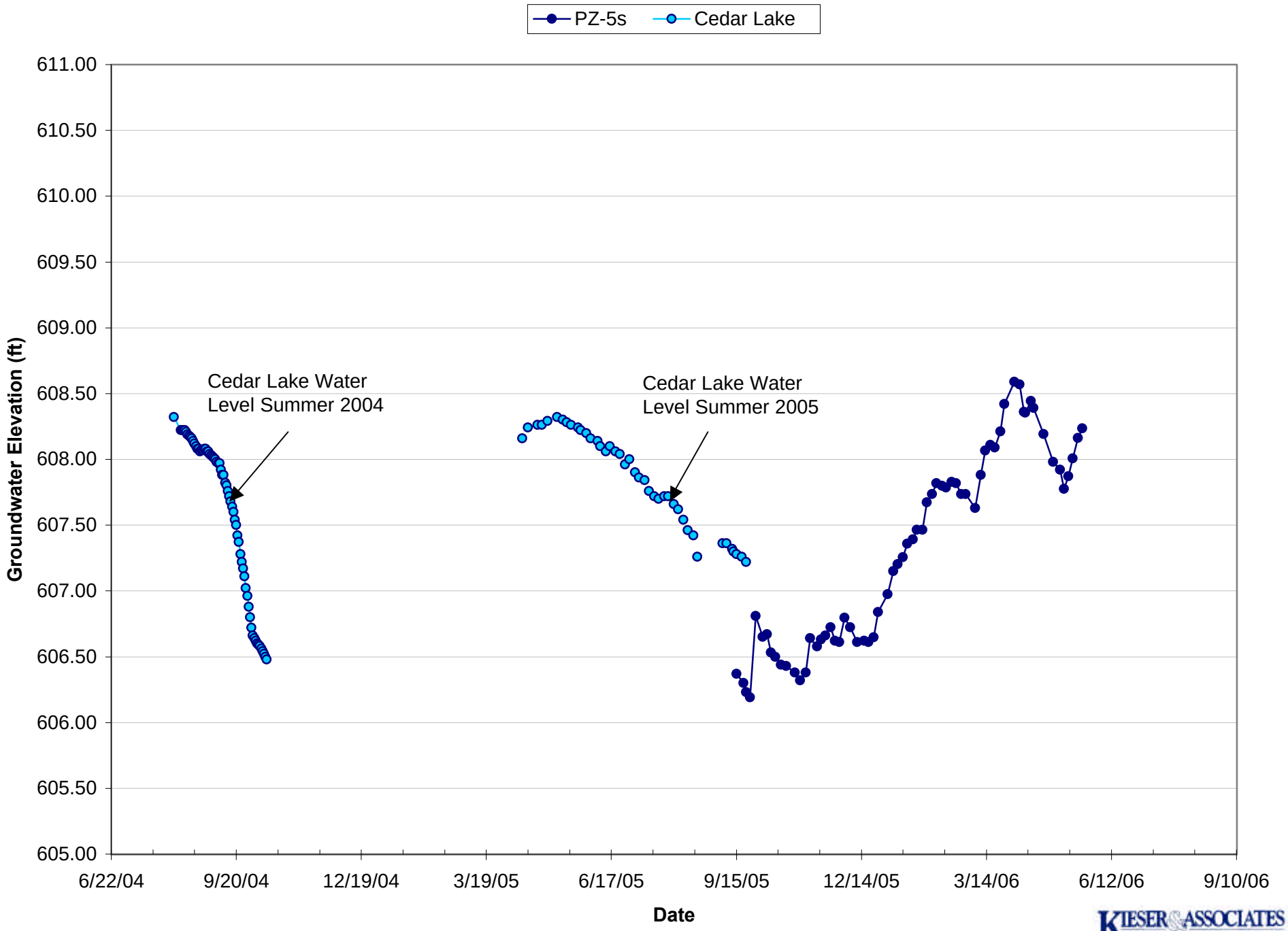
KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 7. Cedar Lake Groundwater Elevations at Site #4
(east side of lake)



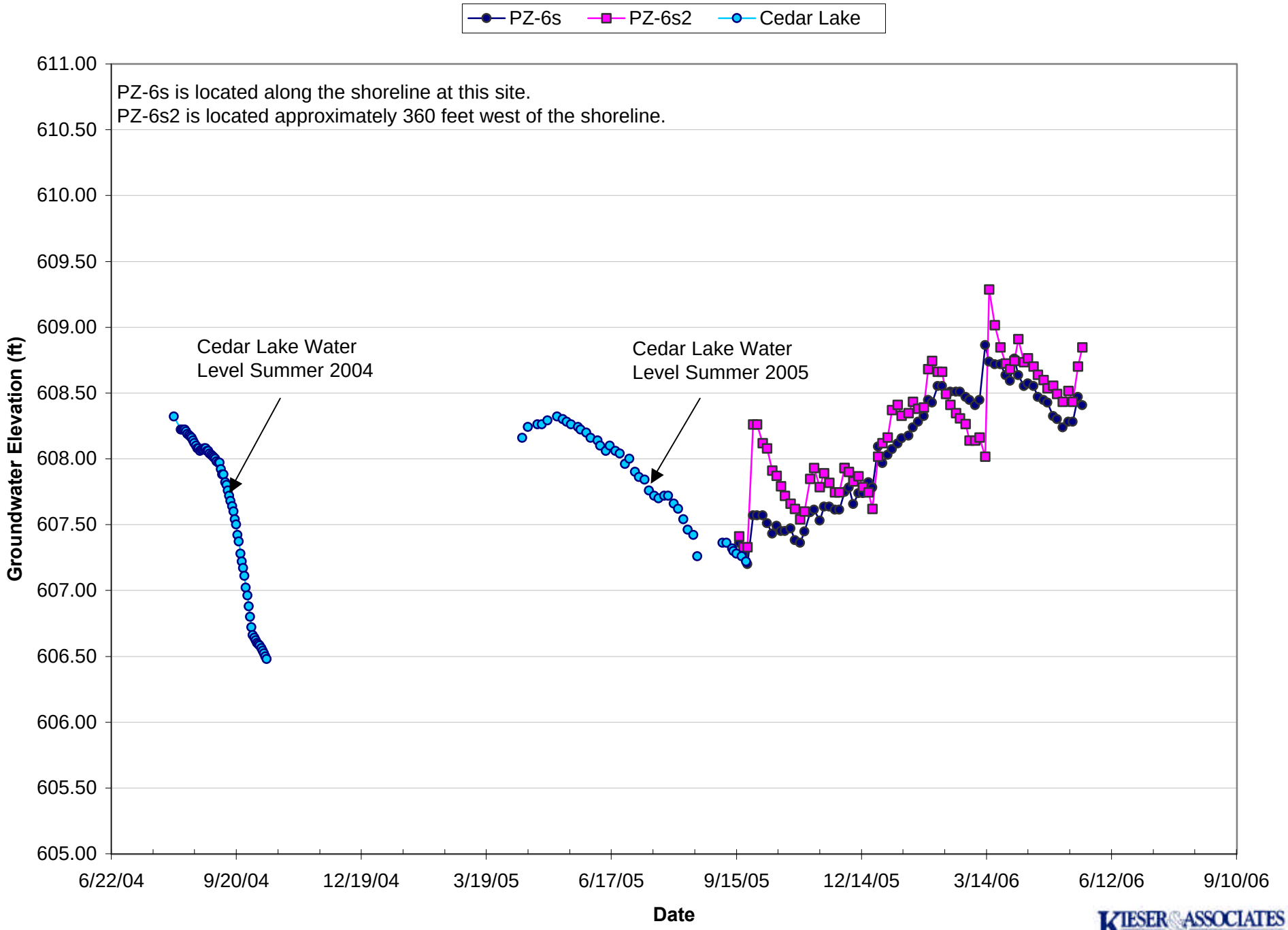
KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 8. Cedar Lake Groundwater Elevations at Site #5
(south end of lake)



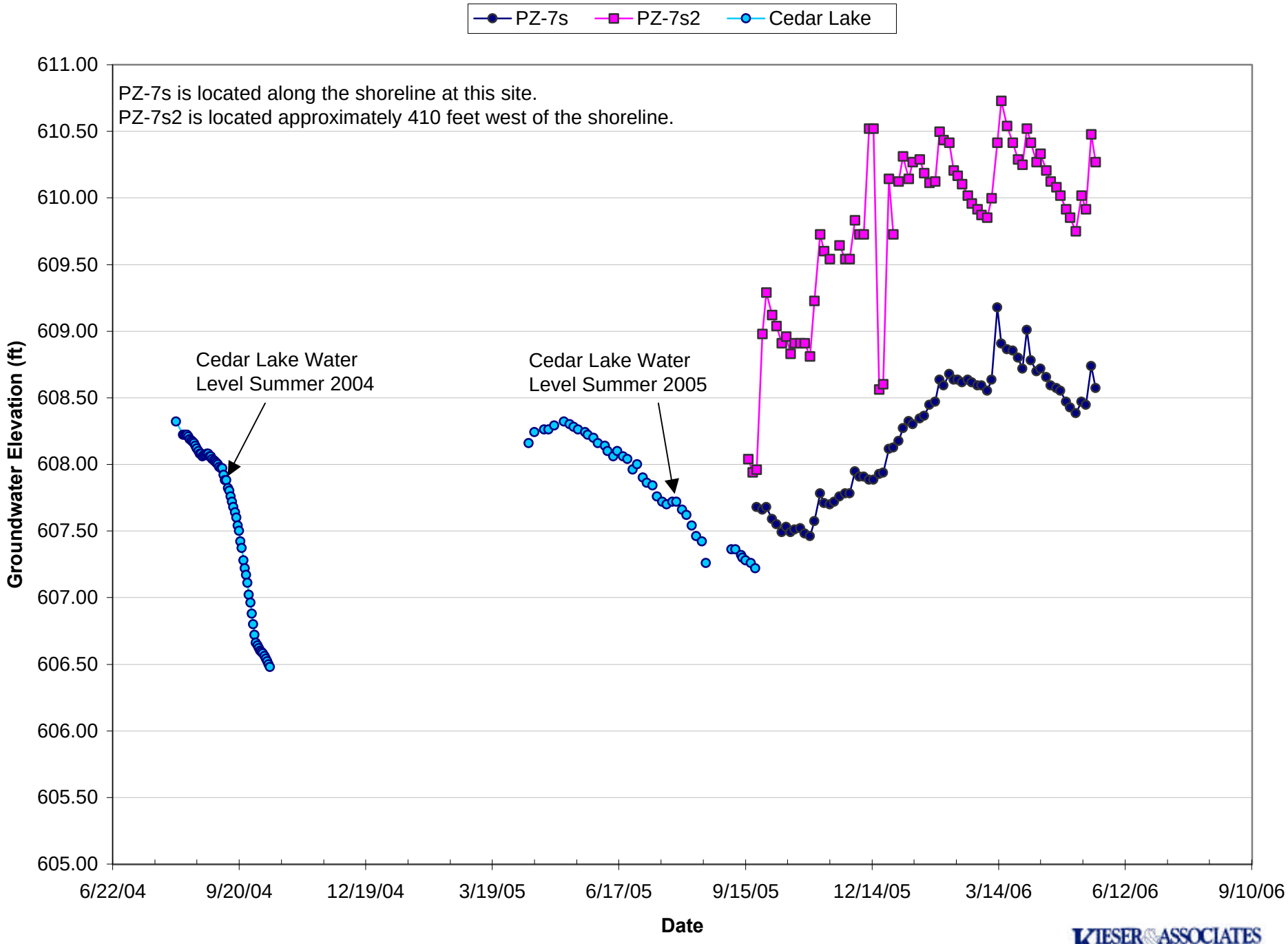
KLEINFELDER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 9. Cedar Lake Groundwater Elevations at Site #6
(west side of lake)



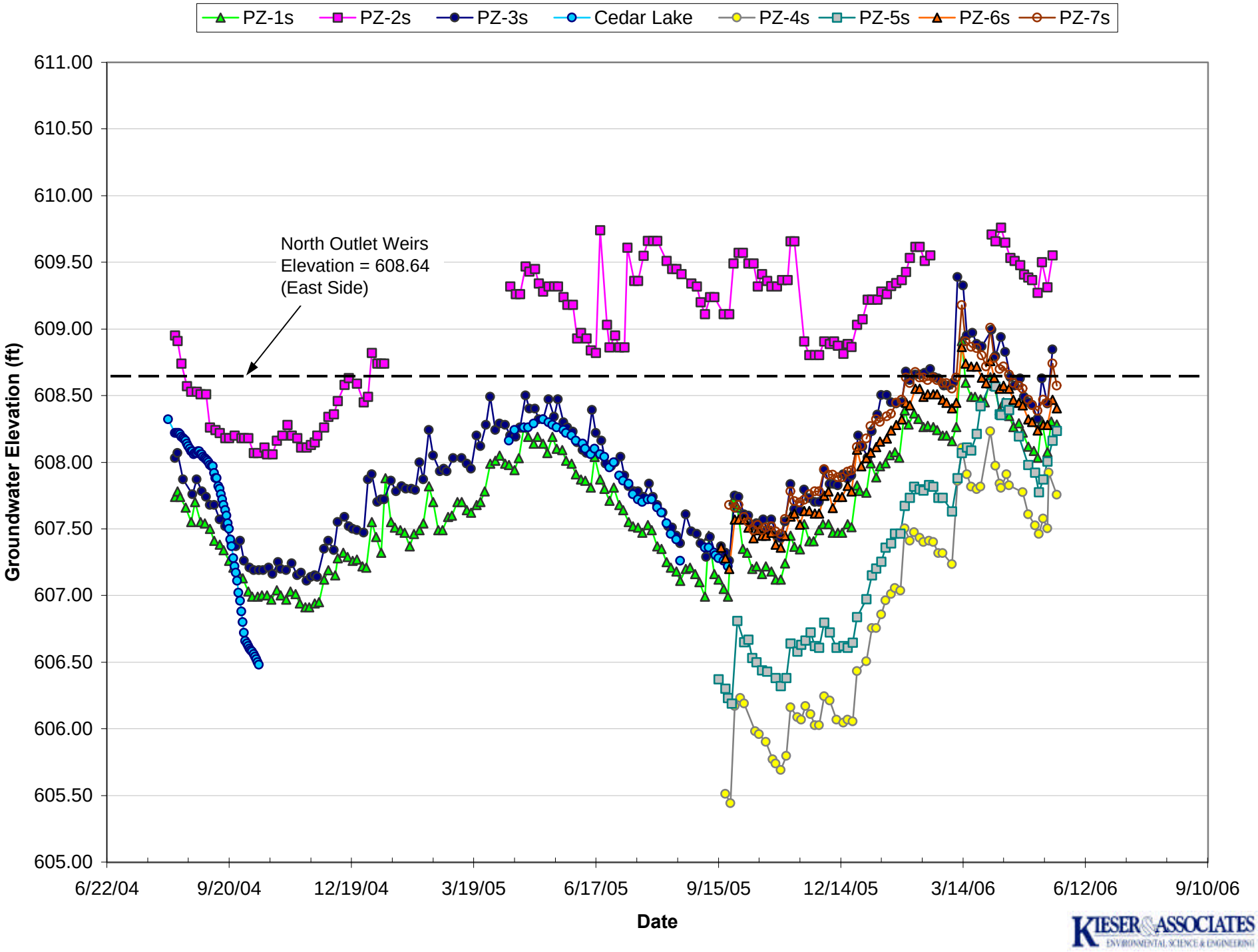
KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 10. Cedar Lake Groundwater Elevations at Site #7
(west side of lake)



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

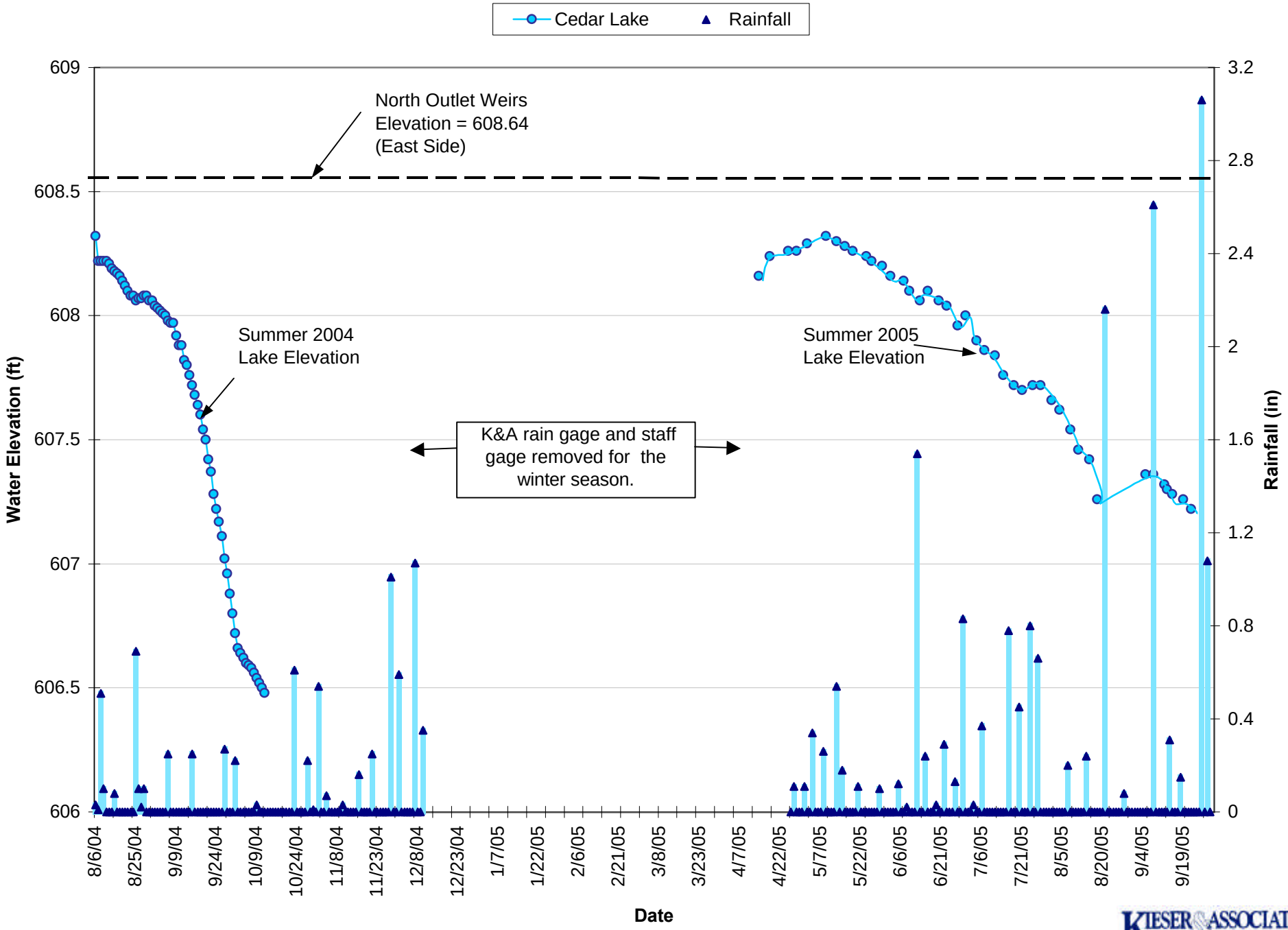
Figure 11. Cedar Lake Perimeter Shallow Groundwater Elevations (all sites).



KLEINFELDER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 12. Cedar Lake Water Elevations and Measured Rainfall for 2004 and 2005.

(Precipitation Source: K&A Rain Gage located at Site #1, East side of Cedar Lake)



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Figure 13. Annual Precipitation Totals for Cedar Lake.
(Precipitation Source: Harrisville, MI, CO-OP Station #203628, Alcona County)

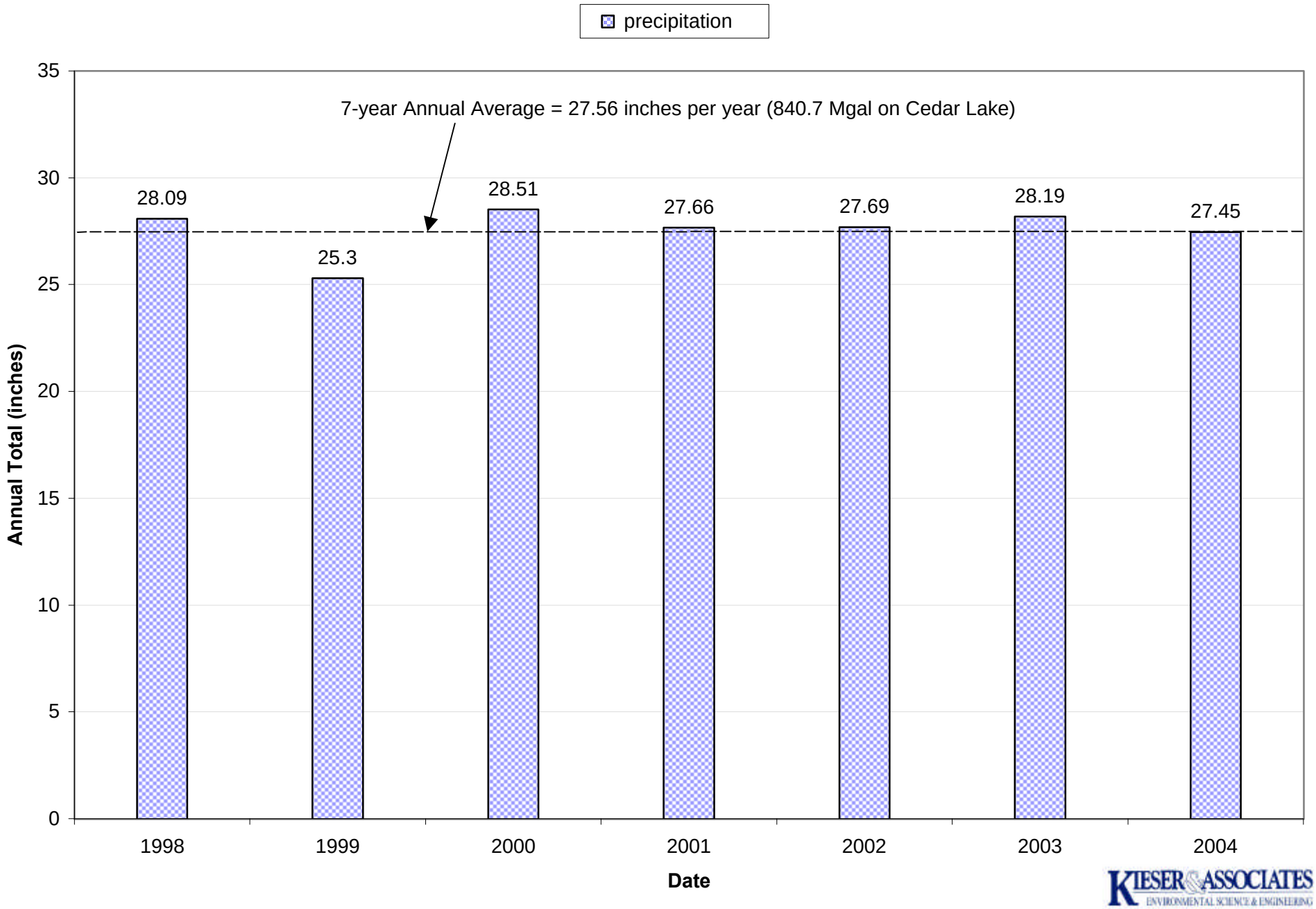


Figure 14. Summer (Jun - Sept) Precipitation Totals for Cedar Lake
(Precipitation Source: Harrisville, MI, CO-OP Station #203628, Alcona County)

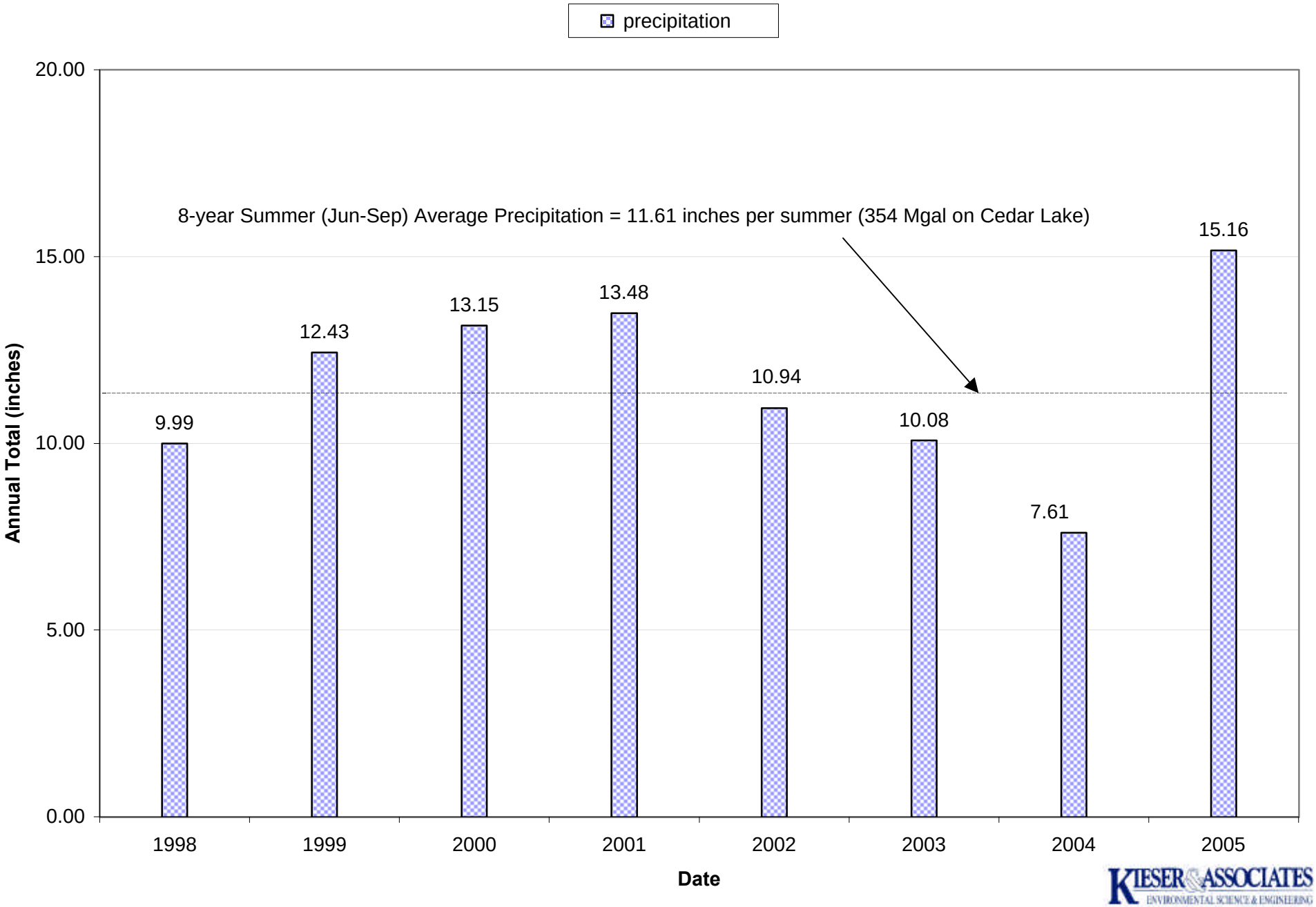


Figure 15. Summer Precipitation (June-September) for the last 8 Years.
(Precipitation Source: Harrisville, MI, CO-OP Station #203628, Alcona County)

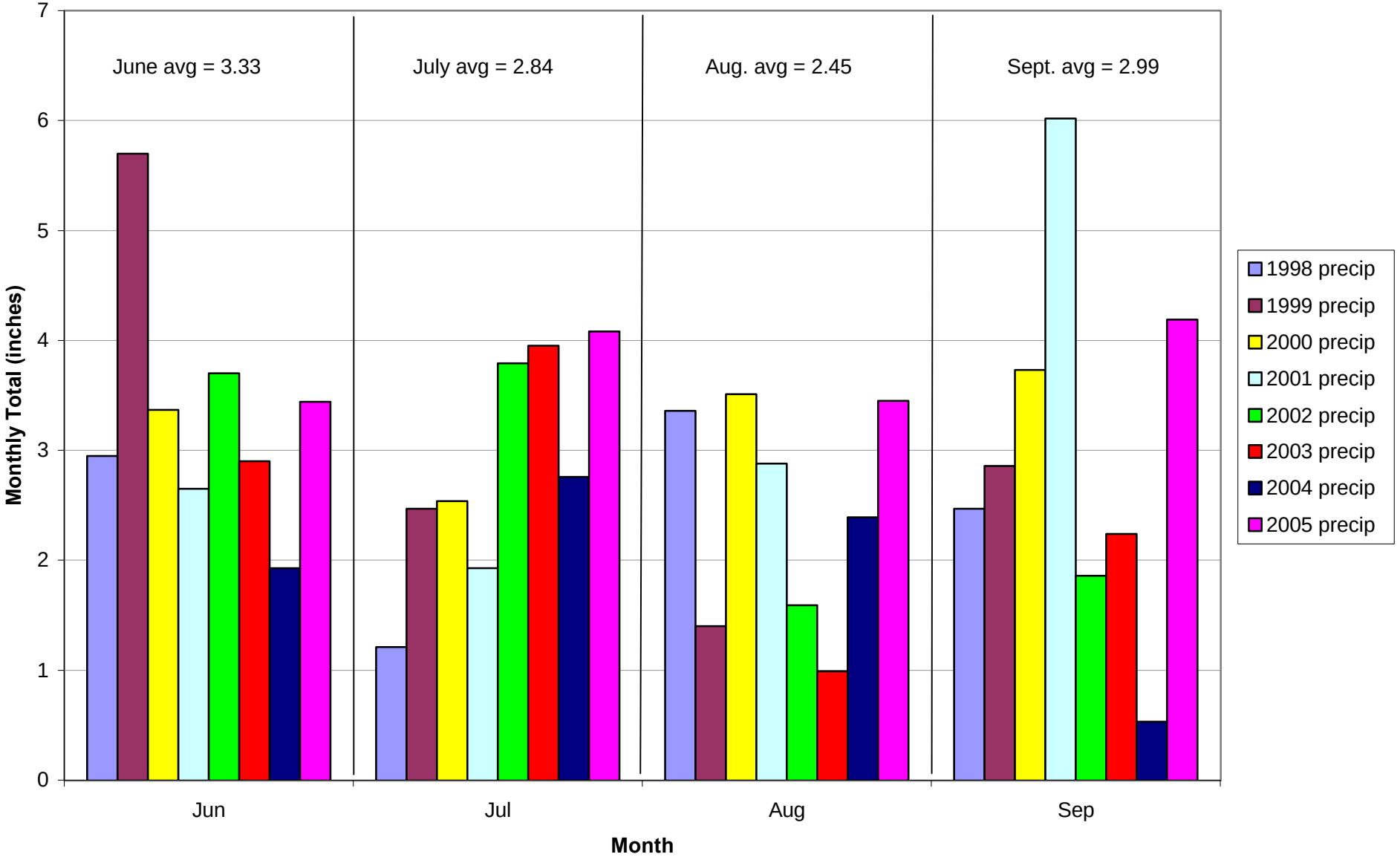
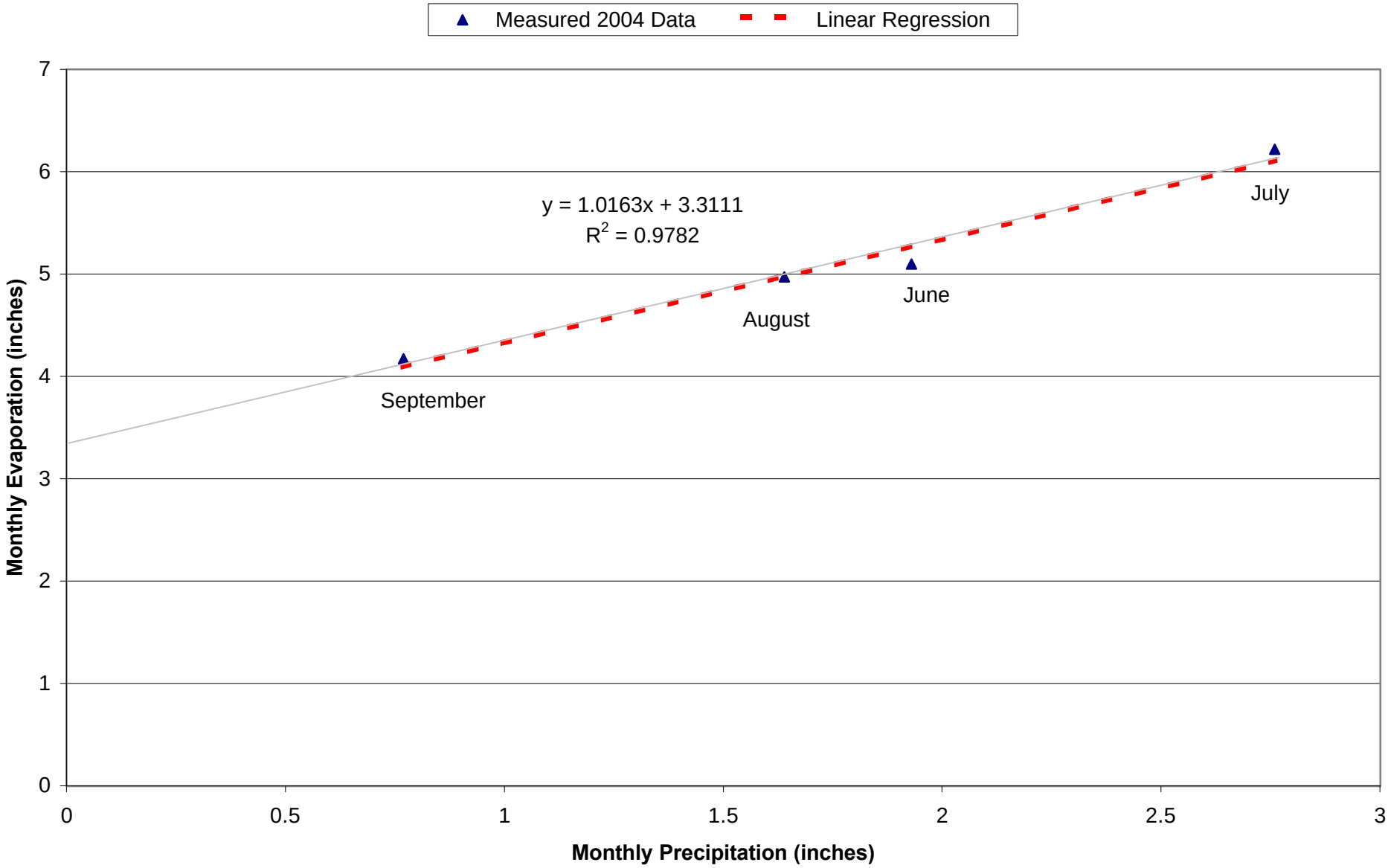


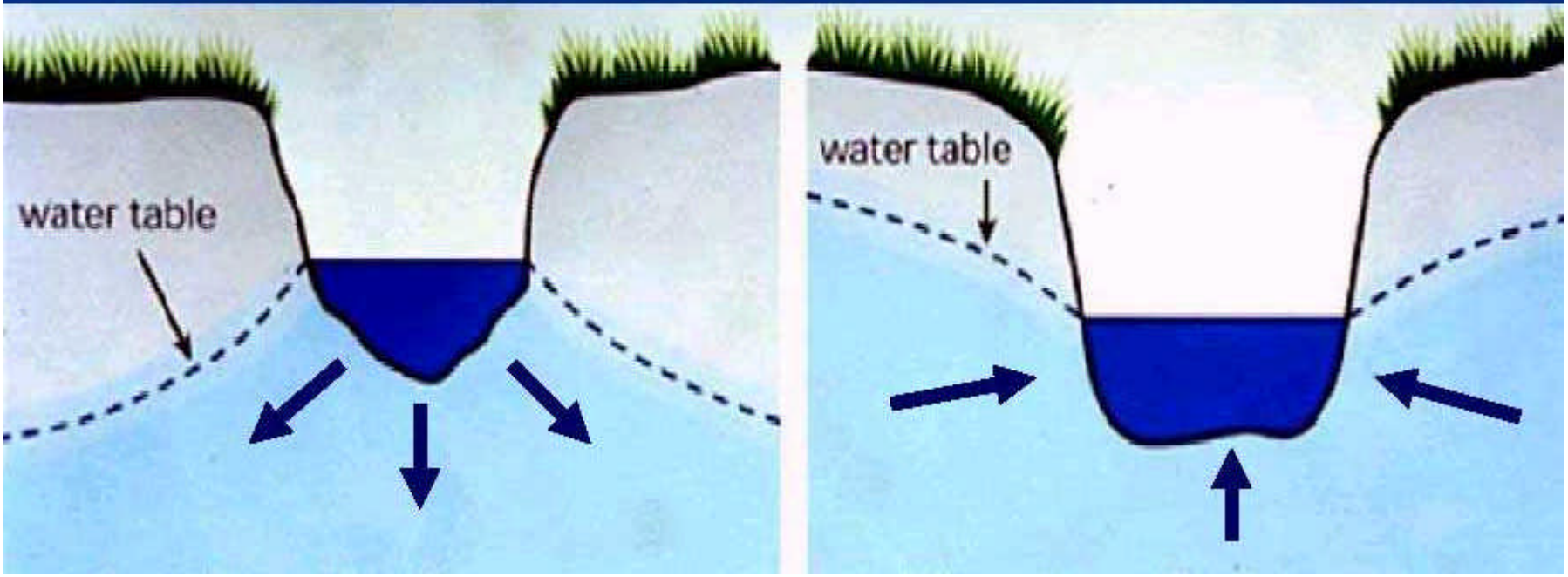
Figure 16. Cedar Lake Monthly Evaporation vs. Monthly Precipitation during Summer 2004
(June-September)



ADJACENT GROUNDWATER USES WILL INFLUENCE CEDAR LAKE LEVELS

LOSING CONDITIONS

GAINING CONDITIONS

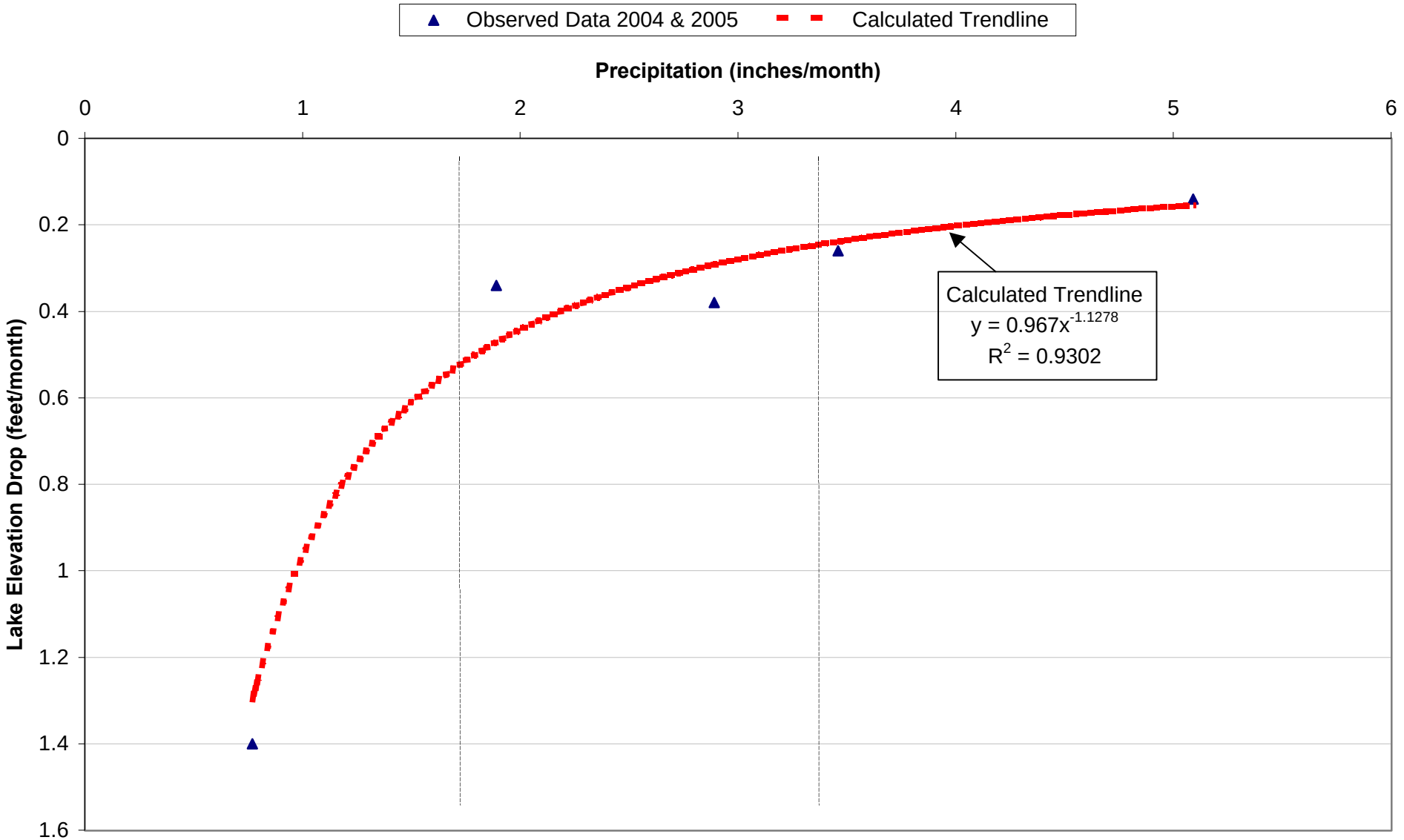


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

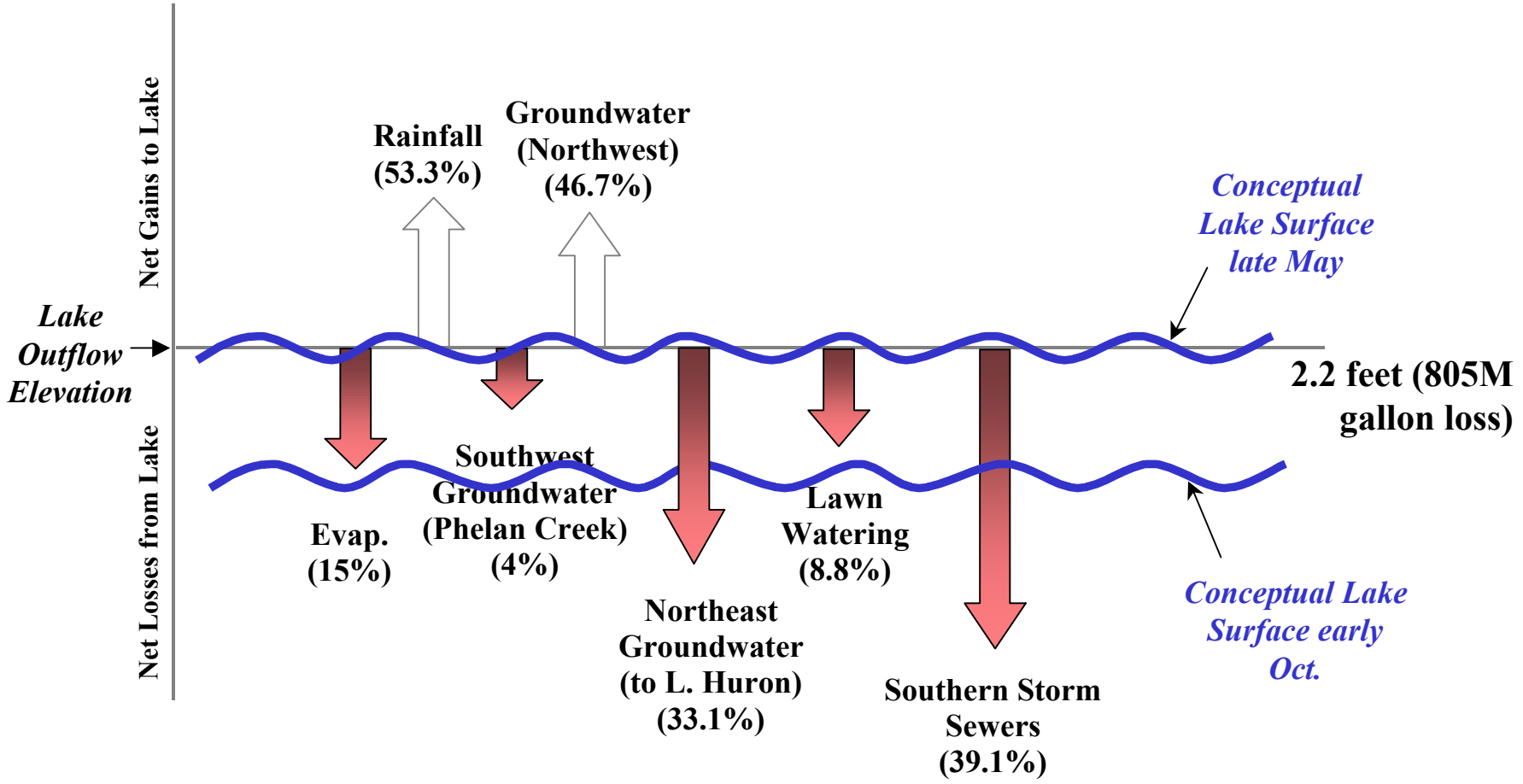
Schematic illustration of "losing" and "gaining" conditions with respect to adjacent groundwater elevations.

FIGURE
17

Figure 18. Cedar Lake Montly Precipitation vs. Monthly Lake Elevation Drop
(June - September Summer Months Only)



Cedar Lake June – Sept. 2004

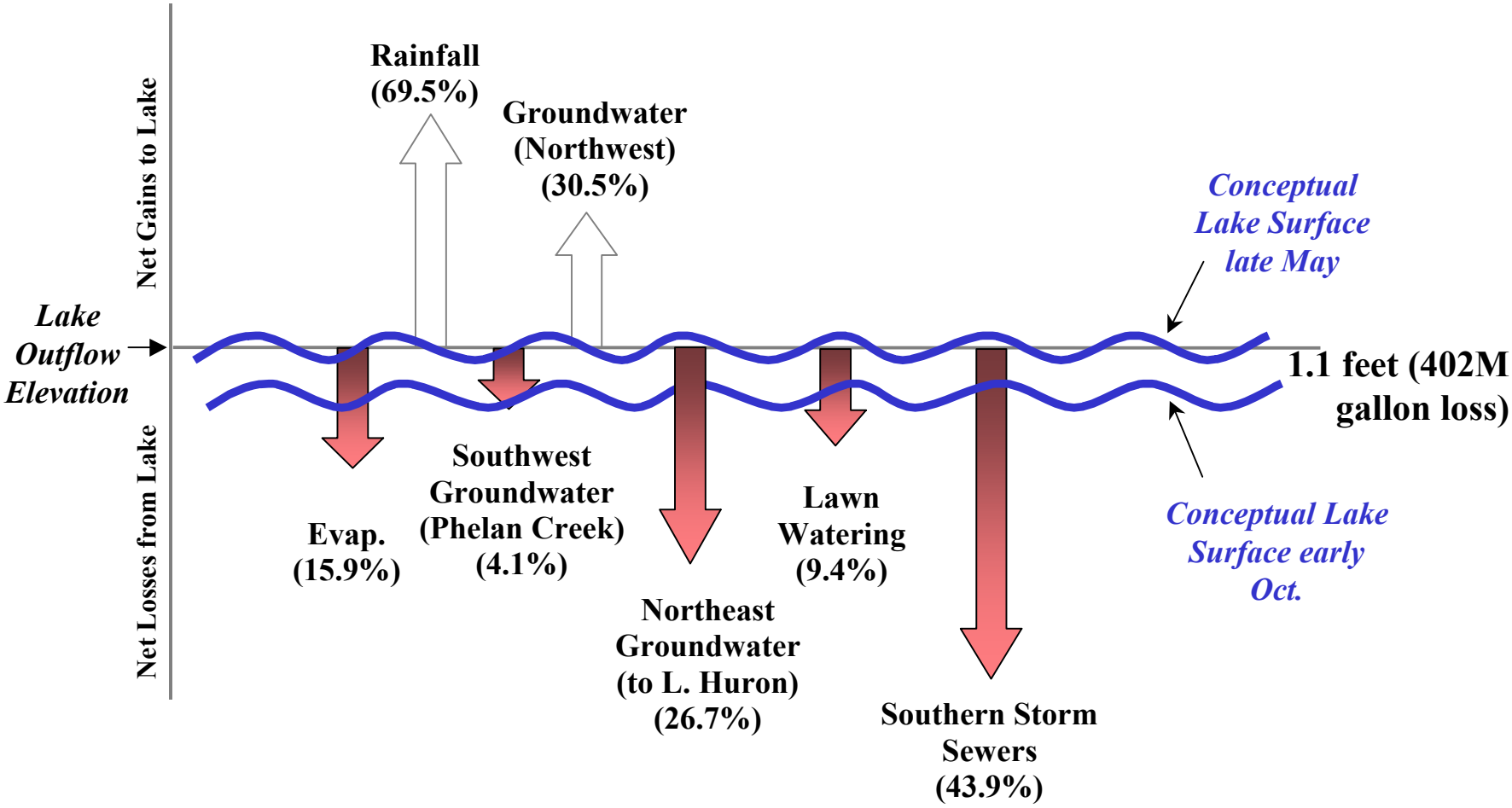


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Revised Phase I conceptual illustration of recreational season water loss estimates for summer 2004 from various areas affecting Cedar Lake water level decreases based on Phase II findings.

FIGURE
19

Cedar Lake June – Sept. 2005



- 2004 levels dropped 2.2 ft (805 M gal with 7.6 inches of rain)
- 2005 levels dropped 1.1 ft (402 M gal with 15.2 inches of rain)

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

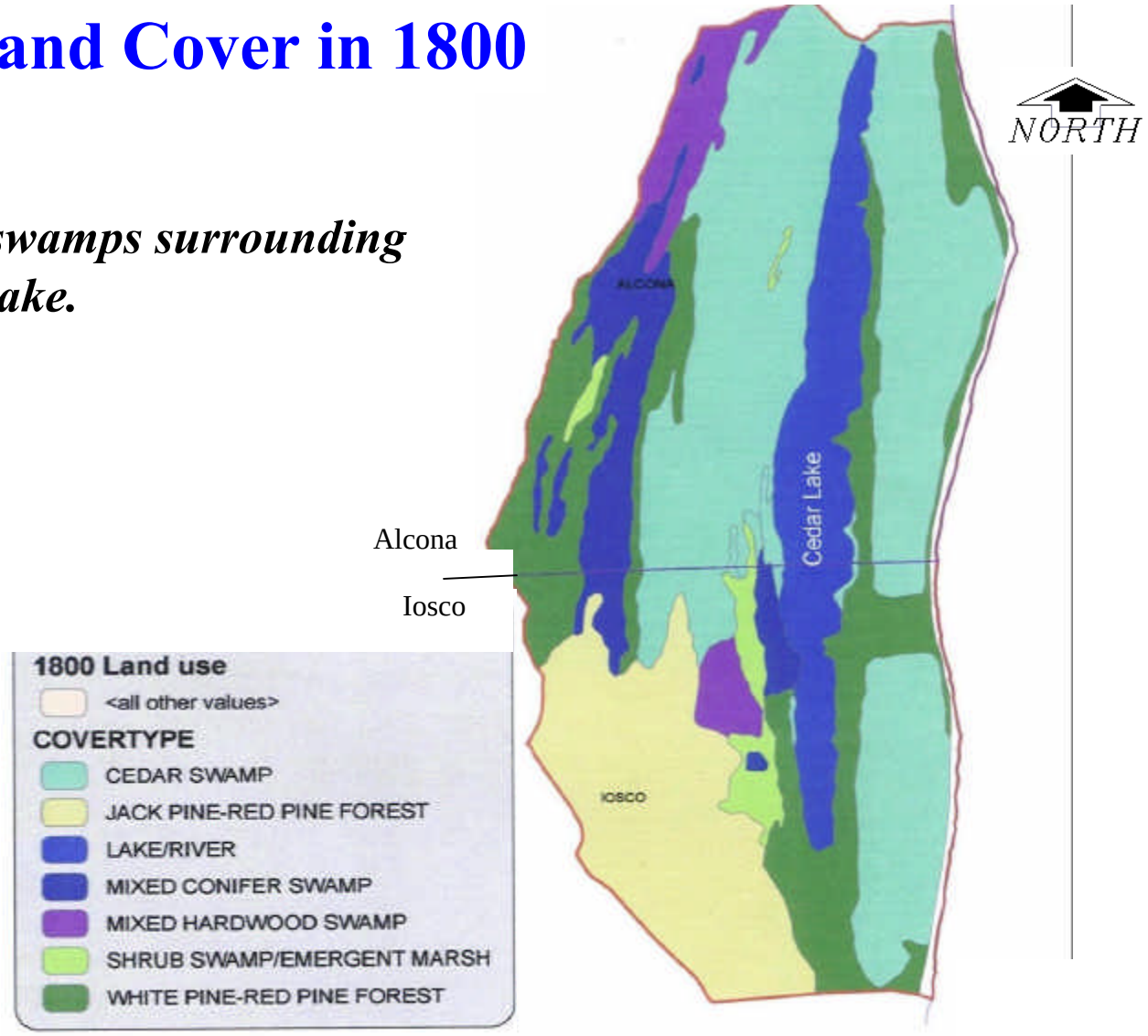
Phase II conceptual illustration of recreational season water loss estimates (summer 2005) from various areas affecting Cedar Lake water level decreases.

FIGURE
20

Cedar Lake Land Cover in 1800

Note:

Land was largely swamps surrounding western extent of lake.



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

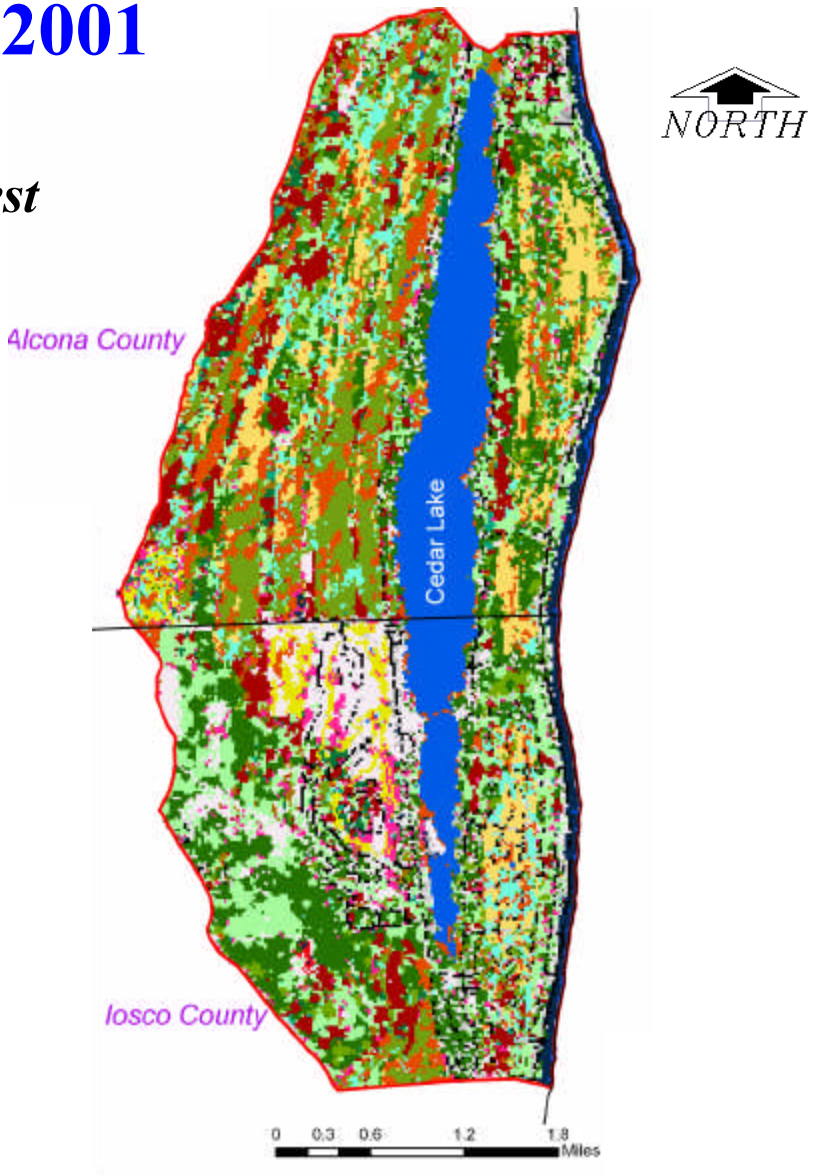
National Wetlands Inventory 1800 land cover map of the Phase II Cedar Lake project area.

FIGURE
21

Cedar Lake Land Cover in 2001

Note:

Wetlands and swamps to west and northwest now greatly diminished and now mixed with extensive upland areas



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Michigan Geographic Data Library 2001 land cover map of the Phase II Cedar Lake project area.

FIGURE
22

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Photos taken on August 6, 2004 by K&A at the road culvert on the north side of King's Corner Road.

FIGURE
23

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Photos taken in late March 2006 by Mr. Russ Anton of the AICLA at the road culvert on the north side of King's Corner Road.

FIGURE
24

Figure 25. Observed Lake Elevation Drop vs. Calculated Elevation Drop at Cedar Lake

(Caclulations are based on the emperical relationship between precipitation and observed lake elevation drop - Fig 18.)

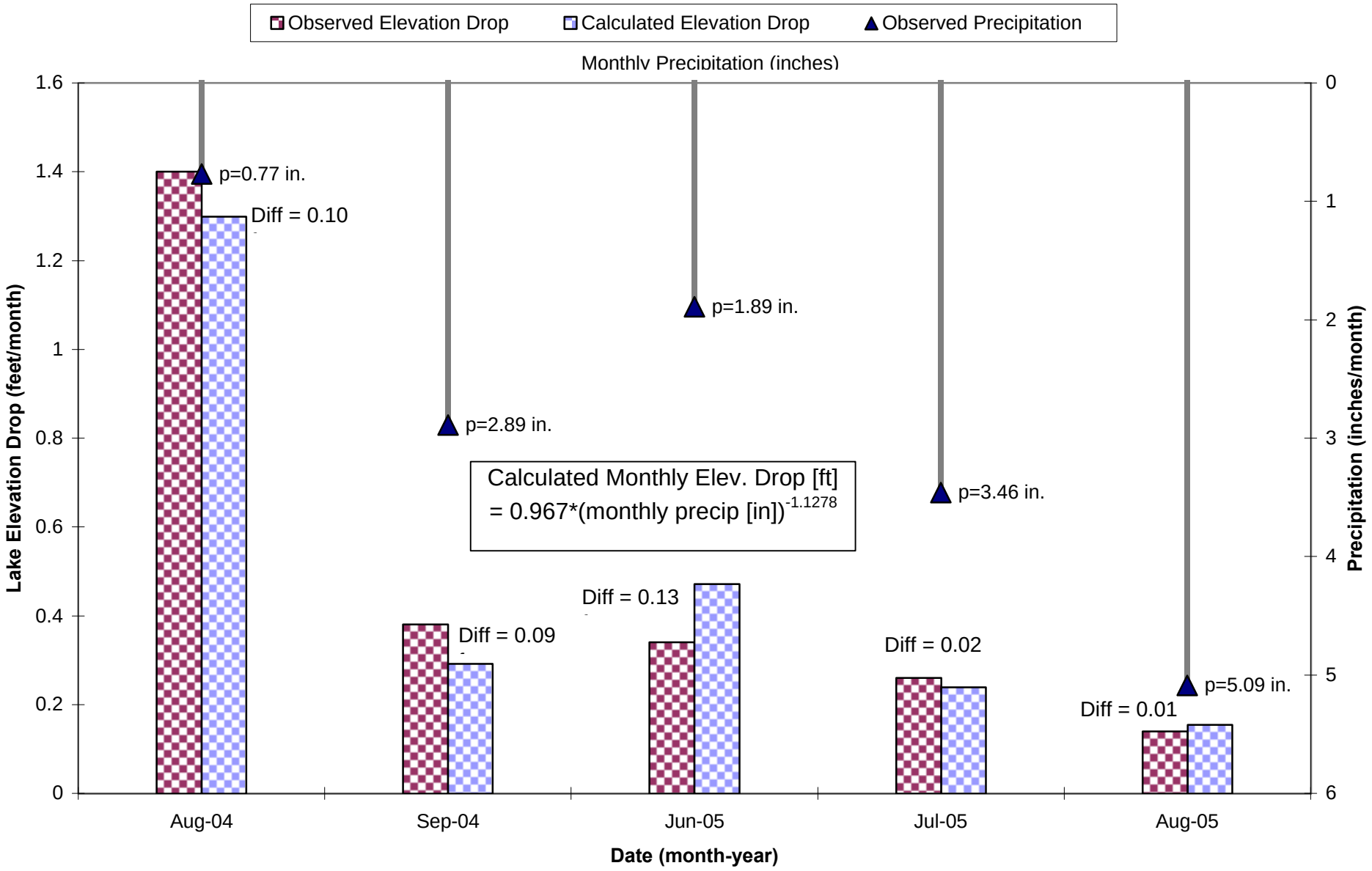
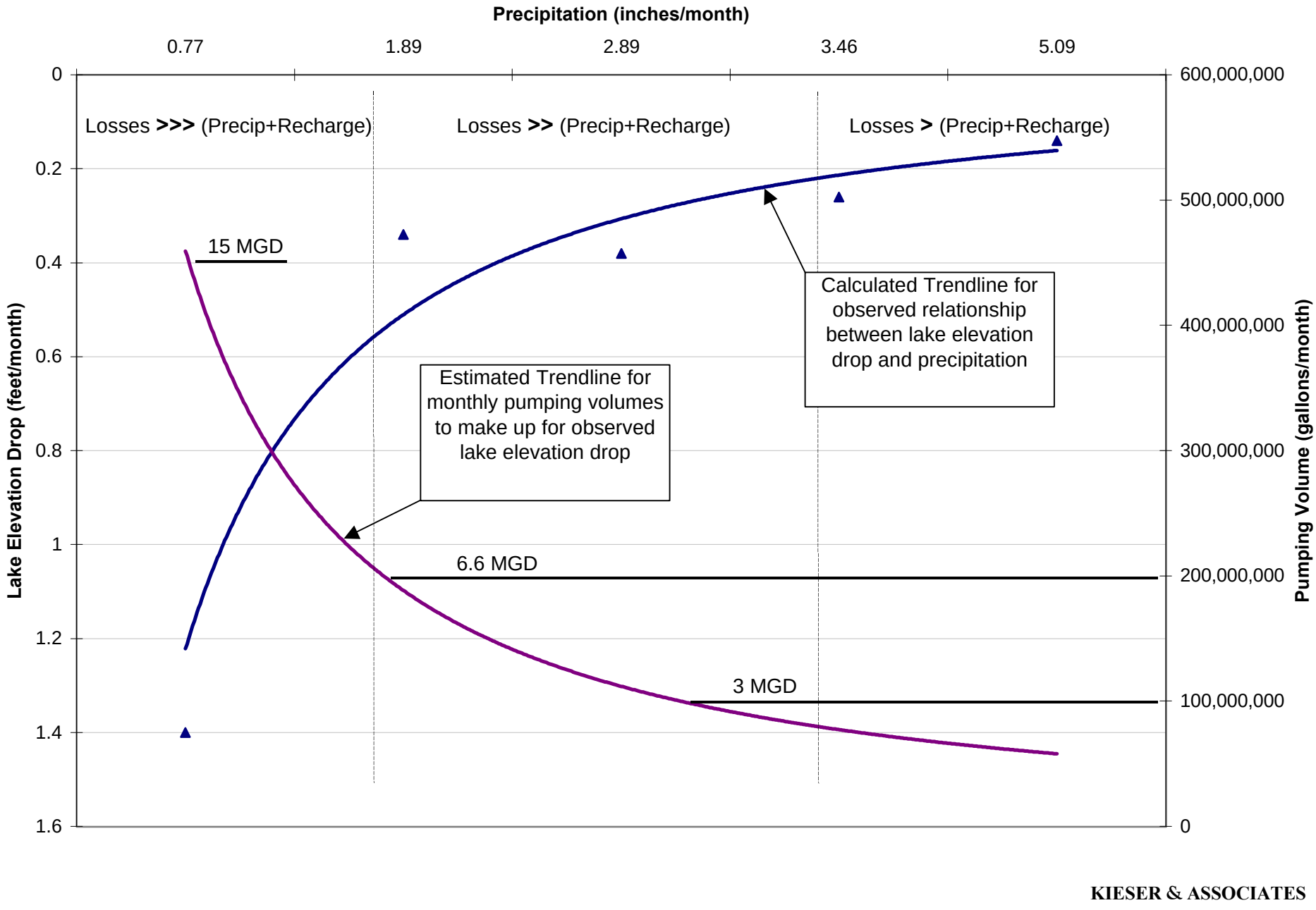


Figure 26. Cedar Lake Monthly Precipitation, Lake Elevation and Pumping Relationships



KIESER & ASSOCIATES

Table 1. Cedar Lake Piezometer Elevations (based on data provided by Rigg Land Surveying, Tawas City, MI).

Piezometer ID #	Total Depth (ft)	Ground Elevation (ft)	Top of Casing Elevation (ft)	Screen Length (ft)	Top of Screen Elevation (ft)	Bottom of Screen Elevation (ft)
PZ-1s	7	609.48	611.45	2	606.45	604.45
PZ-1s2	11	611.54	613.88	3	605.88	602.88
PZ-1d	16	609.47	610.97	3	597.97	594.97
PZ-2s	5.33	NM	611.74	2	608.41	606.41
PZ-2d	13	NM	611.11	3	601.11	598.11
PZ-3s	5.48	609.59	610.95	3	608.47	605.47
PZ-3s2	8	609.70	612.16	3	607.16	604.16
PZ-3d	13	609.59	611.10	3	601.10	598.10
PZ-4s	7.61	610.13	611.90	2.5	606.79	604.29
PZ-5s	6.73	609.19	610.88	2.5	606.65	604.15
PZ-6s	7	609.86	611.01	2.5	606.51	604.01
PZ-6s2	13	615.96	617.14	3	607.14	604.14
PZ-7s	6.06	610.66	611.26	2.5	607.70	605.20
PZ-7s2	7.81	610.50	611.54	3	606.73	603.73

Notes:

From a 1954 report, the outlet structures are established at elevation 608.5 feet based on a court order.
Rigg Land Surveying identifies east outlet structure is constructed at elevation 608.64 feet.
Then Cedar Lake water elev = 608.54 ft. (5-24-05)
Cedar Lake water elev at staff gauge = 608.22 (5-27-05)
Piezometers 1s through 3s2 were installed under Phase I efforts in 2004.

ATTACHMENT A

AICLA Volunteer Monitoring Data Summary

Summary of groundwater elevations recorded at Site #1, 4484 E. Cedar Lake Dr.

	PZ-1s		PZ-1s2		PZ-1d	
Date	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
8/11/04	3.71	607.74	na		3.29	607.68
8/13/04	3.67	607.78	na		3.15	607.82
8/15/04	3.71	607.74	na		3.27	607.70
8/19/04	3.79	607.66	7.32	606.56	3.29	607.68
8/23/04	3.90	607.55	8.25	605.63	3.41	607.56
8/26/04	3.75	607.70	7.90	605.98	3.29	607.68
8/30/04	3.90	607.55	7.90	605.98	3.40	607.57
9/2/04	3.91	607.54	7.99	605.89	3.45	607.52
9/6/04	3.95	607.50	8.03	605.85	3.50	607.47
9/9/04	4.04	607.41	8.07	605.81	3.58	607.39
9/13/04	4.07	607.38	8.15	605.73	3.59	607.38
9/16/04	4.11	607.34	8.20	605.68	3.66	607.31
9/20/04	4.19	607.26	8.27	605.61	3.75	607.22
9/23/04	4.24	607.21	8.31	605.57	3.78	607.19
9/27/04	4.29	607.16	8.32	605.56	3.85	607.12
9/30/04	4.32	607.13	8.42	605.46	3.91	607.06
10/4/04	4.42	607.03	8.49	605.39	3.92	607.05
10/7/04	4.46	606.99	8.52	605.36	3.94	607.03
10/11/04	4.46	606.99	8.54	605.34	4.00	606.97
10/14/04	4.45	607.00	8.55	605.33	4.02	606.95
10/18/04	4.45	607.00	8.57	605.31	4.04	606.93
10/21/04	4.48	606.97	8.57	605.31	4.04	606.93
10/25/04	4.41	607.04	8.46	605.42	4.11	606.86
10/28/04	4.45	607.00	8.49	605.39	4.13	606.84
11/1/04	4.48	606.97	8.49	605.39	4.04	606.93
11/4/04	4.42	607.03	8.40	605.48	4.10	606.87
11/8/04	4.44	607.01	8.47	605.41	4.15	606.82
11/11/04	4.51	606.94	8.48	605.40	4.11	606.86
11/15/04	4.54	606.91	8.53	605.35	4.10	606.87
11/18/04	4.54	606.91	8.54	605.34	4.08	606.89
11/22/04	4.51	606.94	8.50	605.38	4.06	606.91
11/25/04	4.50	606.95	8.48	605.40	4.03	606.94
11/29/04	4.33	607.12	8.19	605.69	3.89	607.08
12/2/04	4.26	607.19	8.10	605.78	3.81	607.16
12/7/04	4.30	607.15	8.10	605.78	3.88	607.09
12/9/04	4.17	607.28	7.92	605.96	3.74	607.23
12/13/04	4.13	607.32	8.14	605.74	3.71	607.26
12/16/04	4.16	607.29	8.13	605.75	3.73	607.24
12/20/04	4.19	607.26	8.10	605.78	3.75	607.22
12/23/04	4.18	607.27	8.09	605.79	3.74	607.23
12/27/04	4.23	607.22	8.08	605.80	3.77	607.20
12/30/04	4.24	607.21	8.11	605.77	3.76	607.21
1/3/05	3.90	607.55	7.82	606.06	3.46	607.51
1/6/05	4.01	607.44	7.77	606.11	3.55	607.42
1/10/05	4.13	607.32	7.63	606.25	3.56	607.41
1/13/05	3.57	607.88	7.38	606.50	3.15	607.82
1/17/05	3.90	607.55	7.31	606.57	3.38	607.59
1/20/05	3.94	607.51	7.44	606.44	3.46	607.51

Date	PZ-1s		PZ-1s2		PZ-1d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
1/24/05	3.96	607.49	7.56	606.32	3.49	607.48
1/27/05	3.98	607.47	7.64	606.24	3.48	607.49
1/31/05	4.08	607.37	7.70	606.18	3.49	607.48
2/3/05	3.99	607.46	7.61	606.27	3.51	607.46
2/7/05	3.96	607.49	7.73	606.15	3.46	607.51
2/10/05	3.91	607.54	7.65	606.23	3.45	607.52
2/14/05	3.63	607.82	7.53	606.35	3.21	607.76
2/17/05	3.75	607.70	7.30	606.58	3.27	607.70
2/21/05	3.96	607.49	7.44	606.44	3.36	607.61
2/24/05	3.96	607.49	7.50	606.38	3.40	607.57
2/28/05	3.86	607.59	7.52	606.36	3.40	607.57
3/3/05	3.85	607.60	7.63	606.25	3.31	607.66
3/7/05	3.75	607.70	7.52	606.36	3.08	607.89
3/10/05	3.75	607.70	7.40	606.48	3.25	607.72
3/14/05	3.81	607.64	7.50	606.38	3.33	607.64
3/17/05	3.83	607.62	7.54	606.34	3.31	607.66
3/21/05	3.77	607.68	7.57	606.31	3.29	607.68
3/24/05	3.75	607.70	7.48	606.40	3.27	607.70
3/27/05	3.67	607.78	7.31	606.57	3.17	607.80
3/31/05	3.46	607.99	7.03	606.85	3.02	607.95
4/4/05	3.44	608.01	6.92	606.96	2.96	608.01
4/7/05	3.40	608.05	6.88	607.00	2.94	608.03
4/11/05	3.46	607.99	6.96	606.92	2.96	608.01
4/14/05	3.47	607.98	7.04	606.84	3.03	607.94
4/18/05	3.51	607.94	7.14	606.74	3.04	607.93
4/21/05	3.42	608.03	7.11	606.77	2.98	607.99
4/25/05	3.19	608.26	6.78	607.10	2.77	608.20
4/28/05	3.26	608.19	6.81	607.07	2.85	608.12
5/2/05	3.31	608.14	6.93	606.95	2.88	608.09
5/5/05	3.26	608.19	6.94	606.94	2.85	608.12
5/9/05	3.31	608.14	6.97	606.91	2.88	608.09
5/12/05	3.38	608.07	7.06	606.82	2.92	608.05
5/16/05	3.26	608.19	6.94	606.94	2.90	608.07
5/19/05	3.35	608.10	7.03	606.85	2.91	608.06
5/23/05	3.36	608.09	7.10	606.78	2.94	608.03
5/26/05	3.44	608.01	7.17	606.71	2.96	608.01
5/30/05	3.46	607.99	7.20	606.68	2.98	607.99
6/2/05	3.54	607.91	7.27	606.61	3.04	607.93
6/6/05	3.58	607.87	7.31	606.57	3.17	607.80
6/9/05	3.59	607.86	7.38	606.50	3.13	607.84
6/13/05	3.64	607.81	7.46	606.42	3.18	607.79
6/16/05	3.41	608.04	7.16	606.72	3.02	607.95
6/20/05	3.58	607.87	7.33	606.55	3.13	607.84
6/23/05	3.65	607.80	7.42	606.46	3.14	607.83
6/27/05	3.74	607.71	7.52	606.36	3.23	607.74
6/30/05	3.64	607.81	7.35	606.53	3.14	607.83
7/4/05	3.77	607.68	7.58	606.30	3.31	607.66
7/7/05	3.81	607.64	7.59	606.29	3.32	607.65
7/11/05	3.90	607.55	7.69	606.19	3.41	607.56
7/14/05	3.93	607.52	7.76	606.12	3.46	607.51

Date	PZ-1s		PZ-1s2		PZ-1d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
7/18/05	3.94	607.51	7.81	606.07	3.43	607.54
7/21/05	3.98	607.47	7.86	606.02	3.49	607.48
7/25/05	3.92	607.53	7.79	606.09	3.42	607.55
7/28/05	3.96	607.49	7.79	606.09	3.49	607.48
8/1/05	4.08	607.37	7.98	605.90	3.60	607.37
8/4/05	4.10	607.35	8.06	605.82	3.65	607.32
8/8/05	4.20	607.25	8.13	605.75	3.72	607.25
8/11/05	4.24	607.21	8.19	605.69	3.78	607.19
8/15/05	4.27	607.18	8.26	605.62	3.85	607.12
8/18/05	4.34	607.11	8.32	605.56	3.86	607.11
8/22/05	4.25	607.20	7.96	605.92	3.77	607.20
8/25/05	4.24	607.21	8.08	605.80	3.75	607.22
8/29/05	4.29	607.16	8.19	605.69	3.77	607.20
9/1/05	4.35	607.10	8.27	605.61	3.88	607.09
9/5/05	4.46	606.99	8.38	605.50	3.96	607.01
9/8/05	4.00	607.45	7.83	606.05	3.75	607.22
9/12/05	4.29	607.16	7.96	605.92	3.81	607.16
9/15/05	4.33	607.12	8.07	605.81	3.83	607.14
9/19/05	4.40	607.05	8.13	605.75	3.91	607.06
9/22/05	4.46	606.99	8.25	605.63	3.98	606.99
9/26/05	3.73	607.72	7.60	606.28	3.33	607.64
9/29/05	3.79	607.66	7.38	606.50	3.31	607.66
10/3/05	4.10	607.35	7.54	606.34	3.65	607.32
10/6/05	4.13	607.32	7.71	606.17	3.65	607.32
10/10/05	4.25	607.20	7.85	606.03	3.77	607.20
10/13/05	4.23	607.22	7.90	605.98	3.77	607.20
10/17/05	4.29	607.16	7.96	605.92	3.81	607.16
10/20/05	4.23	607.22	7.98	605.90	3.79	607.18
10/24/05	4.27	607.18	8.04	605.84	3.82	607.15
10/27/05	4.33	607.12	8.07	605.81	3.85	607.12
10/31/05	4.33	607.12	7.92	605.96	3.85	607.12
11/3/05	4.21	607.24	7.60	606.28	3.77	607.20
11/7/05	4.00	607.45	7.63	606.26	3.56	607.41
11/10/05	4.08	607.37	7.69	606.19	3.63	607.35
11/14/05	4.10	607.35	7.52	606.36	3.63	607.35
11/17/05	3.92	607.53	7.54	606.34	3.44	607.53
11/21/05	4.04	607.41	7.63	606.26	3.56	607.41
11/24/05	4.04	607.41	7.66	606.22	3.60	607.37
11/28/05	3.96	607.49	7.44	606.44	3.54	607.43
12/1/05	3.92	607.53	7.48	606.40	3.44	607.53
12/5/05	3.92	607.53	7.58	606.30	3.44	607.53
12/8/05	3.98	607.47	7.52	606.36	3.48	607.49
12/12/05	3.98	607.47	7.67	606.21	3.48	607.49
12/15/05	3.98	607.47	7.71	606.17	3.48	607.49
12/19/05	3.92	607.53	7.71	606.17	3.46	607.51
12/22/05	3.94	607.51	7.33	606.55	3.46	607.51
12/26/05	3.63	607.83	7.25	606.63	3.19	607.78
12/28/05	3.67	607.78	7.23	606.65	3.21	607.76
1/2/06	3.68	607.77	7.00	606.88	3.23	607.74
1/5/06	3.46	607.99	7.03	606.85	3.04	607.93

Date	PZ-1s		PZ-1s2		PZ-1d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
1/9/06	3.56	607.89	7.04	606.84	3.07	607.90
1/12/06	3.48	607.97	6.88	607.01	3.02	607.95
1/16/06	3.46	607.99	6.85	607.03	2.94	608.03
1/19/06	3.40	608.05	6.96	606.92	2.92	608.05
1/23/06	3.38	608.08	7.04	606.84	2.90	608.07
1/26/06	3.42	608.03	6.56	607.32	2.92	608.05
1/30/06	3.06	608.39	6.58	607.30	2.58	608.39
2/2/06	3.17	608.28	6.52	607.36	2.69	608.28
2/6/06	3.08	608.37	6.71	607.17	2.60	608.37
2/9/06	3.13	608.33	6.77	607.11	2.66	608.31
2/13/06	3.19	608.26	6.85	607.03	2.71	608.26
2/16/06	3.18	608.27	6.90	606.98	2.71	608.26
2/20/06	3.19	608.26	6.96	606.92	2.69	608.28
2/23/06	3.21	608.24	7.00	606.88	2.67	608.30
2/27/06	3.25	608.20	7.02	606.86	2.69	608.28
3/2/06	3.25	608.20	7.04	606.84	2.77	608.20
3/6/06	3.29	608.16	7.00	606.88	2.79	608.18
3/9/06	3.19	608.26	5.85	608.03	2.75	608.22
3/13/06	2.54	608.91	6.02	607.86	2.17	608.80
3/16/06	2.85	608.60	6.31	607.57	2.33	608.64
3/20/06	2.96	608.49	6.40	607.48	2.44	608.53
3/23/06	2.96	608.49	6.50	607.38	2.46	608.51
3/27/06	2.98	608.47	6.52	607.36	2.44	608.53
3/30/06	3.00	608.45	6.29	607.59	2.46	608.51
4/3/06	2.81	608.64	6.38	607.51	2.25	608.72
4/6/06	2.88	608.58	6.46	607.42	2.42	608.55
4/10/06	3.06	608.39	6.50	607.38	2.54	608.43
4/13/06	3.00	608.45	6.52	607.36	2.52	608.45
4/17/06	3.10	608.35	6.66	607.22	2.61	608.36
4/20/06	3.19	608.26	6.71	607.17	2.69	608.28
4/24/06	3.16	608.29	6.73	607.15	2.63	608.35
4/27/06	3.23	608.22	6.85	607.03	2.71	608.26
5/1/06	3.33	608.12	6.90	606.98	2.79	608.18
5/5/06	3.36	608.09	6.98	606.90	2.83	608.14
5/8/06	3.42	608.03	6.83	607.05	2.90	608.07
5/11/06	3.15	608.30	6.94	606.94	2.73	608.24
5/15/06	3.38	608.08	6.65	607.23	2.85	608.12
5/18/06	3.15	608.30	6.48	607.40	2.65	608.32
5/22/06	3.17	608.28			2.69	608.28

Notes:

PZ-1s is a shallow well located adjacent to Cedar Lake.
PZ-1s2 is a shallow well located approximately 200 ft east of PZ-1s.
PZ-1d is a deeper well located adjacent to Cedar Lake.

Summary of groundwater elevations recorded at Site #2, 3481 W. Cedar Lake Rd.

Date	PZ-2s		PZ-2d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
8/11/04	2.79	608.95	2.38	608.73
8/13/04	2.83	608.91	2.40	608.71
8/16/04	3.00	608.74	2.33	608.78
8/20/04	3.17	608.57	2.42	608.69
8/23/04	3.21	608.53	2.56	608.55
8/27/04	3.21	608.53	2.54	608.57
8/30/04	3.23	608.51	2.54	608.57
9/3/04	3.23	608.51	2.56	608.55
9/6/04	3.48	608.26	2.60	608.51
9/10/04	3.50	608.24	2.67	608.44
9/13/04	3.52	608.22	2.69	608.42
9/17/04	3.56	608.18	2.83	608.28
9/20/04	3.56	608.18	2.83	608.28
9/24/04	3.54	608.20	2.85	608.26
9/29/04	3.56	608.18	2.88	608.23
10/1/04	3.56	608.18	2.88	608.23
10/4/04	3.56	608.18	2.92	608.19
10/8/04	3.67	608.07	3.04	608.07
10/11/04	3.67	608.07	3.04	608.07
10/16/04	3.63	608.11	3.08	608.03
10/18/04	3.68	608.06	3.08	608.03
10/22/04	3.68	608.06	3.08	608.03
10/25/04	3.58	608.16	3.04	608.07
10/29/04	3.54	608.20	3.04	608.07
11/2/04	3.46	608.28	3.02	608.09
11/5/04	3.54	608.20	3.04	608.07
11/9/04	3.56	608.18	3.04	608.07
11/12/04	3.63	608.11	3.08	608.03
11/16/04	3.63	608.11	3.05	608.06
11/19/04	3.61	608.13	3.06	608.05
11/22/04	3.59	608.15	3.03	608.08
11/24/04	3.54	608.20	3.06	608.05
11/29/04	3.48	608.26	2.92	608.19
12/2/04	3.40	608.34	2.85	608.26
12/6/04	3.38	608.36	2.82	608.29
12/9/04	3.28	608.46	2.71	608.40
12/14/04	3.16	608.58	2.60	608.51
12/17/04	3.11	608.63	2.63	608.48
12/20/04	3.59	608.15	2.48	608.63
12/23/04	3.15	608.59	na	
12/28/04	3.29	608.45	na	
12/31/04	3.25	608.49	2.54	608.57
1/3/05	2.92	608.82	2.46	608.65
1/7/05	3.00	608.74	na	
1/10/05	3.00	608.74	na	
1/12/05	3.00	608.74	na	

Date	PZ-2s		PZ-2d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
1/17/05	na		na	
1/21/05	na		na	
1/25/05	na		na	
1/28/05	na		na	
2/1/05	na		na	
2/4/05	na		na	
2/7/05	na		na	
2/10/05	na		na	
2/14/05	na		na	
2/17/05	na		na	
2/22/05	na		na	
2/25/05	na		na	
2/27/05	na		na	
3/4/05	na		na	
3/10/05	na		na	
3/14/05	na		na	
3/17/05	na		na	
3/21/05	na		2.04	609.07
3/24/05	na		2.04	609.07
3/28/05	na		1.95	609.16
3/31/05	na		1.79	609.32
4/4/05	na		1.72	609.39
4/7/05	na		1.71	609.40
4/11/05	na		1.76	609.35
4/15/05	2.42	609.32	1.81	609.30
4/19/05	2.48	609.26	1.81	609.30
4/22/05	2.48	609.26	1.83	609.28
4/26/05	2.27	609.47	1.66	609.45
4/29/05	2.31	609.43	1.67	609.44
5/3/05	2.29	609.45	1.65	609.46
5/6/05	2.40	609.34	1.67	609.44
5/9/05	2.46	609.28	1.71	609.40
5/13/05	2.42	609.32	1.75	609.36
5/17/05	2.42	609.32	1.72	609.39
5/20/05	2.42	609.32	1.75	609.36
5/24/05	2.50	609.24	1.83	609.28
5/27/05	2.56	609.18	1.83	609.28
5/31/05	2.56	609.18	1.90	609.21
6/3/05	2.81	608.93	1.92	609.19
6/6/05	2.77	608.97	1.92	609.19
6/10/05	2.81	608.93	2.04	609.07
6/13/05	2.90	608.84	1.92	609.19
6/17/05	2.92	608.82	2.00	609.11
6/20/05	2.00	609.74	2.79	608.32
6/25/05	2.71	609.03	2.13	608.98
6/27/05	2.88	608.86	2.17	608.94
7/1/05	2.79	608.95	2.13	608.98
7/4/05	2.88	608.86	2.21	608.90

Date	PZ-2s		PZ-2d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
7/8/05	2.88	608.86	2.63	608.48
7/10/05	2.13	609.61	2.31	608.80
7/15/05	2.38	609.36	2.17	608.94
7/18/05	2.38	609.36	2.17	608.94
7/22/05	2.19	609.55	2.46	608.65
7/25/05	2.08	609.66	2.75	608.36
7/29/05	2.08	609.66	3.00	608.11
8/1/05	2.08	609.66	3.00	608.11
8/8/05	2.23	609.51	1.60	609.51
8/12/05	2.29	609.45	1.63	609.48
8/15/05	2.29	609.45	1.79	609.32
8/19/05	2.33	609.41	1.29	609.82
8/26/05	2.40	609.34	1.46	609.65
8/30/05	2.42	609.32	1.50	609.61
9/2/05	2.54	609.20	1.50	609.61
9/5/05	2.63	609.11	1.67	609.44
9/9/05	2.50	609.24	1.50	609.61
9/12/05	2.50	609.24	1.58	609.53
9/19/05	2.63	609.11	1.92	609.19
9/23/05	2.63	609.11	1.92	609.19
9/26/05	2.25	609.49	1.50	609.61
9/30/05	2.17	609.57	1.33	609.78
10/3/05	2.17	609.57	1.33	609.78
10/7/05	2.25	609.49	1.58	609.53
10/11/05	2.25	609.49	1.58	609.53
10/14/05	2.42	609.32	1.67	609.44
10/17/05	2.33	609.41	1.58	609.53
10/21/05	2.38	609.36	1.63	609.48
10/24/05	2.42	609.32	1.63	609.48
10/28/05	2.42	609.32	1.67	609.44
11/1/05	2.38	609.37	1.63	609.49
11/5/05	2.38	609.37	1.58	609.53
11/7/05	2.08	609.66	1.42	609.69
11/10/05	2.08	609.66	1.42	609.69
11/17/05	2.83	608.91	2.33	608.78
11/21/05	2.94	608.80	2.33	608.78
11/25/05	2.94	608.80	2.31	608.80
11/28/05	2.94	608.80	2.31	608.80
12/2/05	2.83	608.91	2.24	608.87
12/6/05	2.85	608.89	2.24	608.87
12/9/05	2.83	608.91	2.26	608.85
12/12/05	2.86	608.88	2.28	608.83
12/16/05	2.93	608.81	2.30	608.81
12/19/05	2.85	608.89	2.24	608.87
12/22/05	2.88	608.87	2.25	608.86
12/26/05	2.71	609.03	2.13	608.99
12/30/05	2.67	609.07	na	
1/3/06	2.52	609.22	1.95	609.16

Date	PZ-2s		PZ-2d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
1/6/06	2.52	609.22	na	
1/10/06	2.52	609.22	1.85	609.26
1/13/06	2.46	609.28	1.79	609.32
1/17/06	2.48	609.26	1.73	609.38
1/20/06	2.42	609.32	1.71	609.40
1/24/06	2.40	609.34	na	
1/28/06	2.38	609.37	1.67	609.44
1/31/06	2.31	609.43	1.49	609.62
2/3/06	2.21	609.53	1.47	609.64
2/7/06	2.13	609.62	na	
2/10/06	2.13	609.62	na	
2/14/06	2.23	609.51	1.58	609.53
2/18/06	2.19	609.55	na	
2/21/06	na		na	
2/24/06	na		na	
2/28/06	na		na	
3/3/06	na		na	
3/7/06	na		na	
3/10/06	na		1.35	609.76
3/14/06	na		1.08	610.03
3/17/06	na		1.19	609.92
3/21/06	na		na	
3/24/06	na		1.33	609.78
3/28/06	na		na	
4/4/06	2.03	609.71	1.34	609.77
4/7/06	2.08	609.66	1.42	609.69
4/11/06	1.98	609.76	1.44	609.67
4/14/06	2.09	609.65	1.42	609.69
4/18/06	2.21	609.53	1.53	609.58
4/21/06	2.23	609.51	1.55	609.56
4/25/06	2.26	609.48	1.60	609.51
4/28/06	2.33	609.41	1.64	609.47
5/1/06	2.35	609.39	1.71	609.40
5/4/06	2.38	609.37	1.75	609.36
5/8/06	2.47	609.27	1.77	609.34
5/11/06	2.24	609.50	1.69	609.42
5/15/06	2.43	609.31	1.79	609.32
5/19/06	2.19	609.55	1.61	609.50

Notes:

PZ-2s is a shallow well located adjacent to Cedar Lake.

PZ-2d is a deeper well located adjacent to Cedar Lake.

Summary of groundwater elevations recorded at Site #3, 7588 Teal Rd.

Date	PZ-3s		PZ-3s2		PZ-3d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
8/11/04	2.92	608.03	4.63	607.53	3.33	607.77
8/13/04	2.88	608.07	4.25	607.91	3.29	607.81
8/17/04	3.08	607.87	5.17	606.99	3.08	608.02
8/24/04	3.19	607.76	5.29	606.87	3.46	607.64
8/27/04	3.08	607.87	5.04	607.12	3.35	607.75
8/31/04	3.17	607.78	5.23	606.93	3.44	607.66
9/3/04	3.21	607.74	5.33	606.83	3.50	607.60
9/6/04	3.27	607.68	5.33	606.83	3.56	607.54
9/9/04	3.27	607.68	5.35	606.81	3.54	607.56
9/13/04	3.38	607.57	5.44	606.72	3.63	607.47
9/17/04	3.43	607.52	5.49	606.67	3.70	607.40
9/22/04	3.56	607.39	5.59	606.57	3.82	607.28
9/25/04	3.58	607.37	5.61	606.55	3.83	607.27
9/28/04	3.54	607.41	5.66	606.50	3.81	607.29
10/1/04	3.69	607.26	5.69	606.47	3.95	607.15
10/5/04	3.74	607.21	5.73	606.43	4.01	607.09
10/8/04	3.76	607.19	5.76	606.40	4.04	607.06
10/12/04	3.76	607.19	5.76	606.40	4.01	607.09
10/15/04	3.76	607.19	5.76	606.40	4.01	607.09
10/19/04	3.74	607.21	5.74	606.42	4.01	607.09
10/22/04	3.79	607.16	5.77	606.39	4.04	607.06
10/26/04	3.70	607.25	5.67	606.49	3.98	607.12
10/28/04	3.75	607.20	5.66	606.50	3.93	607.17
11/1/04	3.76	607.19	5.68	606.48	4.03	607.07
11/5/04	3.71	607.24	5.57	606.59	3.96	607.14
11/9/04	3.80	607.15	5.69	606.47	4.05	607.05
11/12/04	3.78	607.17	5.73	606.43	4.04	607.06
11/16/04	3.84	607.11	5.78	606.38	4.02	607.08
11/19/04	3.81	607.14	5.77	606.39	4.06	607.04
11/22/04	3.80	607.15	5.74	606.42	4.06	607.04
11/24/04	3.81	607.14	5.78	606.38	4.06	607.04
11/29/04	3.60	607.35	5.40	606.76	3.92	607.18
12/2/04	3.54	607.41	5.19	606.97	3.77	607.33
12/6/04	3.61	607.34	5.30	606.86	3.81	607.29
12/9/04	3.40	607.55	4.94	607.22	3.64	607.46
12/14/04	3.36	607.59	5.00	607.16	3.63	607.47
12/17/04	3.43	607.52	5.06	607.10	3.67	607.43
12/20/04	3.45	607.50	5.16	607.00	3.71	607.39
12/23/04	3.46	607.49	5.19	606.97	3.67	607.43
12/28/04	3.48	607.47	5.29	606.87	3.75	607.35
12/31/04	3.08	607.87	5.02	607.14	3.38	607.72
1/3/05	3.04	607.91	4.52	607.64	3.35	607.75
1/7/05	3.25	607.70	4.81	607.35	3.50	607.60
1/10/05	3.23	607.72	4.83	607.33	3.52	607.58
1/12/05	3.23	607.72	4.83	607.33	3.52	607.58
1/17/05	3.09	607.86	4.71	607.45	3.34	607.76

Date	PZ-3s		PZ-3s2		PZ-3d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
1/21/05	3.17	607.78	4.79	607.37	3.38	607.72
1/25/05	3.13	607.82	4.83	607.33	3.36	607.74
1/28/05	3.15	607.80	4.93	607.23	3.38	607.72
2/1/05	3.15	607.80	4.96	607.20	3.38	607.72
2/4/05	3.16	607.79	4.99	607.17	3.38	607.72
2/7/05	2.95	608.00	4.81	607.35	3.29	607.81
2/10/05	3.08	607.87	4.92	607.24	3.33	607.77
2/14/05	2.71	608.24	4.23	607.93	3.04	608.06
2/17/05	2.90	608.05	4.50	607.66	3.13	607.97
2/22/05	3.02	607.93	4.85	607.31	3.24	607.86
2/25/05	3.00	607.95	4.90	607.26	3.23	607.87
2/27/05	3.02	607.93	4.96	607.20	3.19	607.91
3/4/05	2.92	608.03	5.00	607.16	3.24	607.86
3/10/05	2.92	608.03	4.85	607.31	3.19	607.91
3/14/05	2.96	607.99	5.00	607.16	3.23	607.87
3/17/05	3.00	607.95	5.00	607.16	3.25	607.85
3/21/05	2.75	608.20	4.85	607.31	3.17	607.93
3/24/05	2.83	608.12	4.85	607.31	3.15	607.95
3/28/05	2.67	608.28	4.93	607.23	2.98	608.12
3/31/05	2.46	608.49	4.95	607.21	2.76	608.34
4/4/05	2.71	608.24	4.29	607.87	2.90	608.20
4/7/05	2.66	608.29	4.36	607.80	2.86	608.24
4/11/05	2.67	608.28	4.52	607.64	2.91	608.19
4/15/05	2.75	608.20	4.65	607.51	2.96	608.14
4/19/05	2.76	608.19	4.73	607.43	3.00	608.10
4/22/05	2.69	608.26	4.67	607.49	2.94	608.16
4/26/05	2.45	608.50	4.19	607.97	2.73	608.37
4/29/05	2.55	608.40	4.25	607.91	2.79	608.31
5/3/05	2.55	608.40	4.50	607.66	2.78	608.32
5/6/05	2.63	608.32	4.61	607.55	2.86	608.24
5/9/05	2.63	608.32	4.58	607.58	2.83	608.27
5/13/05	2.48	608.47	4.60	607.56	2.85	608.25
5/17/05	2.61	608.34	4.61	607.55	2.84	608.26
5/20/05	2.48	608.47	4.60	607.56	2.85	608.25
5/24/05	2.65	608.30	4.77	607.39	2.92	608.18
5/27/05	2.69	608.26	4.82	607.34	2.96	608.14
5/31/05	2.72	608.23	4.86	607.30	2.98	608.12
6/3/05	2.80	608.15	4.86	607.30	3.07	608.03
6/7/05	2.86	608.09	5.03	607.13	3.13	607.97
6/10/05	2.88	608.07	5.07	607.09	3.14	607.96
6/14/05	2.56	608.39	4.38	607.78	2.85	608.25
6/17/05	2.73	608.22	4.68	607.48	2.96	608.14
6/21/05	2.79	608.16	4.85	607.31	3.07	608.03
6/24/05	2.96	607.99	5.00	607.16	3.21	607.89
6/28/05	2.98	607.97	5.06	607.10	3.23	607.87
7/1/05	2.95	608.00	5.05	607.11	3.20	607.90
7/5/05	2.91	608.04	5.03	607.13	3.18	607.92
7/8/05	3.05	607.90	5.15	607.01	3.32	607.78

Date	PZ-3s		PZ-3s2		PZ-3d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
7/11/05	3.13	607.82	5.23	606.93	3.40	607.70
7/15/05	3.17	607.78	5.29	606.87	3.44	607.66
7/18/05	3.17	607.78	5.24	606.92	3.45	607.65
7/22/05	3.21	607.74	5.28	606.88	3.48	607.62
7/26/05	3.11	607.84	5.00	607.16	3.35	607.75
7/29/05	3.21	607.74	5.17	606.99	3.46	607.64
8/1/05	3.27	607.68	5.29	606.87	3.53	607.57
8/5/05	3.33	607.62	5.38	606.78	3.58	607.52
8/9/05	3.43	607.52	5.45	606.71	3.74	607.36
8/12/05	3.44	607.51	5.44	606.72	3.71	607.39
8/15/05	3.50	607.45	5.52	606.64	3.77	607.33
8/18/05	3.56	607.39	5.58	606.58	3.83	607.27
8/22/05	3.34	607.61	5.13	607.03	3.58	607.52
8/26/05	3.47	607.48	5.33	606.83	3.71	607.39
8/30/05	3.49	607.46	5.42	606.74	3.75	607.35
9/2/05	3.56	607.39	5.52	606.64	3.83	607.27
9/6/05	3.66	607.29	5.59	606.57	3.92	607.18
9/9/05	3.51	607.44	5.46	606.70	3.78	607.32
9/13/05	3.64	607.31	5.63	606.53	3.88	607.22
9/17/05	3.58	607.37	5.57	606.59	3.83	607.27
9/20/05	3.63	607.32	5.65	606.51	3.89	607.21
9/23/05	3.69	607.26	5.68	606.48	3.94	607.16
9/27/05	3.20	607.75	4.66	607.50	3.44	607.66
9/30/05	3.21	607.74	4.57	607.59	3.43	607.67
10/4/05	3.34	607.61	4.90	607.26	3.56	607.54
10/7/05	3.35	607.60	5.00	607.16	3.56	607.54
10/10/05	3.42	607.53	5.09	607.07	3.63	607.47
10/13/05	3.41	607.54	5.08	607.08	3.61	607.49
10/18/05	3.38	607.57	5.09	607.07	3.61	607.49
10/21/05	3.46	607.49	5.22	606.94	3.68	607.42
10/24/05	3.38	607.57	5.17	606.99	3.61	607.49
10/28/05	3.50	607.45	5.29	606.87	3.73	607.37
10/31/05	3.52	607.43	5.35	606.81	3.77	607.33
11/3/05	3.40	607.55	4.63	607.54	3.64	607.46
11/7/05	3.11	607.84	4.67	607.49	3.40	607.70
11/10/05	3.30	607.65	4.92	607.24	3.52	607.58
11/14/05	3.31	607.64	4.98	607.18	3.52	607.58
11/17/05	3.16	607.79	4.74	607.42	3.38	607.73
11/21/05	3.22	607.73	4.85	607.31	3.38	607.73
11/25/05	3.25	607.70	4.96	607.20	3.50	607.60
11/28/05	3.25	607.70	4.98	607.18	3.50	607.60
12/2/05	3.01	607.94	4.73	607.43	3.27	607.83
12/6/05	3.11	607.84	4.85	607.31	3.33	607.77
12/9/05	3.11	607.84	4.93	607.23	3.33	607.77
12/12/05	3.13	607.83	4.99	607.17	3.35	607.75
12/16/05	3.04	607.91	4.92	607.24	3.31	607.79
12/19/05	3.07	607.88	5.03	607.13	3.33	607.77
12/22/05	3.05	607.90	4.99	607.17	3.32	607.78

Date	PZ-3s		PZ-3s2		PZ-3d	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
12/27/05	2.75	608.20	4.42	607.74	3.06	608.04
12/30/05	2.83	608.12	4.46	607.70	3.06	608.04
1/3/06	2.92	608.03	4.16	608.00	2.67	608.43
1/6/06	2.72	608.23	4.24	607.92	2.92	608.18
1/10/06	2.59	608.36	4.33	607.83	2.92	608.18
1/13/06	2.45	608.50	3.99	608.17	2.79	608.31
1/17/06	2.45	608.50	4.07	608.09	2.73	608.37
1/20/06	2.50	608.45	4.23	607.93	2.75	608.35
1/24/06	2.51	608.44	4.27	607.89	2.77	608.33
1/28/06	2.50	608.45	4.25	607.91	2.75	608.35
1/31/06	2.27	608.68	3.72	608.44	2.47	608.63
2/3/06	2.33	608.62	3.90	608.26	2.55	608.55
2/7/06	2.29	608.66	4.02	608.14	2.51	608.59
2/10/06	2.29	608.66	4.11	608.05	2.55	608.55
2/14/06	2.28	608.67	4.17	607.99	2.53	608.57
2/18/06	2.25	608.70	4.22	607.94	2.50	608.60
2/21/06	2.31	608.64	4.38	607.79	2.58	608.52
2/24/06	2.32	608.63	4.40	607.76	2.63	608.48
2/28/06	2.38	608.58	4.47	607.69	2.65	608.45
3/3/06	2.38	608.58	4.54	607.62	2.67	608.43
3/7/06	2.35	608.60	4.51	607.65	2.67	608.43
3/10/06	1.56	609.39	2.92	609.24	2.05	609.05
3/14/06	1.63	609.33	na		2.04	609.06
3/17/06	2.00	608.95	3.38	608.79	2.17	608.93
3/21/06	1.98	608.97	3.63	608.54	2.06	609.04
3/24/06	2.06	608.89	3.79	608.37	2.31	608.79
3/28/06	2.08	608.87	3.92	608.24	2.38	608.73
4/4/06	1.96	608.99	3.52	608.64	2.19	608.91
4/7/06	2.16	608.79	3.92	608.24	2.41	608.69
4/11/06	2.01	608.94	3.68	608.48	2.34	608.76
4/14/06	2.13	608.83	3.72	608.44	2.38	608.73
4/18/06	2.31	608.64	4.15	608.01	2.52	608.58
4/21/06	2.38	608.58	4.24	607.92	2.61	608.49
4/25/06	2.32	608.63	4.13	608.04	2.56	608.54
4/28/06	2.46	608.49	4.35	607.81	2.68	608.42
5/1/06	2.50	608.45	4.46	607.70	2.75	608.35
5/4/06	2.52	608.43	4.48	607.68	2.79	608.31
5/8/06	2.63	608.33	4.59	607.57	2.88	608.23
5/11/06	2.32	608.63	4.13	608.04	2.67	608.43
5/15/06	2.51	608.44	4.48	607.68	2.76	608.34
5/19/06	2.10	608.85	3.65	608.51	2.40	608.70

Notes:

PZ-3s is a shallow well located adjacent to Cedar Lake.

PZ-3s2 is a shallow well located approximately 325 ft west of PZ-3s.

PZ-3d is a deeper well located adjacent to Cedar Lake.

Summary of groundwater elevations recorded at Site #4, 4840 E. Cedar Lake Dr.

Date	PZ-4s	
	Field Reading (ft)	GW Elev (ft)
9/20/05	6.39	605.51
9/24/05	6.46	605.44
9/27/05	5.73	606.17
10/1/05	5.67	606.23
10/4/05	5.71	606.19
10/12/05	5.92	605.98
10/15/05	5.94	605.96
10/20/05	6.00	605.90
10/25/05	6.13	605.77
10/27/05	6.16	605.74
10/31/05	6.21	605.69
11/4/05	6.10	605.80
11/7/05	5.74	606.16
11/12/05	5.81	606.09
11/15/05	5.83	606.07
11/18/05	5.73	606.17
11/22/05	5.79	606.11
11/25/05	5.88	606.03
11/28/05	5.88	606.03
12/2/05	5.66	606.24
12/6/05	5.69	606.21
12/11/05	5.83	606.07
12/16/05	5.85	606.05
12/19/05	5.83	606.07
12/23/05	5.84	606.06
12/26/05	5.47	606.43
1/2/06	5.40	606.50
1/6/06	5.15	606.75
1/9/06	5.15	606.75
1/13/06	5.04	606.86
1/16/06	4.94	606.96
1/20/06	4.89	607.01
1/23/06	4.84	607.06
1/27/06	4.86	607.04
1/30/06	4.40	607.50
2/3/06	4.49	607.41
2/6/06	4.43	607.47
2/10/06	4.47	607.43
2/13/06	4.50	607.40
2/17/06	4.49	607.41
2/20/06	4.50	607.40
2/24/06	4.58	607.32
2/27/06	4.58	607.32
3/6/06	4.67	607.23
3/10/06	4.04	607.86
3/13/06	3.79	608.11

Date	PZ-4s	
	Field Reading (ft)	GW Elev (ft)
3/17/06	3.99	607.91
3/20/06	4.08	607.82
3/24/06	4.10	607.80
3/27/06	4.08	607.82
4/3/06	3.67	608.23
4/7/06	3.93	607.97
4/10/06	4.06	607.84
4/11/06	4.09	607.81
4/15/06	3.99	607.91
4/17/06	4.07	607.83
4/27/06	4.13	607.78
5/1/06	4.29	607.61
5/6/06	4.38	607.53
5/9/06	4.44	607.46
5/12/06	4.32	607.58
5/15/06	4.40	607.50
5/16/06	3.98	607.92
5/22/06	4.15	607.75

Notes:

PZ-4s is a shallow well located adjacent to Cedar Lake.

Summary of groundwater elevations recorded at Site #5, 6967 Lakewood Dr.

Date	PZ-5s	
	Field Reading (ft)	GW Elev (ft)
9/15/05	4.51	606.37
9/20/05	4.58	606.30
9/22/05	4.65	606.23
9/25/05	4.69	606.19
9/29/05	4.07	606.81
10/4/05	4.23	606.65
10/7/05	4.21	606.67
10/10/05	4.35	606.53
10/13/05	4.38	606.50
10/17/05	4.44	606.44
10/21/05	4.45	606.43
10/27/05	4.50	606.38
10/31/05	4.56	606.32
11/4/05	4.50	606.38
11/7/05	4.24	606.64
11/12/05	4.30	606.58
11/15/05	4.25	606.63
11/18/05	4.22	606.66
11/22/05	4.16	606.72
11/25/05	4.26	606.62
11/28/05	4.27	606.61
12/2/05	4.08	606.80
12/6/05	4.16	606.72
12/11/05	4.27	606.61
12/16/05	4.26	606.62
12/19/05	4.27	606.61
12/23/05	4.23	606.65
12/26/05	4.04	606.84
1/2/06	3.91	606.97
1/6/06	3.73	607.15
1/9/06	3.68	607.20
1/13/06	3.63	607.26
1/16/06	3.52	607.36
1/20/06	3.49	607.39
1/23/06	3.42	607.46
1/27/06	3.42	607.46
1/30/06	3.21	607.67
2/3/06	3.15	607.73
2/6/06	3.06	607.82
2/10/06	3.08	607.80
2/13/06	3.09	607.79
2/17/06	3.05	607.83
2/20/06	3.06	607.82
2/24/06	3.15	607.73
2/27/06	3.15	607.73
3/6/06	3.25	607.63

Date	PZ-5s	
	Field Reading (ft)	GW Elev (ft)
3/10/06	3.00	607.88
3/13/06	2.81	608.07
3/17/06	2.77	608.11
3/20/06	2.79	608.09
3/24/06	2.67	608.21
3/27/06	2.46	608.42
4/3/06	2.29	608.59
4/7/06	2.31	608.57
4/10/06	2.52	608.36
4/11/06	2.53	608.35
4/15/06	2.44	608.44
4/17/06	2.49	608.39
4/24/06	2.69	608.19
5/1/06	2.90	607.98
5/6/06	2.96	607.92
5/9/06	3.10	607.78
5/12/06	3.01	607.87
5/15/06	2.88	608.01
5/19/06	2.72	608.16
5/22/06	2.65	608.23

Notes:

PZ-5s is a shallow well located adjacent to Cedar Lake.

Summary of groundwater elevations recorded at Site #6, 7906 W. Cedar Lake Rd.

Date	PZ-6s		PZ-6s2	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
9/17/05	3.65	607.36	9.73	607.41
9/20/05	3.73	607.28	9.81	607.33
9/23/05	3.81	607.20	9.81	607.33
9/27/05	3.44	607.57	8.88	608.26
9/30/05	3.44	607.57	8.88	608.26
10/4/05	3.44	607.57	9.02	608.12
10/7/05	3.50	607.51	9.06	608.08
10/11/05	3.58	607.43	9.23	607.91
10/14/05	3.52	607.49	9.27	607.87
10/17/05	3.56	607.45	9.35	607.79
10/20/05	3.56	607.45	9.42	607.72
10/24/05	3.54	607.47	9.48	607.66
10/27/05	3.63	607.38	9.52	607.62
10/31/05	3.65	607.36	9.60	607.54
11/3/05	3.56	607.45	9.54	607.60
11/7/05	3.42	607.59	9.29	607.85
11/10/05	3.40	607.61	9.21	607.93
11/14/05	3.48	607.53	9.35	607.79
11/17/05	3.38	607.64	9.25	607.89
11/21/05	3.38	607.64	9.32	607.82
11/25/05	3.40	607.61	9.40	607.74
11/28/05	3.40	607.61	9.40	607.74
12/2/05	3.26	607.75	9.21	607.93
12/2/05	3.26	607.75	9.21	607.93
12/5/05	3.23	607.78	9.24	607.90
12/8/05	3.35	607.66	9.31	607.83
12/12/05	3.27	607.74	9.27	607.87
12/15/05	3.27	607.74	9.35	607.79
12/19/05	3.19	607.82	9.40	607.74
12/22/05	3.23	607.78	9.52	607.62
12/26/05	2.92	608.09	9.13	608.02
12/29/05	3.04	607.97	9.02	608.12
1/2/06	2.98	608.03	8.98	608.16
1/5/06	2.94	608.07	8.77	608.37
1/9/06	2.90	608.11	8.73	608.41
1/12/06	2.85	608.16	8.81	608.33
1/17/06	2.83	608.18	8.79	608.35
1/20/06	2.77	608.24	8.71	608.43
1/24/06	2.73	608.28	8.76	608.38
1/28/06	2.69	608.32	8.75	608.39
1/31/06	2.56	608.45	8.46	608.68
2/3/06	2.58	608.43	8.40	608.74
2/7/06	2.46	608.55	8.48	608.66
2/10/06	2.46	608.55	8.48	608.66
2/13/06	2.52	608.49	8.65	608.49
2/16/06	2.50	608.51	8.73	608.41

Date	PZ-6s		PZ-6s2	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
2/20/06	2.50	608.51	8.79	608.35
2/23/06	2.50	608.51	8.83	608.31
2/27/06	2.54	608.47	8.88	608.27
3/2/06	2.56	608.45	9.00	608.14
3/6/06	2.60	608.41	9.00	608.14
3/9/06	2.56	608.45	8.98	608.16
3/13/06	2.15	608.86	9.13	608.02
3/16/06	2.27	608.74	7.85	609.29
3/20/06	2.29	608.72	8.13	609.02
3/24/06	2.29	608.72	8.29	608.85
3/28/06	2.38	608.64	8.42	608.72
3/31/06	2.42	608.59	8.46	608.68
4/3/06	2.25	608.76	8.40	608.74
4/6/06	2.38	608.64	8.23	608.91
4/10/06	2.46	608.55	8.41	608.73
4/13/06	2.44	608.57	8.38	608.77
4/17/06	2.46	608.55	8.44	608.70
4/20/06	2.54	608.47	8.50	608.64
4/24/06	2.56	608.45	8.54	608.60
4/27/06	2.58	608.43	8.60	608.54
5/1/06	2.69	608.32	8.58	608.56
5/4/06	2.71	608.30	8.65	608.49
5/8/06	2.77	608.24	8.71	608.43
5/12/06	2.73	608.28	8.63	608.52
5/15/06	2.73	608.28	8.71	608.43
5/19/06	2.54	608.47	8.44	608.70
5/22/06	2.60	608.41	8.29	608.85

Notes:

PZ-6s is a shallow well located adjacent to Cedar Lake.

PZ-6s2 is a shallow well located approximately 360 ft west of PZ-6s.

Summary of groundwater elevations recorded at Site #7, 4795 W. Cedar Lake Rd.

Date	PZ-7s		PZ-7s2	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
9/17/05	na		3.50	608.04
9/20/05	na		3.60	607.94
9/23/05	3.58	607.68	3.58	607.96
9/27/05	3.60	607.66	2.56	608.98
9/30/05	3.58	607.68	2.25	609.29
10/4/05	3.67	607.59	2.42	609.12
10/7/05	3.71	607.55	2.50	609.04
10/11/05	3.77	607.49	2.63	608.91
10/14/05	3.73	607.53	2.58	608.96
10/17/05	3.77	607.49	2.71	608.83
10/20/05	3.75	607.51	2.63	608.91
10/24/05	3.74	607.52	2.63	608.91
10/27/05	3.78	607.48	2.63	608.91
10/31/05	3.80	607.46	2.73	608.81
11/3/05	3.69	607.57	2.31	609.23
11/7/05	3.48	607.78	1.81	609.73
11/10/05	3.55	607.71	1.94	609.60
11/14/05	3.56	607.70	2.00	609.54
11/17/05	3.54	607.72	na	
11/21/05	3.50	607.76	1.90	609.64
11/25/05	3.48	607.78	2.00	609.54
11/28/05	3.48	607.78	2.00	609.54
12/2/05	3.31	607.95	1.71	609.83
12/2/05	na		na	
12/5/05	3.35	607.91	1.81	609.73
12/8/05	3.35	607.91	1.81	609.73
12/12/05	3.38	607.89	1.02	610.52
12/15/05	3.38	607.89	1.02	610.52
12/19/05	3.33	607.93	2.98	608.56
12/22/05	3.32	607.94	2.94	608.60
12/26/05	3.15	608.11	1.40	610.14
12/29/05	3.14	608.12	1.81	609.73
12/31/05	na		na	
1/2/06	3.08	608.18	1.42	610.12
1/5/06	2.99	608.27	1.23	610.31
1/9/06	2.94	608.32	1.40	610.14
1/12/06	2.96	608.30	1.27	610.27
1/17/06	2.92	608.34	1.25	610.29
1/20/06	2.90	608.36	1.35	610.19
1/24/06	2.81	608.45	1.43	610.11
1/28/06	2.79	608.47	1.42	610.12
1/31/06	2.63	608.64	1.04	610.50
2/3/06	2.67	608.59	1.10	610.44
2/7/06	2.58	608.68	1.13	610.42
2/10/06	2.63	608.64	1.33	610.21
2/13/06	2.63	608.64	1.38	610.17

Date	PZ-7s		PZ-7s2	
	Field Reading (ft)	GW Elev (ft)	Field Reading (ft)	GW Elev (ft)
2/16/06	2.65	608.61	1.44	610.10
2/20/06	2.63	608.64	1.52	610.02
2/23/06	2.65	608.61	1.58	609.96
2/27/06	2.67	608.59	1.63	609.92
3/2/06	2.67	608.59	1.67	609.87
3/6/06	2.71	608.55	1.69	609.85
3/9/06	2.63	608.64	1.54	610.00
3/13/06	2.08	609.18	1.13	610.42
3/16/06	2.35	608.91	0.81	610.73
3/20/06	2.40	608.86	1.00	610.54
3/24/06	2.41	608.85	1.13	610.42
3/28/06	2.46	608.80	1.25	610.29
3/31/06	2.54	608.72	1.29	610.25
4/3/06	2.25	609.01	1.02	610.52
4/6/06	2.48	608.78	1.13	610.42
4/10/06	2.56	608.70	1.27	610.27
4/13/06	2.54	608.72	1.21	610.33
4/17/06	2.60	608.66	1.33	610.21
4/20/06	2.67	608.59	1.42	610.12
4/24/06	2.69	608.57	1.46	610.08
4/27/06	2.71	608.55	1.52	610.02
5/1/06	2.79	608.47	1.63	609.92
5/4/06	2.83	608.43	1.69	609.85
5/8/06	2.88	608.39	1.79	609.75
5/12/06	2.79	608.47	1.52	610.02
5/15/06	2.81	608.45	1.63	609.92
5/19/06	2.52	608.74	1.06	610.48
5/22/06	2.69	608.57	1.27	610.27

Notes:

PZ-7s is a shallow well located adjacent to Cedar Lake.

PZ-7s2 is a shallow well located approximately 410 ft west of PZ-7s.

Summary of precipitation data recorded at Site #1, 4484 E. Cedar Lake Dr.

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
8/6/04	0.00	0.00	0.00
8/11/04	0.03	0.03	0.26
8/12/04	0.04	0.01	0.00
8/13/04	0.55	0.51	0.11
8/14/04	0.65	0.10	0.06
8/15/04	0.65	0.00	0.00
8/16/04	0.00	0.00	0.00
8/17/04		0.00	0.00
8/18/04	0.08	0.08	0.08
8/19/04	0.08	0.00	0.00
8/20/04		0.00	0.00
8/21/04		0.00	0.00
8/22/04		0.00	0.00
8/23/04		0.00	0.00
8/24/04		0.00	0.00
8/25/04		0.00	0.00
8/26/04	0.77	0.69	0.64
8/27/04	0.87	0.10	0.32
8/28/04	0.89	0.02	0.01
8/29/04	0.99	0.10	0.10
8/30/04	0.99	0.00	0.00
8/31/04	0.99	0.00	0.00
9/1/04	0.00	0.00	0.00
9/2/04	0.00	0.00	0.01
9/3/04		0.00	0.00
9/4/04		0.00	0.00
9/5/04		0.00	0.00
9/6/04		0.00	0.01
9/7/04	0.25	0.25	0.44
9/8/05		0.00	0.01
9/9/04		0.00	0.00
9/10/04		0.00	0.00
9/11/05		0.00	0.00
9/12/04		0.00	0.00
9/13/04		0.00	0.00
9/14/04		0.00	0.00
9/15/04		0.00	0.00
9/16/04	0.25	0.25	0.02
9/17/04		0.00	0.00
9/18/04		0.00	0.00
9/19/04		0.00	0.00
9/20/04		0.00	0.00
9/21/04		0.00	0.00
9/22/04		0.00	0.00
9/23/04		0.00	0.00
9/24/04		0.00	0.00

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
9/25/04		0.00	0.00
9/26/04		0.00	0.00
9/27/04		0.00	0.00
9/28/04	0.27	0.27	0.04
9/29/04		0.00	0.00
9/30/04		0.00	0.00
10/1/04		0.00	0.00
10/2/04	0.22	0.22	0.23
10/3/04		0.00	0.01
10/4/04		0.00	0.00
10/5/04		0.00	0.00
10/6/04		0.00	0.00
10/7/04		0.00	0.00
10/8/04		0.00	0.00
10/9/04		0.00	0.95
10/10/04	0.03	0.03	0.00
10/11/04		0.00	0.00
10/12/04		0.00	0.00
10/13/04		0.00	0.00
10/14/04		0.00	0.01
10/15/04		0.00	0.04
10/16/04		0.00	0.66
10/17/04		0.00	0.17
10/18/04		0.00	0.03
10/19/04		0.00	0.00
10/20/04		0.00	0.00
10/21/04		0.00	0.00
10/22/04		0.00	0.00
10/23/04		0.00	0.00
10/24/04	0.64	0.61	0.38
10/25/04		0.00	0.00
10/26/04		0.00	0.00
10/27/04		0.00	0.02
10/28/04		0.00	0.01
10/29/04	0.86	0.22	0.16
10/30/04		0.00	0.00
10/31/04	0.87	0.01	0.07
11/1/04		0.00	0.00
11/2/04	1.41	0.54	0.33
11/3/04		0.00	0.03
11/4/04		0.00	0.00
11/5/04	1.48	0.07	0.14
11/6/04		0.00	0.00
11/7/04		0.00	0.00
11/8/04		0.00	0.00
11/9/04		0.00	0.05
11/10/04		0.00	0.00
11/11/04	1.51	0.03	0.03

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
11/12/04		0.00	0.00
11/13/04		0.00	0.00
11/14/04		0.00	0.00
11/15/04		0.00	0.00
11/16/04		0.00	0.00
11/17/04	1.67	0.16	0.01
11/18/04		0.00	0.08
11/19/04		0.00	0.00
11/20/04		0.00	0.17
11/21/04		0.00	0.02
11/22/04	1.92	0.25	0.00
11/23/04		0.00	0.00
11/24/04		0.00	0.00
11/25/04		0.00	0.22
11/26/04		0.00	0.02
11/27/04		0.00	0.33
11/28/04		0.00	0.30
11/29/04	2.93	1.01	0.07
11/30/04		0.00	0.00
12/1/04		0.00	0.41
12/2/04	3.52	0.59	0.01
12/3/04		0.00	0.03
12/4/04		0.00	0.00
12/5/04		0.00	0.02
12/6/04		0.00	0.00
12/7/04		0.00	0.02
12/8/04	4.59	1.07	0.73
12/9/04		0.00	0.00
12/10/04		0.00	0.00
12/11/04	4.94	0.35	0.15
12/12/04	removed	removed	0.03
12/13/04	na	na	0.37
12/14/04	na	na	0.04
12/15/04	na	na	0.00
12/16/04	na	na	0.00
12/17/04	na	na	0.03
12/18/04	na	na	0.00
12/19/04	na	na	0.00
12/20/04	na	na	0.00
12/21/04	na	na	0.12
12/22/04	na	na	0.06
12/23/04	na	na	0.01
12/24/04	na	na	0.05
12/25/04	na	na	0.00
12/26/04	na	na	0.02
12/27/04	na	na	0.07
12/28/04	na	na	0.00
12/29/04	na	na	0.00

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
12/30/04	na	na	0.00
12/31/04	na	na	0.15
1/1/05	na	na	0.00
1/2/05	na	na	0.50
1/3/05	na	na	0.04
1/4/05	na	na	0.00
1/5/05	na	na	0.00
1/6/05	na	na	0.00
1/7/05	na	na	0.17
1/8/05	na	na	0.00
1/9/05	na	na	0.00
1/10/05	na	na	0.00
1/11/05	na	na	0.00
1/12/05	na	na	0.05
1/13/05	na	na	0.63
1/14/05	na	na	0.49
1/15/05	na	na	0.00
1/16/05	na	na	0.00
1/17/05	na	na	0.00
1/18/05	na	na	0.00
1/19/05	na	na	0.08
1/20/05	na	na	0.03
1/21/05	na	na	0.00
1/22/05	na	na	0.15
1/23/05	na	na	0.16
1/24/05	na	na	0.02
1/25/05	na	na	0.00
1/26/05	na	na	0.19
1/27/05	na	na	0.01
1/28/05	na	na	0.00
1/29/05	na	na	0.00
1/30/05	na	na	0.00
1/31/05	na	na	0.00
2/1/05	na	na	0.00
2/2/05	na	na	0.00
2/3/05	na	na	0.00
2/4/05	na	na	0.00
2/5/05	na	na	0.00
2/6/05	na	na	0.00
2/7/05	na	na	0.02
2/8/05	na	na	0.04
2/9/05	na	na	0.03
2/10/05	na	na	0.06
2/11/05	na	na	0.00
2/12/05	na	na	0.00
2/13/05	na	na	0.00
2/14/05	na	na	0.33
2/15/05	na	na	0.11

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
2/16/05	na	na	0.00
2/17/05	na	na	0.00
2/18/05	na	na	0.00
2/19/05	na	na	0.00
2/20/05	na	na	0.00
2/21/05	na	na	0.28
2/22/05	na	na	0.00
2/23/05	na	na	0.01
2/24/05	na	na	0.00
2/25/05	na	na	0.00
2/26/05	na	na	0.00
2/27/05	na	na	0.00
2/28/05	na	na	0.08
3/1/05	na	na	0.22
3/2/05	na	na	0.08
3/3/05	na	na	0.01
3/4/05	na	na	0.00
3/5/05	na	na	0.00
3/6/05	na	na	0.00
3/7/05	na	na	0.22
3/8/05	na	na	0.35
3/9/05	na	na	0.00
3/10/05	na	na	0.00
3/11/05	na	na	0.00
3/12/05	na	na	0.09
3/13/05	na	na	0.00
3/14/05	na	na	0.00
3/15/05	na	na	0.00
3/16/05	na	na	0.00
3/17/05	na	na	0.02
3/18/05	na	na	0.00
3/19/05	na	na	0.00
3/20/05	na	na	0.28
3/21/05	na	na	0.05
3/22/05	na	na	0.00
3/23/05	na	na	0.00
3/24/05	na	na	0.00
3/25/05	na	na	0.00
3/26/05	na	na	0.00
3/27/05	na	na	0.00
3/28/05	na	na	0.00
3/29/05	na	na	0.00
3/30/05	na	na	0.00
3/31/05	na	na	0.00
4/1/05	na	na	0.00
4/2/05	na	na	0.00
4/3/05	na	na	0.00
4/4/05	na	na	0.00

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
4/5/05	na	na	0.00
4/6/05	na	na	0.00
4/7/05	na	na	0.11
4/8/05	na	na	0.00
4/9/05	na	na	0.00
4/10/05	na	na	0.00
4/11/05	na	na	0.00
4/12/05	na	na	0.00
4/13/05	na	na	0.00
4/14/05	na	na	0.00
4/15/05	na	na	0.00
4/16/05	na	na	0.00
4/17/05	na	na	0.00
4/18/05	na	na	0.00
4/19/05	na	na	0.00
4/20/05	na	na	0.48
4/21/05	na	na	0.05
4/22/05	na	na	0.00
4/23/05	na	na	0.00
4/24/05	na	na	0.52
4/25/05	na	na	0.39
4/26/05	reinstalled	reinstalled	0.00
4/27/05	0.85	0.00	0.00
4/28/05	0.96	0.11	0.33
4/29/05	0.00	0.00	0.00
4/30/05		0.00	0.00
5/1/05		0.00	0.00
5/2/05	0.11	0.11	0.25
5/3/05		0.00	0.35
5/4/05		0.00	0.00
5/5/05	0.45	0.34	0.00
5/6/05		0.00	0.00
5/7/05		0.00	0.14
5/8/05		0.00	0.00
5/9/05	0.71	0.26	0.00
5/10/05		0.00	0.00
5/11/05		0.00	0.00
5/12/05		0.00	0.00
5/13/05		0.00	0.00
5/14/05	1.25	0.54	0.00
5/15/05		0.00	0.24
5/16/05	1.43	0.18	0.01
5/17/05		0.00	0.00
5/18/05		0.00	0.00
5/19/05	1.43	0.00	0.00
5/20/05		0.00	0.00
5/21/05		0.00	0.00
5/22/05	1.54	0.11	0.00

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
5/23/05		0.00	0.04
5/24/05		0.00	0.06
5/25/05		0.00	0.00
5/26/05		0.00	0.00
5/27/05		0.00	0.00
5/28/05		0.00	0.00
5/29/05		0.00	0.04
5/30/05		0.00	0.00
5/31/05		0.00	0.00
6/1/05		0.00	0.00
6/2/05	1.64	0.00	0.00
6/3/05		0.00	0.00
6/4/05		0.00	0.00
6/5/05		0.00	0.00
6/6/05	1.76	0.12	0.06
6/7/05		0.00	0.00
6/8/05		0.00	0.37
6/9/05	1.78	0.02	0.17
6/10/05		0.00	0.13
6/11/05		0.00	0.10
6/12/05		0.00	0.01
6/13/05	3.32	1.54	0.02
6/14/05		0.00	0.87
6/15/05		0.00	0.20
6/16/05	3.56	0.24	0.19
6/17/05		0.00	0.03
6/18/05		0.00	0.00
6/19/05		0.00	0.00
6/20/05	3.59	0.03	0.00
6/21/05		0.00	0.00
6/22/05		0.00	0.31
6/23/05	3.88	0.29	0.00
6/24/05		0.00	0.00
6/25/05		0.00	0.00
6/26/05		0.00	0.08
6/27/05	4.01	0.13	0.06
6/28/05		0.00	0.00
6/29/05		0.00	0.84
6/30/05	4.84	0.83	0.00
7/1/05		0.00	0.16
7/2/05		0.00	0.00
7/3/05		0.00	0.00
7/4/05	4.87	0.03	0.00
7/5/05		0.00	0.39
7/6/05		0.00	0.00
7/7/05	0.37	0.37	0.00
7/8/05		0.00	0.00
7/9/05		0.00	0.00

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
7/10/05		0.00	0.00
7/11/05	0.37	0.00	0.00
7/12/05		0.00	0.00
7/13/05		0.00	0.00
7/14/05		0.00	0.00
7/15/05		0.00	0.00
7/16/05		0.00	0.00
7/17/05	1.15	0.78	0.00
7/18/05		0.00	
7/19/05		0.00	1.85
7/20/05		0.00	0.00
7/21/05	1.60	0.45	
7/22/05		0.00	0.36
7/23/05		0.00	0.00
7/24/05		0.00	0.18
7/25/05	2.40	0.80	0.48
7/26/05		0.00	0.54
7/27/05		0.00	0.06
7/28/05	3.06	0.66	0.00
7/29/05		0.00	0.06
7/30/05		0.00	0.00
7/31/05		0.00	0.00
8/1/05	3.06	0.00	0.24
8/2/05		0.00	0.36
8/3/05		0.00	0.00
8/4/05		0.00	0.00
8/5/05		0.00	0.23
8/6/05		0.00	0.00
8/7/05		0.00	0.00
8/8/05	0.20	0.20	0.00
8/9/05		0.00	0.00
8/10/05		0.00	0.00
8/11/05		0.00	0.02
8/12/05		0.00	0.57
8/13/05		0.00	0.05
8/14/05		0.00	0.00
8/15/05	0.44	0.24	0.00
8/16/05		0.00	0.00
8/17/05		0.00	0.00
8/18/05		0.00	0.00
8/19/05		0.00	1.77
8/20/05		0.00	0.21
8/21/05		0.00	na
8/22/05	2.60	2.16	na
8/23/05		0.00	na
8/24/05		0.00	na
8/25/05		0.00	na
8/26/05		0.00	na

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
8/27/05		0.00	na
8/28/05		0.00	na
8/29/05	2.68	0.08	na
8/30/05		0.00	na
8/31/05		0.00	na
9/1/05		0.00	na
9/2/05		0.00	na
9/3/05		0.00	na
9/4/05		0.00	na
9/5/05		0.00	na
9/6/05		0.00	na
9/7/05		0.00	na
9/8/05		0.00	na
9/9/05	2.61	2.61	na
9/10/05		0.00	na
9/11/05		0.00	na
9/12/05		0.00	na
9/13/05		0.00	na
9/14/05		0.00	na
9/15/05	2.92	0.31	na
9/16/05		0.00	na
9/17/05		0.00	na
9/18/05		0.00	na
9/19/05	3.07	0.15	na
9/20/05		0.00	na
9/21/05		0.00	na
9/22/05		0.00	na
9/23/05		0.00	na
9/24/05		0.00	na
9/25/05		0.00	na
9/26/05		0.00	na
9/27/05	6.13	3.06	na
9/28/05		0.00	na
9/29/05	1.08	1.08	na
9/30/05		0.00	na
10/1/05		0.00	na
10/2/05		0.00	na
10/3/05		0.00	na
10/4/05		0.00	na
10/5/05		0.00	na
10/6/05	1.36	0.28	na
10/7/05		0.00	na
10/8/05		0.00	na
10/9/05		0.00	na
10/10/05		0.00	na
10/11/05		0.00	na
10/12/05		0.00	na
10/13/05		0.00	na

Date	Field Reading (cumulative)	Calculated K&A gage Precip.	NOAA Harrisville Precip.
10/14/05		0.00	na
10/15/05		0.00	na
10/16/05		0.00	na
10/17/05	1.42	0.06	na
10/18/05		0.00	na
10/19/05		0.00	na
10/20/05	1.85	0.43	na
10/21/05		0.00	na
10/22/05		0.00	na
10/23/05		0.00	na
10/24/05	2.06	0.21	na
10/25/05		0.00	na
10/26/05		0.00	na
10/27/05	2.12	0.06	na
10/28/05		0.00	na
10/29/05		0.00	na
10/30/05		0.00	na
10/31/05	2.12	0.00	na
10/31/05	removed	removed	na

Summary of Cedar Lake water level elevations recorded at Site #1, 4484 E. Cedar Lake Dr.

Date	Time	Staff Gage Field Reading (ft)	Lake Elev (ft)
8/6/04	7:45 AM	1.58	608.32
8/11/04	9:00 AM	1.50	608.22
8/12/04	8:00 AM	1.50	608.22
8/13/04	9:00 AM	1.50	608.22
8/14/04	7:30 AM	1.50	608.22
8/15/04	7:00 AM	1.49	608.21
8/16/04	7:30 AM	1.47	608.19
8/17/04	8:00 AM	1.46	608.18
8/18/04	7:30 AM	1.45	608.17
8/19/04	8:00 AM	1.44	608.16
8/20/04	8:00 AM	1.42	608.14
8/21/04	8:00 AM	1.40	608.12
8/22/04	8:00 AM	1.38	608.10
8/23/04	8:00 PM	1.36	608.08
8/24/04	7:30 AM	1.36	608.08
8/25/04	7:30 AM	1.34	608.06
8/26/04	7:30 AM	1.35	608.07
8/27/04	7:00 AM	1.35	608.07
8/28/04	8:45 AM	1.36	608.08
8/29/04	na	na	608.08
8/30/04	12:00 PM	1.34	608.06
8/31/04	1:30 PM	1.34	608.06
9/1/04	8:00 AM	1.32	608.04
9/2/04	7:00 AM	1.31	608.03
9/3/04	1:00 PM	1.30	608.02
9/4/04	7:30 AM	1.29	608.01
9/5/04	7:00 AM	1.28	608.00
9/6/04	7:30 AM	1.26	607.98
9/7/04	8:00 AM	1.25	607.97
9/8/04	na	na	607.97
9/9/04	8:00 AM	1.20	607.92
9/10/04	12:00 PM	1.16	607.88
9/11/04	na	na	607.88
9/12/04	8:00 AM	1.10	607.82
9/13/04	8:30 AM	1.08	607.80
9/14/04	7:30 AM	1.04	607.76
9/15/04	7:30 AM	1.00	607.72
9/16/04	7:30 AM	0.96	607.68
9/17/04	7:30 AM	0.92	607.64
9/18/04	7:30 AM	0.88	607.60
9/19/04	8:00 AM	0.82	607.54
9/20/04	7:30 AM	0.78	607.50
9/21/04	7:30 AM	0.70	607.42
9/22/04	8:00 AM	0.65	607.37
9/23/04	8:30 AM	0.56	607.28
9/24/04	8:00 AM	0.50	607.22

Date	Time	Staff Gage Field Reading (ft)	Lake Elev (ft)
9/25/04	8:00 AM	0.45	607.17
9/26/04	8:00 AM	0.39	607.11
9/27/04	8:00 AM	0.30	607.02
9/28/04	8:00 AM	0.24	606.96
9/29/04	8:00 AM	0.16	606.88
9/30/04	8:00 AM	0.08	606.80
10/1/04	8:30 AM	0.00	606.72
10/2/04	9:00 AM	0.06	606.66
10/3/04	8:30 AM	0.08	606.64
10/4/04	8:00 AM	0.10	606.62
10/5/04	8:00 AM	0.12	606.60
10/6/04	8:15 AM	0.13	606.59
10/7/04	8:30 AM	0.14	606.58
10/8/04	8:45 AM	0.16	606.56
10/9/04	8:30 AM	0.18	606.54
10/10/04	8:30 AM	0.20	606.52
10/11/04	8:45 AM	0.22	606.50
10/12/04	8:30 AM	0.24	606.48
10/13/04	removed for the season		
11/18/04		at north weir	607.51
12/11/04	1:00 PM	at north weir	607.72
4/13/05	reinstalled for the season		
4/14/05	3:00 PM	1.90	608.16
4/15/05			
4/16/05			
4/17/05			
4/18/05	8:00 AM	1.98	608.24
4/19/05			
4/20/05			
4/21/05			
4/22/05			
4/23/05			
4/24/05			
4/25/05	8:00 PM	2.00	608.26
4/26/05			
4/27/05			
4/28/05	7:30 AM	2.00	608.26
4/29/05			
4/30/05			
5/1/05			
5/2/05	8:00am	2.03	608.29
5/3/05			
5/4/05			
5/5/05			
5/6/05			
5/7/05			
5/8/05			
5/9/05	8:00am	2.06	608.32

Date	Time	Staff Gage Field Reading (ft)	Lake Elev (ft)
5/10/05			
5/11/05			
5/12/05			
5/13/05	8:00am	2.04	608.30
5/14/05			
5/15/05			
5/16/05	8:00pm	2.02	608.28
5/17/05			
5/18/05			
5/19/05	7:30am	2.00	608.26
5/20/05			
5/21/05			
5/22/05			
5/23/05			
5/24/05	8:00pm	1.98	608.24
5/25/05			
5/26/05	8:00am	1.96	608.22
5/27/05			
5/28/05			
5/29/05			
5/30/05	8:00am	1.94	608.20
5/31/05			
6/1/05			
6/2/05	7:30 AM	1.90	608.16
6/3/05			
6/4/05			
6/5/05			
6/6/05			
6/7/05	7:00 AM	1.88	608.14
6/8/05			
6/9/05	7:30 AM	1.84	608.10
6/10/05			
6/11/05			
6/12/05			
6/13/05	8:00 AM	1.80	608.06
6/14/05			
6/15/05			
6/16/05	8:00 AM	1.84	608.10
6/17/05			
6/18/05			
6/19/05			
6/20/05	7:00 AM	1.80	608.06
6/21/05			
6/22/05			
6/23/05	7:30 AM	1.78	608.04
6/24/05			
6/25/05			
6/26/05			

Date	Time	Staff Gage Field Reading (ft)	Lake Elev (ft)
6/27/05	7:30 AM	1.70	607.96
6/28/05			
6/29/05			
6/30/05	7:30 AM	1.74	608.00
7/1/05			
7/2/05			
7/3/05			
7/4/05	7:00 AM	1.64	607.90
7/5/05			
7/6/05			
7/7/05	7:30 AM	1.60	607.86
7/8/05			
7/9/05			
7/10/05			
7/11/05	7:30 AM	1.58	607.84
7/12/05			
7/13/05			
7/14/05	7:30 AM	1.50	607.76
7/15/05			
7/16/05			
7/17/05			
7/18/05	7:00 AM	1.46	607.72
7/19/05			
7/20/05			
7/21/05	8:00 AM	1.44	607.70
7/22/05			
7/23/05			
7/24/05			
7/25/05	7:30 AM	1.46	607.72
7/26/05			
7/27/05			
7/28/05	7:30 AM	1.46	607.72
7/29/05			
7/30/05			
7/31/05			
8/1/05	7:30 PM	1.40	607.66
8/2/05			
8/3/05			
8/4/05	7:30 AM	1.36	607.62
8/5/05			
8/6/05			
8/7/05			
8/8/05	7:30 AM	1.28	607.54
8/9/05			
8/10/05			
8/11/05	6:00 PM	1.20	607.46
8/12/05			
8/13/05			

Date	Time	Staff Gage Field Reading (ft)	Lake Elev (ft)
8/14/05			
8/15/05	8:00 AM	1.16	607.42
8/16/05			
8/17/05			
8/18/05	7:30 AM	1.00	607.26
8/19/05			
8/20/05			
8/21/05			
8/22/05			
8/23/05	8:00 AM	2.40	
8/24/05			
8/25/05	8:00 AM	2.20	
8/26/05			
8/27/05			
8/28/05			
8/29/05	7:30 AM	1.90	
8/30/05			
8/31/05			
9/1/05	7:30 AM	1.40	
9/2/05			
9/3/05			
9/4/05			
9/5/05	8:00 AM	1.10	607.36
9/6/05			
9/7/05			
9/8/05	7:30 AM	1.10	607.36
9/9/05			
9/10/05			
9/11/05			
9/12/05	7:30 AM	1.06	607.32
9/13/05		1.04	607.30
9/14/05			
9/15/05	7:30 AM	1.02	607.28
9/16/05			
9/17/05			
9/18/05			
9/19/05	7:00 AM	1.00	607.26
9/20/05			
9/21/05			
9/22/05	7:30 AM	0.96	607.22
9/23/05			
9/24/05			
9/25/05			
9/26/05			
9/27/05	8:30 AM	1.20	
9/28/05			
9/29/05	8:30 AM	1.26	
9/30/05	removed for the season		

ATTACHMENT B

Model Attributes and Settings

Filename: **Cedar Lake with swamps 3.whm**

Cedar Lake WhAEM Attributes/Model Settings

Regional Characteristics

Aquifer Bottom:	569.5	ft	
Aquifer Top:	+38	ft	
Thickness:	38	ft	
Hydraulic Conductivity:	201	ft/d	
Effective Porosity:	0.4		
Avg Annual Precip:	0.0063	ft/d	(this is an observed 7-yr average from 1998-2004)

Point Sinks (Wells) Data from May 1, 2006 observations/measurements.

PZ-1s	608.12	ft	head-specified
PZ-1s2	607.03	ft	head-specified
PZ-2s	609.39	ft	head-specified
PZ-3s	608.45	ft	head-specified
PZ-3s2	607.7	ft	head-specified
PZ-4s	607.61	ft	head-specified
PZ-5s	607.98	ft	head-specified
PZ-6s	608.32	ft	head-specified
PZ-6s2	608.56	ft	head-specified
PZ-7s	608.47	ft	head-specified
PZ-7s2	609.92	ft	head-specified
Kings Corner Stm Structure	608.08	ft	head-specified
LWS Pumping Well	1 ft. dia. Pumping well @ 45,000 ft3/day		discharge-specified
2nd Well to represent SW use	1 ft. dia. Pumping well @ 90,000 ft3/day		discharge-specified

Line Sinks (Water Features) - head-specified elevations

Cedar Lake	608.8	ft	(estimated)
Lake Huron	579	ft	(estimated/avg)
Van Etten Lake	588	ft	(estimated/avg)

Phelan Creek	start 614; end 588 (Van Etten)	width:	5.8	ft	depth:	1.3	ft	0.11 ft/s; 0.61 cfs (est. from previc
Sherman Creek	start 611; end 608.8 (Cedar Lake)	width:	2.25	ft	depth:	1	ft	4.40 cfs (meas. 4-10-06)
"Jones" Creek	start 611; end 608.8 (Cedar Lake)	width:	1.5	ft	depth:	0.75	ft	1.19 cfs (meas. 4-10-06)
Unknown Creek 2	start 605; end 579 (Huron)	width:	2.25	ft	depth:	1	ft	0.2 cfs (est.)
Storm Drain 1	start 585; end 579 (Huron)	width:	0.75	ft	depth:	0.3	ft	0.055 cfs (meas. Sept 2005)
Storm Drain 2	start 585; end 579 (Huron)	width:	0.75	ft	depth:	0.3	ft	0.055 cfs (est.)
Storm Drain 3	start 585; end 579 (Huron)	width:	0.75	ft	depth:	0.3	ft	0.055 cfs (est.)
Storm Drain 4	start 585; end 579 (Huron)	width:	0.75	ft	depth:	0.3	ft	0.055 cfs (est.)
Storm Drain 5	start 585; end 579 (Huron)	width:	0.75	ft	depth:	0.3	ft	0.055 cfs (est.)
Cedar Swamp (NW corner)	start 611; end 611	width:	200	ft	depth:	0.5	ft	
King's Corner Culvert	start 610; end 609.92 (N to S)	width:	2	ft	depth:	0.42	ft	(meas. 4-10-06)
Cedar Lake Outflow (north)	start 608.8; end 605	width:	1.5	ft	depth:	0.75	ft	

Seasonal Influences

Direct surface flows from Cedar Swamp (via Sherman and "Jones" Creeks)

Surface outflow from north lake outflow structures (in the range of 2.5" overtopping)

Golf course pumping well is operational (est. 45,000 gal/d over 214 days)

Golf course surface water withdrawal also included (est. 90,000 gal/d over 214 days)

Phelan Creek is modeled with a forced midpoint elevation of 603 near south end of Cedar Lake.

King's Corner culvert flowing from north to south into Phelan Creek drainage area

ATTACHMENT C

Copies of the Alcona and Iosco County Data Summaries

Groundwater Mapping Project

County Summaries

Alcona Summary

Alcona County is in the northeastern portion of the Lower Peninsula of Michigan. The Lone Lake-Ocqueoc, Thunder Bay, Au Sable, and Lake Huron watersheds drain the county. According to the February 2005 Wellogic database, approximately 94% of the wells in Alcona County are completed in the glacial deposits, and less than 1% in the bedrock units. There is insufficient information to make this distinction for 6% of the wells in the county.

With the available information, glacial lithologies cannot be regionally correlated in the subsurface in the Michigan Basin. This is likely due to the lateral and vertical heterogeneity of glacial deposits that resulted from a complex depositional history (Westjohn and others, 1994). The glacial deposits in Alcona County range from 101 to 800 ft thick. However, the majority of the deposits range from 201 to 600 ft thick (Western Michigan University, 1981). The glacial deposits consist of till, outwash, and lacustrine deposits. Fine- to coarse-grained till occurs in moraines and till plains. Glacial outwash and ice-contact outwash is also present in the county, and primarily consists of sand and gravel. Coarse-grained lacustrine deposits are present on the surface in the south-central, southeastern, and northeastern portions of the county (Farrand and Bell, 1982). Aquifers in the glacial deposits consist largely of sands and gravels and vary regionally in thickness and permeability.

Bedrock underlies the glacial deposits. The bedrock surface of Alcona County is composed of the Marshall Sandstone, Coldwater Shale, Sunbury Shale, Berea Sandstone, Bedford Shale, and Antrim Shale (Milstein, 1987). The Marshall Sandstone forms the bedrock surface in the southwestern portion of the county. The Marshall Sandstone consists of one or more stratigraphically continuous permeable sandstones. The upper sandstone is a quartzarenite to sublitharenite that is referred to as the Napoleon Sandstone Member. A shale, siltstone, and/or carbonate layer separates the Napoleon Sandstone Member from the underlying lower Marshall sandstone. The lower Marshall sandstone is comprised of two units. The upper unit is generally 50 to 125 ft of fine- to medium-grained quartzarenite to sublitharenite. The basal unit is a fine- to medium-grained litharenite that ranges in thickness from 30 to 125 ft. Permeable sandstones in the Marshall Sandstone comprise the Marshall aquifer. The Marshall aquifer ranges in thickness from 75 to greater than 200 ft within the State (Westjohn and Weaver, 1998). The Marshall aquifer contains fresh water in Alcona County (Westjohn and Weaver, 1996c).

The Coldwater Shale underlies the Marshall Sandstone, and consists of primarily shale with interbeds or lenses of sandstone, siltstone, and dolomite. The Coldwater Shale is relatively impermeable and is considered a confining unit in most of Michigan (Westjohn and Weaver, 1998).

The Sunbury Shale is a black, carbonaceous shale and underlies the Coldwater Shale (Harrell and others, 1991). The Sunbury Shale thins towards the center of the basin and is 147.6 ft thick in the eastern portion of the State (Gutschick and Sandberg, 1991). Shale is generally considered to be a confining unit.

The Berea Sandstone underlies the Sunbury Shale. The Berea Sandstone is fine- to medium-grained sandstone, and is greater than 114.8 ft thick in eastern Michigan and thins to the west (Gutschick and Sandberg, 1991). The Berea Sandstone grades into the underlying Bedford Shale and thus the upper portion of the shale is silty or sandy. The Bedford Shale is primarily gray shale in the Michigan Basin. The Bedford Shale may be greater than 213.3 ft thick in eastern Michigan and thins toward the center of the Michigan Basin (Gutschick and Sandberg, 1991). Shale is generally considered to be a confining unit.

The Antrim Shale is composed of primarily carbonaceous, black to dark-gray shale. Near the base of the sequence, thin layers of gray shale and limestone may occur. The major constituents in the Antrim Shale consist of quartz, illite, and kerogen. Kaolinite, chlorite, and pyrite also compose the Antrim Shale. The Antrim Shale has been found to have bituminous limestone concretions up to 3 ft in diameter (Matthews, 1993). The Antrim Shale can be up to 656 ft thick, which occurs at the center of the Michigan Basin (Gutschick and Sandberg, 1991). Antrim Shale is generally not considered to be an aquifer.

Groundwater Mapping Project

County Summaries

Iosco Summary

Iosco County is in the northeastern portion of the Lower Peninsula. The Saginaw Lowlands extend from the southwest to northwest along the southeastern portion of the county. The Lone Lake-Ocqueoc, Au Sable, Au Gres-Rifle, and Lake Huron watersheds drain through the county. According to the February 2005 Wellogic database, approximately 74% of the wells in Iosco County are completed in the glacial deposits, and 22% in the bedrock units. There is insufficient information to make this distinction for 4% of the wells in the county. The bedrock wells are concentrated in the south-central portion of the county.

In the Michigan Basin, glacial aquifers consist of sand and gravel that are part of a thick sequence of Pleistocene glacial deposits. With the available information, glacial lithologies cannot be regionally correlated in the subsurface. This is likely due to the lateral and vertical heterogeneity of glacial deposits that resulted from a complex depositional history (Westjohn and others, 1994). The thickness of the glacial deposits ranges between 11 and 800 ft within the county, and generally decreases from north to south (Western Michigan University, 1981). Lacustrine deposits, till, and outwash compose the glacial deposits in Iosco County. Lacustrine deposits are the most abundant glacial deposit in the county, and are primarily coarse grained, except for in the southeast portion of the county, where the lacustrine deposits are fine grained. Till is primarily fine grained; however, in the north-central portion of there is an area of county medium- and coarse-grained till. The outwash deposits are composed of sand and gravel and occur in the northwestern portion of the county. Ice-contact outwash is present in the central portion of the county (Farrand and Bell, 1982). According to the Public Water Supply database, the estimated transmissivity for glacial wells in Iosco County ranges from approximately 3,530 to 4,145 ft^2/day.

In the northeastern portion of Iosco County, in the Au Sable watershed, is the location of the Wurtsmith Air Force base. In this area, the glacial aquifer is contaminated with volatile organic hydrocarbons. The generally unconfined aquifer consists of a medium to coarse-grained sand with some gravel. The aquifer extends from the surface to 80 to 30 ft underground, in the northern and western areas of the base, respectively. The average thickness of the aquifer is 65 ft. In the northern part of the area, the aquifer also contains thin clay layers generally 5 to 15 ft below the surface. A clay unit underlies the glacial aquifer (Stark and others, 1983; Cummings and Twenter, 1986). The clay unit dips to the east and the exact thickness is unknown, but may be greater than 250 ft in areas (Stark and others, 1983). Water levels in the aquifer at Wurtsmith Air Force base range between 10 to 25 ft below the ground surface, and fluctuate 1 to 3 feet annually. A groundwater divide extends from the northeast to southwest across the base. Ground water flows to the east north of the divide and to the south, south of the divide (Stark and others, 1983; Cummings and Twenter, 1986). The transmissivity and specific yield of the glacial aquifer at Wurtsmith Air Force Base was estimated from an aquifer test and ranges from 5,000 to 20,000 ft^2/day and 0.2, respectively. The hydraulic conductivity was estimated from an aquifer test and specific capacity tests and ranges from 16 to 310 ft/day (Stark and others, 1983).

Bedrock underlies the glacial deposits. The bedrock surface of Iosco County is composed the Michigan Formation, Marshall Sandstone and Coldwater Shale (Milstein, 1987). The Michigan Formation consists of layers of sandstone, siltstone, anhydrite or gypsum, dolomite, limestone, and shale. The lower permeability lithologies of the Michigan Formation are considered a confining unit. The thickness of the Michigan confining unit ranges from less than 50 to 400 ft within the State (Westjohn and Weaver, 1998).

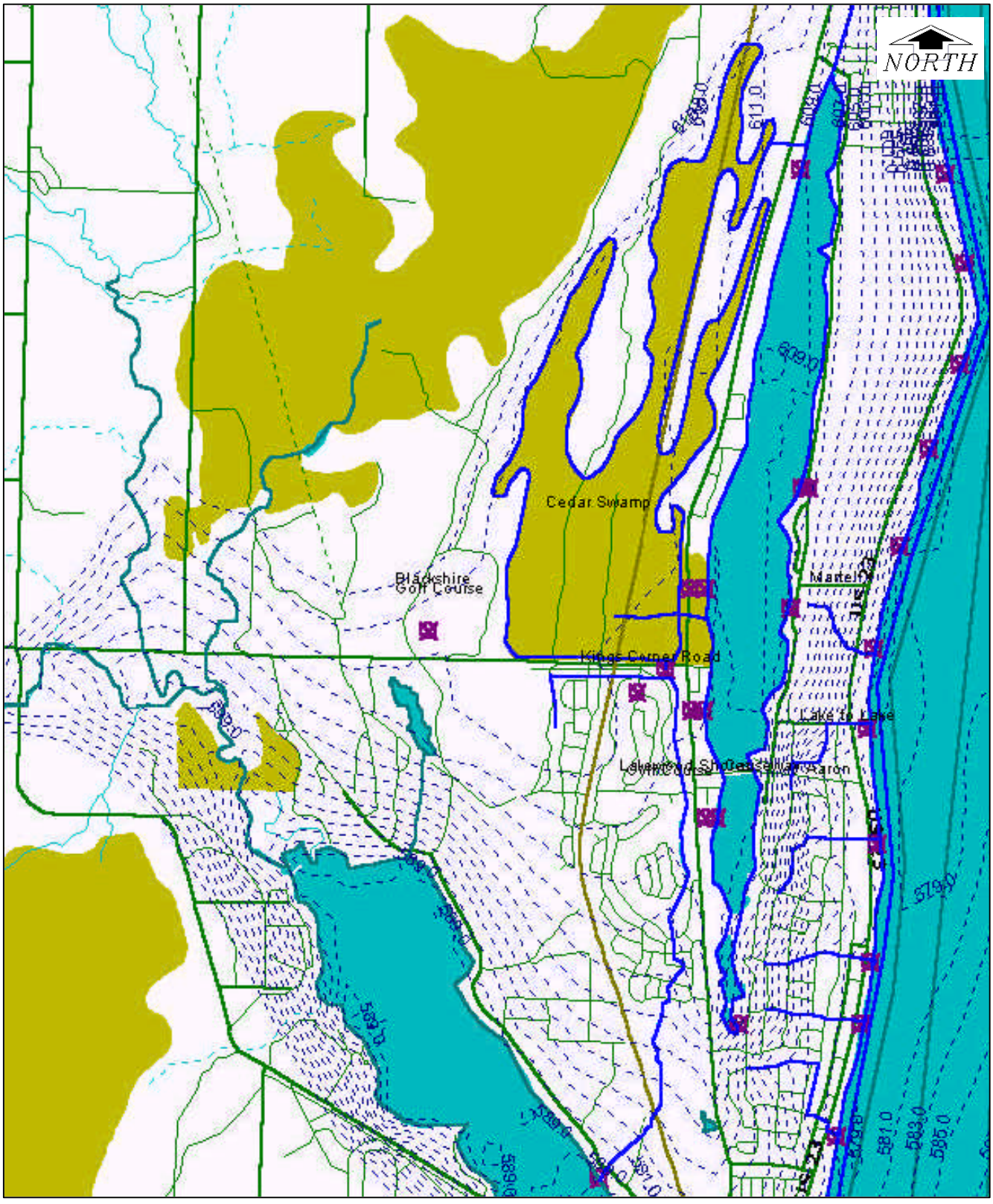
The Marshall Sandstone underlies the Michigan Formation. The Marshall Sandstone consists of one or more stratigraphically continuous permeable sandstones. The upper sandstone is a quartzarenite to sublitharenite that is referred to as the Napoleon Sandstone Member. A shale, siltstone, and/or carbonate layer separates the Napoleon Sandstone Member from the underlying lower Marshall sandstone. The lower Marshall sandstone is comprised of two units. The upper unit is generally 50 to 125 ft of fine- to medium-grained quartzarenite to sublitharenite. At the base of the Marshall Sandstone is a fine- to medium-grained litharenite that ranges in thickness from 30 to 125 ft. Permeable sandstones in the Marshall Sandstone comprise the Marshall aquifer. The Marshall aquifer ranges in thickness from 75 to greater than 200 ft within the State (Westjohn and Weaver, 1998). The Marshall Sandstone yields saline and fresh water in the southern and northern portion of Iosco County, respectively (Westjohn and Weaver, 1996c)

The Coldwater Shale underlies the Marshall Sandstone. The Coldwater Shale consists of primarily shale with interbeds or lenses of sandstone, siltstone, and dolomite. The Coldwater Shale is considered a confining unit in most of Michigan (Westjohn and Weaver, 1996b).

ATTACHMENT D

Groundwater Model Piezometric Contour Maps

Cedar lake w swamps#3_rev

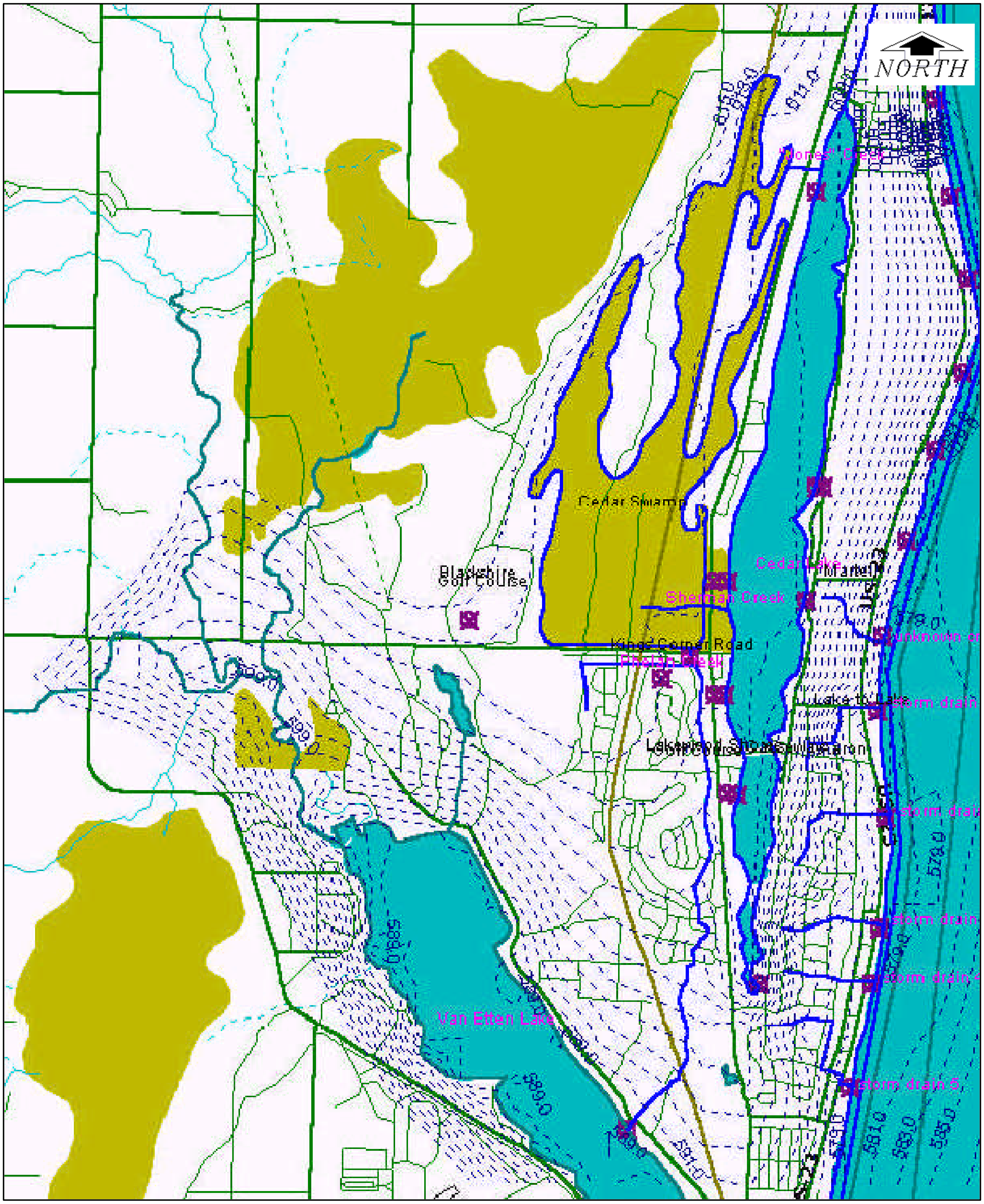


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting average annual precipitation and reported groundwater pumping from the golf course.

FIGURE
D-1

Cedar lake w swamps#3_no pumping at all

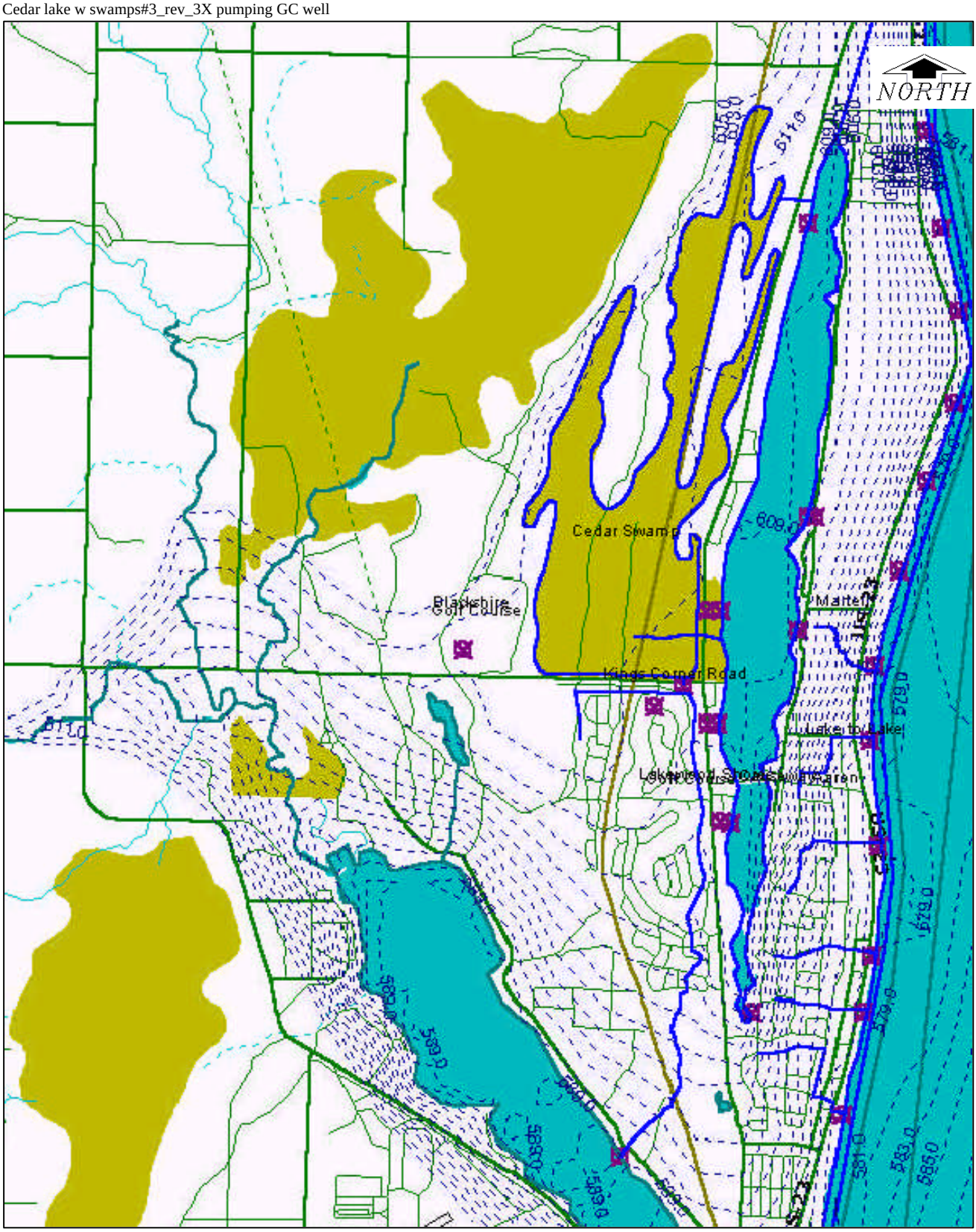


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting average annual precipitation and no groundwater pumping from the golf course.

FIGURE D-2

Cedar lake w swamps#3_rev_3X pumping GC well

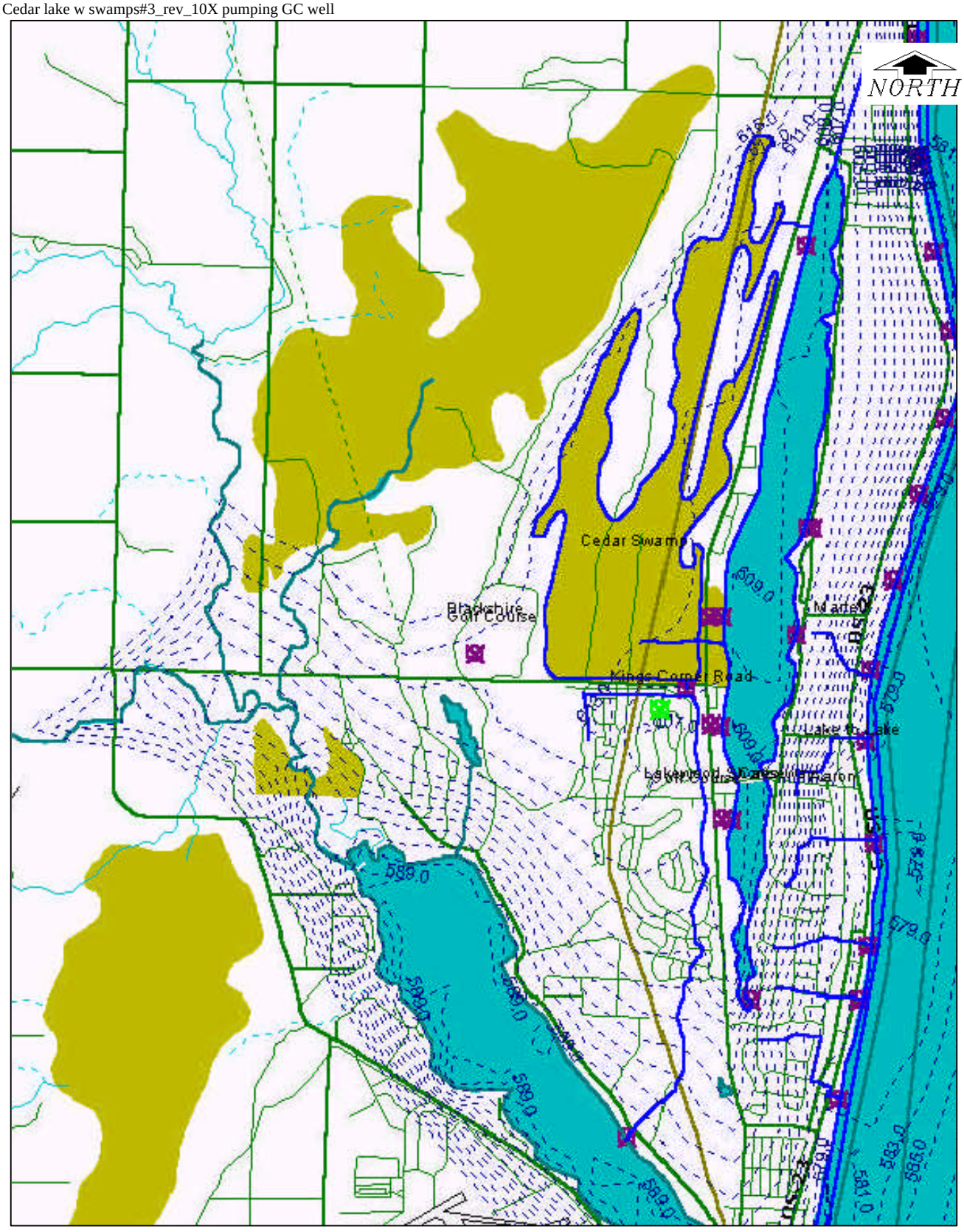


KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting average annual precipitation and 3 times reported groundwater pumping from the golf course.

FIGURE
D-3

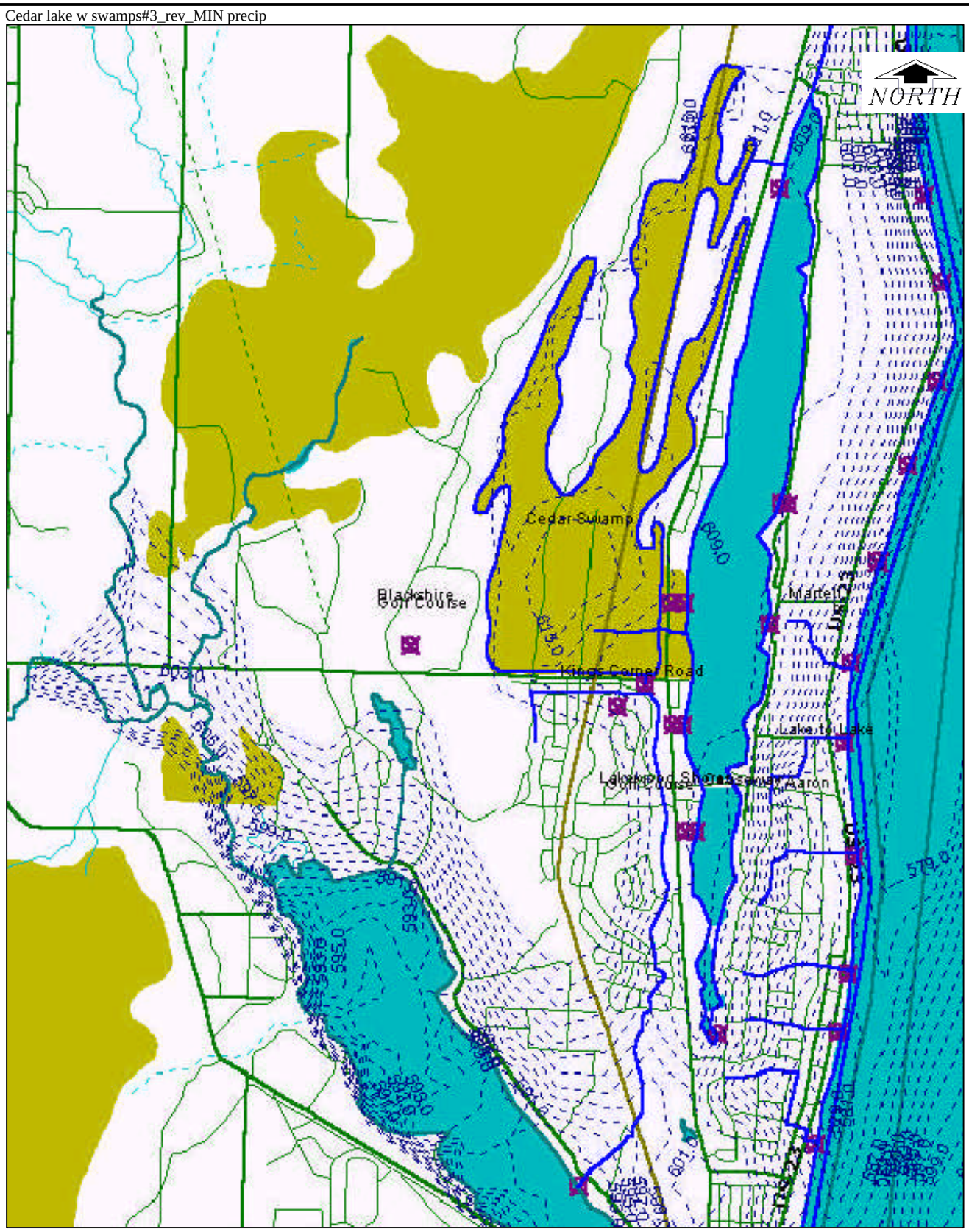
Cedar lake w swamps#3_rev_10X pumping GC well



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting average annual precipitation and 10 times reported groundwater pumping from the golf course.

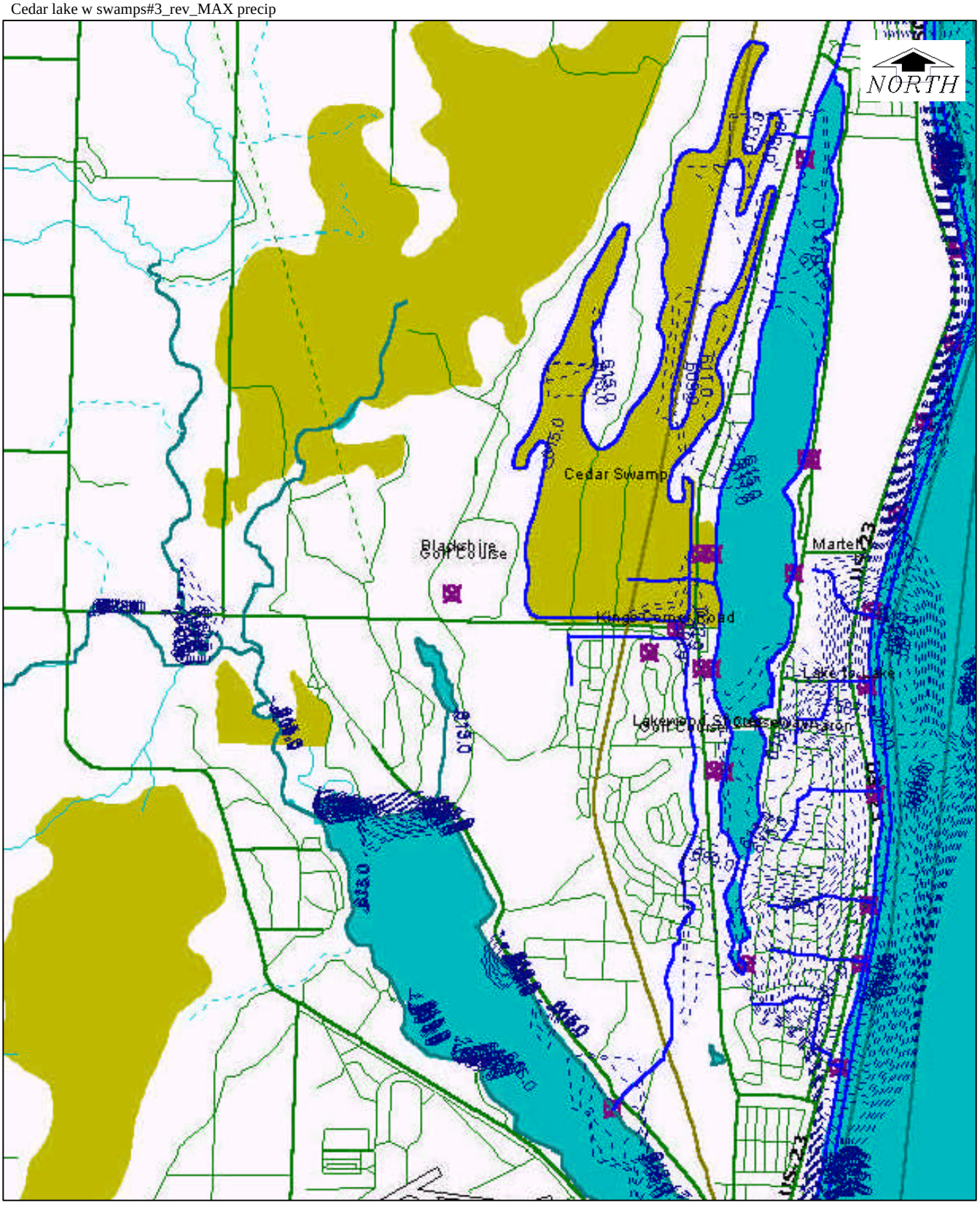
FIGURE
D-4



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting minimum observed precipitation rate (past seven years) and reported groundwater pumping from the golf course.

FIGURE
D-5



KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING
536 E. Michigan Ave., Suite 300, Kalamazoo, MI 49007
phone (269) 344-7117 fax (269) 344-2493

Model results depicting maximum observed precipitation rate (past seven years) and reported groundwater pumping from the golf course.

FIGURE
D-6