MANAGEMENT OF THE EASTERN PRAIRIE FRINGED ORCHID IN THE LAKE KOSHKONONG WETLANDS

LAKE KOSHKONONG WETLAND ASSOCIATION

ROCK COUNTY, WISCONSIN

December 20, 2006

Photo: Gary Shackelford

NRC Project # 03-189

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Project Overview

Several populations of Eastern prairie fringed orchid (*Platanthera leucophaea*) have been discovered in areas adjacent to Lake Koshkonong in Rock County, Wisconsin. This species is listed as Endangered by the State of Wisconsin and Threatened by the U.S. Government under the federal Endangered Species Act. These populations were discovered on the properties following active management and habitat restoration activities, including burning and removal of woody vegetation. The orchid discoveries were an unexpected result of these various management activities. Monitoring of these populations has been implemented for several years and includes annual orchid counts, surveying orchid locations with Global Positioning System (GPS), caging and labeling individuals, and recording seed and fruit production. The annual surveys are performed under the direction of Ursula Petersen with the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) and the landowners. An overall vegetation survey and floristic quality assessment of the orchid locations was performed in 2005 by Natural Resources Consulting, Inc. (NRC). In addition, the hydrology at the orchid locations has been monitored with the use of several shallow groundwater monitoring wells. Water level data has been collected during the 2004 and 2005 growing seasons. Elevations at each orchid location were surveyed for analysis with the water level data. This work is being done by the Lake Koshkonong Wetlands Association (LKWA) in consultation with NRC and is funded by a Lake Planning Grant from the Wisconsin Department of Natural Resources (WDNR).

While monitoring and management activities have been implemented on the two properties prior to and since the discovery of the orchid, a management plan specific to this species has not yet been developed. One of the properties, Property A, has been designated a State Natural Area (SNA), and a management plan for the entire property was completed in 2005 by the landowners and the WDNR. A reed canary grass (*Phalaris arundinacea*) management plan was also developed for this property in consultation with Willis E. Brown from Michler & Brown, LLC. In addition, a Pesticide Management Plan was signed in 1996 by the landowners with DATCP and a Rare Plant Stewardship Memorandum was signed in 2001 with the Bureau of Endangered Resources (BER) of the WDNR for the property.

The objectives of this project were to develop an overall management plan for the Eastern prairie fringed orchid, develop an understanding of the influences hydrology has on the distribution of the orchids, and test for correlations between water levels occurring in Lake Koshkonong and water levels at the orchid sites. This plan incorporates excerpts from the above-mentioned existing management plans and signed agreements for the SNA, the monitoring protocols implemented by DATCP, NRC, and the landowners, and data collected by NRC including groundwater monitoring and a plant survey.

Introduction

Lake Koshkonong is a shallow impoundment on the Rock River which supports more than 4000 acres of wetlands. Due to the shallow conditions of the lake and increased watercraft size, the Rock-Koshkonong Lake District (RKLD) filed a change order request with the WDNR to increase summer water levels by 6-8 inches. The WDNR denied the change order request, but the RKLD was granted a contested case hearing, which occurred in spring 2006, to appeal this permit denial. A rise in lake levels could have many implications for the adjacent wetlands, including those that support populations of the Eastern prairie fringed orchid.

Orchids were discovered in 1996 and have been monitored annually since that time. The orchid locations on both properties have a history of farming and/or grazing, but had been out of production for several years before the orchids were discovered. Since their discovery, active management has been undertaken to some degree at both properties. At Property A, management has included prescribed fire, application of herbicide, removal of woody vegetation, and mowing. At Property B, management has included much of the same: periodic fire, application of herbicide, and mechanical shrub clearing. In addition, at both sites, when feasible, orchids have been caged to prevent damage from herbivores, primarily deer.

The objectives of this management plan are to 1) maintain viable populations of the Eastern prairie fringed orchid on both properties where it is currently found; 2) maintain population numbers at or near their current level, and to prevent a permanent decline in individuals; 3) prevent further encroachment by non-native invasive species into current orchid habitat; 4) promote the expansion or creation of additional orchid habitat; and 5) continue annual monitoring to assess the effectiveness of the management strategy and adjust management techniques as necessary.

Orchid Status and Biology

The Eastern prairie fringed orchid (*Platanthera leucophaea* (Nuttal) Lindley) was federally listed as Threatened in 1989 and is protected by the U.S. Endangered Species Act. It is also listed as Endangered in the State of Wisconsin. At the time the USFWS Recovery Plan was drafted for this species (USFWS 1999), it was known to persist in 59 populations in six states (USFWS 1999); only six of these populations were considered highly viable with high potential for long term persistence. The USFWS reported that the orchid declined more than 70% from original county records in the U.S., citing succession to woody vegetation, competition from invasive and non-native species, over collecting, and drainage and development of wetland habitats as its primary threats. The Eastern prairie fringed orchid's range currently includes several northeast and north-central states as well as southeastern Canada. In Wisconsin, it is found in several counties in the southern portion of the state, including Jefferson, Rock, Kenosha, Ozaukee, and Winnebago Counties, where DATCP has been intensively monitoring populations since 1997 (DATCP 2004).

Life History

The Eastern prairie fringed orchid is a perennial herbaceous plant with a complex life history. It grows from an underground tuber, and, like many terrestrial orchids, it has a mycorrhizal association. The leaves and developing flower clusters form on the tuber during the previous growing season, and begin to emerge from the ground in April or May. Flowering occurs in late June or July and persists for only 1-2 weeks. Seed capsules mature over the growing season and the tiny seeds are wind dispersed in late summer. Vegetative spread and dormancy are apparently rare in this species. However, individual plants can remain vegetative for many years before and after producing flowers. In general, it takes 3-7 years for individuals to reach reproductive maturity. Metapopulation dynamics characterize many of the known extant orchid populations in the US, where population numbers, reemergence of previously identified individuals, seedling establishment, and reproductive status (flowering, producing seed, vegetative, etc.) can vary greatly from year to year. While many environmental conditions influence the persistence and reproductive status of this species, water level fluctuations, rainfall, temperature cycles, and various disturbances such as fire, have been shown to be correlated with orchid flowering and persistence over time (USFWS 1999).

Eastern prairie fringed orchids are pollinated by night flying hawkmoths (Bowles 1983, 1985). Previous studies have identified several species as pollinators or potential pollinators, including the pandorus sphinx (*Eumorpha pandorus*), Achemon sphinx (*E. achemon*), and the hermit sphinx (*Sphinx eremitus*) (USFWS 1999). The orchid is most often found in areas where herbaceous plants dominate, and the flowers often rise just above the height of the other vegetation. Bowles (1985) found that the more exposed flower clusters tended to be visited more often by hawkmoths. Thousands of seeds are produces within each capsule, which are wind or water dispersed when the capsule dries in late summer.

The requirements for germination and seedling establishment are not well known; however, the development of a mycorrhizal association is imperative to seedling survival and promotes water and nutrient uptake in many species of orchids (Stoutamire 1974). Patch disturbances also appear to be important to seedling establishment, as is true of many terrestrial orchids (Sheviak 1974, Case 1987, Pavlovic 1994, USFWS 1999).

Ecology and Habitat Requirements

The Eastern prairie fringed orchid is generally found in open, sunny habitats dominated by herbaceous vegetation, where it occupies a broad moisture gradient. It has been found in wet and mesic prairies, wet meadows, sedge meadows, fens, and even bogs. Most Midwestern populations occur in silt-loam soils (USFWS 1999).

Patch dynamics and the maintenance of early to mid-successional habitats appear to be essential to orchid survival and reproduction (USFWS 1999). In some areas, these conditions have been created due to past disturbances such as grazing or drainage. In other areas, the conditions are maintained by natural disturbances, periodic fire and/or other management tools. Disturbance is particularly important for seedling establishment, because colonization usually occurs in areas where competition from other plants has been reduced. Additionally, reduced cover from competitive plants can also be important for pollination, as stated above.

The use of management tools to create patch dynamics may be essential to the maintenance of many of the extant populations of Eastern prairie fringed orchid, as population densities appear to be highest in early to mid-successional habitats (USFWS 1999). While dormant season disturbances, such as fire, can maintain and create orchid habitat, growing season disturbances, such as mowing, can damage and/or kill individual plants (Sheviak 1990). In appropriate habitats, such as prairies, dormant season fire can be used to reduce woody vegetation cover (a threat to orchid habitat), maintain patches of mixed-successional habitat, and, along with high precipitation, has been suggested to promote flowering of the Eastern prairie fringed orchid (Sheviak 1974, Roosa and Eilers 1979, Bowles 1983).

Hydrology and precipitation patterns also appear to influence orchid establishment and persistence. Flowering may be positively correlated with precipitation, as evidenced by a study in Illinois (Bowles et al. 1992). It is yet unclear how hydrology influences orchid establishment and persistence, as studies need to be done on a site-by-site basis. At a site managed by the Leopold Wetland Management District (WMD), water level management was implemented, based upon hydrology and elevation studies, to prevent extensive and/or prolonged inundation in orchid locations while maintaining appropriate soil moisture conditions and maintaining waterfowl habitat. Additionally, natural population fluctuations of the Eastern prairie fringed orchid in relation to natural shoreline fluctuations on some of the Great Lakes have been studied by several authors (Case 1987, Case and Case 1990, Windus and Cochrane 1997, Watson 1998; summarized

in USFWS 1999). Their studies have suggested that there may be an optimal lake level that promotes flowering and that changing lake levels and the timing and duration of flooding may influence population size. To date, while it is unclear what overall trends exist in the relationship between hydrology, flooding, and orchid establishment and persistence, it is evident that understanding hydrology is an important aspect of this species' conservation.

Site Descriptions

Site History and Management

Property A

Property A consists of 380 acres of rural land including retired cropland, apple orchards, and wetlands, which were previously managed for hunting. The orchids were found in two formerly tilled fields (Areas A and C and Area B, see Figure 2), which are adjacent to the wetlands. The water table is relatively near the surface in these fields, which both have sandy soils. Microtopographic differences have led to differences in species composition, for example the wetter areas within Area A were dominated by prairie cord grass (*Spartina pectinata*) and dense cover of red osier dogwood (*Cornus stolonifera*) and multiflora rose (*Rosa multiflora*). Area B contained dense cover of reed canary grass with some dogwood.

In April 1995, Site A was burned; however, because areas with dense cover of dogwood did not carry the fire, they were chopped with a brush hog in December of that year. The following July (1996), three orchids were discovered in this area, and during the first official count in July 1997, fourteen orchids were found. Additionally, 53 blooming orchids were discovered in 1997 in Area B, which had been sprayed with herbicide the previous August to control reed canary grass.

Since 1997, the landowners have utilized a variety of management techniques to protect existing orchid habitat, create new habitat, and restore native communities. Techniques utilized have included prescribed burning approximately every two years, usually in March or April and application of herbicide to specific areas of management concern (such as areas with high infestations of reed canary grass) either in spring or fall. In addition, all observed orchids, when feasible, have been caged to prevent herbivore damage.

Currently, Area A is a native wet prairie, Area C is a restored tall grass prairie, and Area B is primarily a wet meadow, dominated by reed canary grass.

Observations by the landowners indicate that regeneration of the orchids requires the removal of competing red osier dogwood and reed canary grass.

Property B

Property B contains approximately 180 acres of wetland, most of which was previously farmed and pastured. The fields where orchids are currently found were all farmed with corn or pastured with dairy cattle. Pesticides were periodically applied to these fields when they were farmed. Cropping was stopped about fifteen years ago, and pasturing ceased in most fields about twenty years ago. One of the orchid locations has been pastured for the past fifteen years by two horses and is still active pasture. The remainder of the fields have been left fallow and were allowed to regenerate. All of the orchid

locations have poorly to very poorly drained loamy soils with approximately 0-4 feet to the water table.

Orchids were first discovered on-site in 1996. No management activities had been undertaken prior to this discovery—the fields were all left fallow and allowed to naturally regenerate. However, since the discovery of the orchids, active management has been extensive onsite, both in and adjacent to orchid locations. Brush and weed control was done by rotary chopper until conditions were appropriate to use controlled burns as a management tool. Herbicide has been applied periodically to control reed canary grass as well as to remove woody vegetation. In addition, all observed orchids, when feasible, have been caged to prevent herbivore damage.

Currently, orchids are found in a variety of habitat types throughout the property, which, are all dominated by herbaceous vegetation and can be described as wet meadow or wet prairie. A few areas are dominated by reed canary grass; other areas are dominated by native wetland species. Several orchids are found along the edge of a wetland scrape and a pond, and some are found in a current horse pasture.

Observations by the landowners indicate that disturbance is the key to establishing new sites for the orchid.

Orchid Population Monitoring Summary

An orchid census has been performed annually in July since 1997 on both properties. Results of the 2005 survey are shown on Figure 1. Data obtained indicate that reproduction and survival are extremely variable from year to year and that there are likely many factors influencing the viability of these populations. These factors include the presence, dominance and/or spread of invasive species, precipitation, flood events, and management practices, among others.

The protocol for orchid monitoring follows that developed by DATCP and is outlined in the Orchid Management section below.

Property A

Results of annual orchid counts at Property A have ranged from 3 in 1996 to a high of 191 in 2000 (Figure 4). Since the initial discover of the orchids in Area A, the number of individuals censused has ranged from 14 in 1997 to 188 in 2000. 53 orchids were discovered in Area B in 1997. Since this initial discovery, the population numbers have ranged from 1 to 39. At this site, several orchids died in 2004 due to abnormally high water levels in the adjacent marsh, which led to prolonged inundation at the orchid locations under several feet of water from June through mid-July. In 2003, 3 individuals were discovered in an area to the east of this original population (Area C). The number of individuals found in Area C has increased since that time, reaching 26 individuals in 2005. After 1996, the total number of orchid individuals has ranged from 67 in 1997 to 191 in 2000.

Property B

Orchids were first discovered on this property in 1996. In 2005, approximately twenty individuals were scattered throughout several acres of wetland and are found in a variety of habitats. Since the discovery of the orchid at this location, the population size has ranged from a low of 20 in 2005 to a high of 426 in 1998. The exact location of individuals and the number of individuals found in each habitat has varied greatly throughout the years during which data has been collected.

Associated Plant Species and Communities

Methods

A vegetation survey was performed in orchid locations at both Properties during late summer of 2005 by NRC. A meander survey technique was utilized, and all species encountered were identified to the species level (when possible). The cover of each species at the site was estimated using the following cover classes:

1 = <1% cover
2 = 1-10% cover
3 = 10-25% cover
4 = 25-50% cover
5 = >50% cover

A GPS capable of sub-meter accuracy was used to mark the extent of the orchid locations and/or the extent of an area of management concern, depending on what was appropriate and possible. Observations were recorded regarding the general locations of individual orchids throughout the site, species often (or not often) found with individuals, areas seemingly devoid of orchids, vegetation density, the location and density of invasive species, etc. A Floristic Quality Analysis was conducted for each site using Coefficient of Conservatism (CC) values from the WI Floristic Quality Assessment Report (Bernthal 2003) and the Wisconsin State Herbarium website. Non-native species were given a CC value of '0' and were included in all calculations. A mean CC, traditional Floristic Quality Index (FQI) and quantitative FQI (qFQI) was calculated for each site. The methodology for calculating a mean CC and traditional FQI was developed by and is outlined in Swink and Wilhelm (1994). The mean CC value for a given site is the arithmetic mean of all the coefficients of all vascular plants present on the site, without regard to dominance or frequency. The FQI is the mean C times the square root of the species richness (N) of the site (FQI = meanCC * sqrtN). SqrtN is used in order to attempt to reduce the effect of the size of the site on the overall FQI; however, larger sites still often tend to have higher FQI values than smaller sites. A qFQI was also calculated for each site using each species' estimated abundance (cover class value) as a weighting factor. For this calculation, the average of the product of species' abundances and CC values is multiplied times the square root of species richness for the stand. This calculation results in an FQI value that more accurately takes into account species dominance, and thus floristic composition and quality, within a site.

Property A

Property A was surveyed on August 17, 2005. Areas A and C were surveyed as one unit, because they are contiguous, and Area B was surveyed as a separate unit.

Areas A & C

In general, Area A is a native wet prairie and Area C is a restored tall grass prairie. As surveyed in August 2005, these areas are dominated by several tall, competitive grasses including big blue stem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) in the tall grass prairie and prairie cord grass and reed canary grass in the wet prairie. In several areas throughout this site, these species tended to be overwhelming dominants, and in 2005, the orchids were absent from these areas. Other dominants included common mountain mint (*Pycnanthemum virginianum*) and goldenrods (*Solidago canadensis* and *S. gigantea*). Where the tall, competitive grasses were absent, the vegetation consisted of a mix of the above-mentioned dominant forbs and a mix of other grasses, sedges, and forbs. In total, 72 species were encountered, of which 8 are non-native (Table 1). The native species have an average CC of 4.29, and all species had an average CC of 3.8, an FQI of 30.6, and a qFQI of 28.6. As previously mentioned, orchid individuals, though found throughout Areas A and C, were generally not found where one species comprised greater than 50% cover. Species that attained this cover in certain locations included the dominant, competitive, tall grasses mentioned above. Surprisingly, however, orchids were commonly found in areas which were characterized by moderate cover (~25 %) of reed canary grass. The orchids also commonly occurred in areas where goldenrods, Joe-Pye weed (*Eupatorium maculatum*), and sneezeweed (*Helenium autumnale*) were dominant. Other species often co-occurring with orchids include poverty rush (*Juncus tenuis*), narrow-leaved loostrife (*Lysimachia quadriflora*), common false foxglove (*Agalinis tenuifolia*), and water-horehound (*Lycopus* spp.).

Two locations within Areas A and C were identified and mapped as potential threats to the orchid's long-term persistence (Figure 2). The first area (line 1) is a large portion dominated by prairie cord grass. While this is a native species, it is also a tall and competitive species that reaches over 50% cover at this location, and no orchids were found within this area in 2005. However, individuals have been found there in previous years, and continued monitoring is necessary to determine the longer-term extent of the population within this cord grass-dominated area. The second area identified in Figure 2 by line 2 is dominated by greater than 50% reed canary grass. While some orchids are found within these boundaries, reed canary grass is known to form monocultural stands and could pose a threat to the long-term sustainability of this orchid population.

Area B

Area B is dominated by reed canary grass, which averages over 50% cover within the site and reaches a near-monoculture in several areas. Other sub-dominant species include Queen Anne's lace (*Daucus carota*), Canada goldenrod, Joe-Pye weed, and narrow-leaved hedge-nettle (*Stachys tenuifolia*) (Table 2). Orchids are dispersed throughout the site, with the majority contained within line 4 in Figure 2, which is the area primarily

dominated by reed canary grass. Three plants were found in a nearby mowed area in 2005 (line 3), and several were found on the edge of the marsh (line 5) in an area dominated by indigo bush (*Amorpha fruticosa*). In addition to the above-mentioned dominant species, orchid individuals were often found with false nettle (*Boehmeria cylindrica*), orange jewelweed (*Impatiens capensis*), common water-horehound (*Lycopus americanus*), and small bedstraw (*Galium trifidum*). A total of 57 species were encountered in this area, of which 12 are non-native. The average CC of this site is 2.9, and the FQI is 21.1. The qFQI, which better accounts for the dominance of reed canary grass in this area, is 18.3. Native species have a mean CC of 3.7. These lower numbers as compared to Areas A and C are likely a result of both the smaller size of this area and the dominance of reed canary grass.

The primary management concern identified within Area B is the extent and dominance of reed canary grass. While orchids are currently found within dense stands of reed canary grass, the population numbers have ranged from 1 to 53, and it is uncertain how the continued dominance and/or spread of reed canary grass will influence the population.

A total of 71 different species were encountered during the survey in Areas A, B, and C at Property A. Of these, 13 are non-native, and reed canary grass represents the most extensive and potentially the greatest and most immediate threat to the orchid populations at this time, in regards to invasive species encroachment. The average CC of all areas is 3.4, and the FQI is 31.3.

Property B

Because of the number of different orchid locations, the variation in orchid location and individual numbers each year, and the generally small number of orchids found in each of the many different sites, the entire property was treated as one unit for the vegetation survey, which was performed on September 15, 2005. A total of 77 species were encountered during the survey, of which 9 are non-native (Table 3). The average CC of species encountered is 3.8, the FQI of the site is 32.4, and the qFQI is 29.8. Native species present possess relatively high average floristic quality with an average CC of 4.3. The dominant species throughout the site include redtop (*Agrostis gigantea*), poverty rush, Canada and giant goldenrods, and Indian grass. Indian grass is locally abundant at a couple of the orchid sites, while the rest of the above-mentioned dominant species are widespread. One of the orchid sites contained approximately 50% cover of reed canary grass. In two areas, orchids were found on the banks of wetland scrapes. Other species often found with orchids include redtop, poverty rush, false foxglove, bottle gentian (*Gentiana andrewsii*), Bebb's sedge (*Carex bebbii*), and crested sedge (*C. cristatella*).

Two areas of particular interest were identified and mapped on this property (Figure 3). The first, represented by line 2, is an area of heavy reed canary infestation near one of the monitoring wells well 5. This area, in past years, contained many orchid individuals, but in 2005 the numbers were unusually low. The second area, represented by line 1,

represents the extent of the orchid population adjacent to the scrape. In this area, orchids were only found along the banks of the scrape, not in the adjacent area dominated by Indian grass and other tall species.

Summary

Several observations can summarize the results of the field work performed in 2005. First, the orchids, in general, were not found in great numbers (or at all), in areas heavily dominated by tall, competitive grasses. The exception to this seems to be areas containing 25-50% reed canary grass. The presence of orchids in areas characterized by dominance, but not a monoculture, of reed canary grass can be partially explained by recent management activities within many of those areas, including brush removal and/or herbicide treatment. Most areas approaching a reed canary grass monoculture were devoid of orchids. Secondly, the orchids appear to be associated with areas that have experienced some relatively recent disturbance, whether it was fire, clearing of shrubs, scraping, or something else. While this is important to note, it is also important to note that the long-term persistence of these orchids within the context of regular disturbances is unknown. Any disturbance, whether it is a natural disturbance, disturbance due to management activities, or something else, should be done on a small-scale at first, in order to determine the response of the orchid population to the particular disturbances. The orchid populations, and the various management tools used within their habitat need to be carefully documented and monitored so that short-term and long-term adaptive management can be utilized and adjusted as needed.

Hydrology

Methods

The objectives of this study were to identify hydrologic trends consistent with the location of the orchid plants in order to determine their "preferred" hydrologic regimes. In addition, in order to assess potential impacts of altering the water levels in Lake Koshkonong, correlations between water levels occurring in the Lake and water levels occurring within the wetlands at the orchid locations were examined. Five monitoring wells were installed in the spring of 2004 within close proximity to the orchid populations. The water levels in the five monitoring wells were hand measured on weekly intervals when conditions provided. In addition, the monitoring wells were housed with maximum/minimum recorders that marked the maximum and minimum water levels between weekly visits. While the hydrology information obtained from this recording method is useful, analysis at the end of the growing season revealed that more frequent recordings would be more beneficial to measure the desired correlations. As a result, in the spring of 2005, the monitoring wells were housed with electronic data recorders that recorded water levels on hourly increments. In addition, in the spring of 2005 an additional monitoring well was installed near the margin of Lake Koshkonong (approximately 40 feet landward) to obtain accurate recordings of groundwater near the lake that responded to water table changes more similar to the other monitoring wells.

In the summer of 2005, the elevation and location of 100 orchids within the several different locations were surveyed. Four separate study areas were identified based on clusters of orchid locations, each study area contained at least on groundwater monitoring well (Figures 2 & 3). Study Areas 1 and 2 were located on Property A and Study Areas 3 and 4 were located on Property B. Each individual orchid was evaluated in 2005 and in previous growing seasons for health and vigor and was assigned an identification number. These identification numbers were also included with the elevation and location information obtained during this study. Elevations of individual orchids were used to estimate specific hydrologic parameters at each location based on the nearest monitoring well recordings.

The hydrologic data set obtained during the two years of groundwater monitoring, although useful, presents various challenges for analysis. Hydrologic data obtained during 2004 was recorded at weekly intervals; however there are several gaps in the data set due to missed measurements during flood events and lack of available field personnel to obtain measurements during several sample periods. The data set obtained in 2004 is very useful for development of a hydrology/orchid relationship but has little use for evaluating correlations with water levels occurring in Lake Koshkonong due to the long sampling intervals. In addition, precipitation patterns that occurred in 2004 and 2005 were both unusual. In 2004, excessive precipitation resulted in extreme and prolonged flooding in Lake Koshkonong and at several well locations. In contrast, 2005 was a drought year resulting in the groundwater elevation dropping below the depth of all of the monitoring wells at the orchid locations by mid August.

The late season dry wells in 2005 present the greatest challenge for analysis of this data set because during this portion of the growing season the shallow water table is influenced primarily by groundwater baseflow. During the earlier part of the growing season the shallow water table is influence primarily by precipitation. Groundwater conditions during baseflow periods are the most useful for understanding correlations between groundwater levels at Lake Koshkonong and groundwater levels at the orchid locations. Correlations between groundwater elevations at these locations in the absence of late season water level data were examined by comparing hydrologic conditions during dry periods of the early growing season while water levels were steadily declining, but before the wells were dry. The rate of the water level decline during these periods are likely heavily influenced by the character of the local groundwater table and is an acceptable method for analyzing such correlations (Fetter 1994).

Results—Water Level Trends and Characteristics

Hydrographs were produced of water levels at each monitoring well and at Lake Koshkonong with the available data from 2004 and 2005 (Figure 5). 2004 monitoring well hydrographs are based only on instantaneous measurements. 2005 monitoring well hydrographs are presented as a daily average derived from hourly recordings. Water level elevations in Lake Koshkonong are daily averages recorded at the Indianford Dam obtained from the USGS Water Resources. One distinct characteristic of this hydrograph is the excessively high water levels in Lake Koshkonong in 2004; during May through

June the water level in the Lake exceeded the 2005 water level elevations at three wells by several feet. Most notably is the distinct similarity in the hydrograph patterns between all of the monitoring wells including the monitoring well near the Lake shore, which is most pronounced in the daily water level hydrographs generated in 2005. In particular, the steady rate of decline in water levels at the orchid sites recorded between early May and late June tended to decline at very similar rates as ground water levels adjacent to Lake Koshkonong.

While water level patterns at each well location were very similar, the groundwater elevation at each location varied, demonstrating the apparent groundwater gradient that increased in elevation further from the Lake (Figure 6). The lowest mean water level elevation (May-Aug) occurred in the well at the Lake shore (Well 6) with a mean elevation of 776.49 ft and the highest occurred near the upper extent of the orchids range (Well 2) with a mean elevation of 785.79 ft (Table 4). Despite the differences in groundwater elevations, the water levels relative to the ground surface were similar between all of the monitoring wells due to the gradient of the groundwater table occurring somewhat parallel to the ground surface. The mean water levels relative to the ground surface (May-Aug) varied by only 1 foot between all of the wells. The highest water levels occurred at Well 1 with a mean of 1.03 ft below the surface and lowest occurred at Well 4 with a mean of 2.02 ft below the surface (Table 4). The mean between all of the monitoring wells was 1.48 feet (SD: 0.42) below the surface.

Hydrology threshold statistics were very similar between Study Areas. Hydrology threshold parameters analyzed included inundation frequency (% of time soils are flooded) and root zone saturation frequency (% of time groundwater is within 12 inches of the soil surface). The frequency and duration of inundation and root zone saturation are thought to be one of the most important hydrologic characteristics determining plant species distribution and occurrence (Mitsch and Gosselink 1993, Hunt et al. 1999b, Kraemer 2002). During the growing season of 2005 these threshold parameters were very similar between Study Sites and between orchid locations (Table 6). In fact, 90% of the orchids occurred where the soils were inundated only between 1-10% of the growing season. Similarly, 85% of the orchids occurred where the root zone was saturated between 30-60% of the time.

Results—Orchid Elevation and Hydrology

The orchid elevation survey was summarized by Study Area (1, 2, 3, and 4) (Figures 2 & 3). The majority of the orchids (82%) occur within two of these Study Areas, 1 and 2 (Table 5). The mean elevation of orchids between sites ranged by 4.5 feet, however within a site the range averaged 1.15 feet (interquartile range) (Table 5). The lowest mean orchid elevation site occurred at Study Area 4 with a mean elevation of 781.08 ft (near Well 5) and the highest occurred at Study Area 1 (near Wells 2 & 3) with a mean elevation of 785.56 ft. The lowest lying orchid (#17) surveyed occurred at an elevation of 780.21 ft at Study Area 2. During the high water in 2004, this orchid was inundated for a prolonged period of time and did not return in 2005 (along with several others adjacent to this one that were not surveyed) (Personnel Observation). Hydrologic

characteristics at the orchid sites were estimated based on the nearest monitoring well location. The mean water level elevation between May and August ranged from 779.37 ft to 784.55 ft between sites (Table 5). Since the monitoring wells were dry beyond August, the only information we know is that water levels between August and October were below 778.78 ft at Study Area 4 (lowest late season water level elevation) and below 782.66 ft at Study Area 1 (highest late season water level elevation) based on the maximum depth of the monitoring wells. However, it is apparent that water levels were even well below these elevations during this time period based on groundwater elevations observed in a borehole in late October. Measured groundwater elevation at Study Area 3 within a bore hole was at 776.45 ft; 0.3 ft above the water level elevation within the monitoring well near the Lake shore during the same day.

Groundwater Correlations

As describe previously, examining the correlations between groundwater patterns at the orchid sites and within Lake Koshkonong is difficult with the current hydrologic data set. However, based on the general appearance and similarity in all of the monitoring well hydrographs it is obvious that there are correlations, at least during the early part of the growing season. Although, this would be expected, as precipitation amounts and timing are nearly identical at all well locations and precipitation is the primary influence on the character of the water table during this time period. In order to reduce bias correlations resulting from precipitation events, correlations were examined during a relatively dry period when water levels were declining steadily (June 11-20). Water levels in the Lake shore well (Well 6) were approaching Lake water elevation (776.2 ft) at this time and the monitoring wells near the orchid locations were at a steady decline, approaching minimum recordable elevations (bottom of well screen). Based on simple linear regression models of mean daily water level elevations at each monitoring well plotted against elevations at the Lake shore monitoring well, all of these sites were significantly correlated (with the exception of Well 4, which was already dry). The regression coefficients ranged from 0.79 to 0.96, with Well 1 having the most significant correlation (Figure 8).

Orchid Management

Overall Management

Management in the orchid habitat near Lake Koshkonong will utilize both an experimental and adaptive approach. The primary strategy will incorporate dividing the potential and existing orchid habitat into management units, performing different management techniques (or different time intervals) in management units, monitoring the response of the orchid populations to management actions, and adapting future management based upon the populations' responses to particular management techniques.

Primary management concerns for the orchids near Lake Koshkonong include invasive species (reed canary grass and various shrubs), hydrologic modifications, herbivore damage, and potential undesired results from particular management practices.

Periodic disturbance appears to play an important role in orchid establishment, and likely in population persistence and viability. Therefore, it is recommended that various management tools be used periodically during the dormant season to mimic natural disturbance. This should be done on a small-scale at various orchid locations, and at different times, so as to create a mosaic of successional stages throughout the properties. Management actions should occur during the orchids' dormant season to the greatest extent possible. If management actions need to be performed during the growing season (such as herbicide treatment), then orchid plants must be properly protected and/or avoided. In addition, patch disturbances should occur at intervals long enough to allow orchid plants to flower, but short enough to prevent tall, competitive vegetation or woody plants from persisting or invading. In many prairies, low-heat burns can occur every 3-7 years. A variety of techniques should be utilized, including burning, mowing, and herbicide spraying as necessary. However, none of these management techniques, particularly mowing and cropping, should be utilized in orchid habitat after the plants have emerged from the ground. Monitoring should be done in conjunction with any management technique utilized, and should be continued for several years following the management action. This will be done in order to document both the short and long term response of orchid individuals and populations to specific management actions. This information can be used to develop a long-term adaptive management plan for the orchid populations near Lake Koshkonong.

Prescribed Fire

Fire is important both for maintaining and creating orchid habitat. Periodic fire should be utilized as a management tool in early spring, whenever possible, before the emergence of the orchids. If the objective is to create orchid habitat (i.e. areas were orchids have recently occurred) and/or to kill off invasive shrubs, then fire can be used more aggressively, and more often, until appropriate habitat is maintained. Fire can be used as often as every other year in these areas, provided enough fuel has been produced by

existing vegetation. However, a careful survey of burned areas should be undertaken following each burn season to look for new orchid occurrences.

In areas where orchids have already been found, periodic fire should be used approximately every 3-7 years, depending on management concerns and objectives in that particular area. This is a typical burn cycle for native prairies in the Midwest, where fire is important for preserving open habitat, preventing or reducing shrub invasion, and maintaining native vegetation, as native prairie plants are physiologically and/or morphologically adapted to fire. Burns should be done in the early spring so as not to damage existing orchids. Burning must be done in conjunction with careful monitoring of orchids to see if they persist and if they flower. While it is not clear how fire influences reproduction and persistence of orchids, it has been suggested that dormant season fire can stimulate flowering. Additionally, spring burns can stimulate mycorrhizal activity in the soil, which may enhance the ability of new seedlings to successfully establish. However, the use of fire should be approached with caution, used only at appropriate intervals in the management units, since frequent or intense fire may also damage orchid tubers. Since the orchid reproduces by seed, and seedlings take an average of 3-7 years to reach reproductive maturity, fire should be utilized at a frequency that would allow new orchid individuals to develop and reach reproductive age.

Another factor to consider is the life cycle of known pollinators of the orchid and how this may be influenced by fire. Many hawkmoths, including the three mentioned above as potential pollinators of the orchid, overwinter underground in the pupal stage and emerge in spring or early summer in their adult phase. Prescribed fire should be timed as such that it will not interfere with the timing of pupal emergence and/or larval burrowing and that it will not reduce the likelihood of potential pollinators overwintering near orchid locations. More research is needed on orchid-pollinator interactions and how these interactions relate to management activities.

Careful monitoring is of utmost importance so that information gathered on how populations and individuals respond to fire management can be incorporated into an adaptive long-term management plan for these properties.

Mechanical Removal

Mowing and mechanical removal of woody vegetation will also be used as management techniques in some management units. In appropriate orchid habitat, these activities should be undertaken only during the orchids' dormant season, regardless whether the orchids have been documented in that particular area. If appropriate habitat exists it is possible that the orchid may also exist. Oftentimes, non-flowering individuals are hard to identify, in particular in areas where vegetation is dense. Mowing is a useful tool in that it can ecologically mimic or replace fire (or historical grazing) in areas where prescribed burning is not possible or could have negative effects. Because the influence of fire on Eastern prairie fringed orchid reproduction and persistence is still unknown, mowing should be used instead of prescribed burning (or in conjunction with a prescribed burning

cycle) in some management units. Mechanical removal techniques are particularly useful in areas with dense shrub. Again, monitoring will be essential in conjunction with these techniques in order to inform land managers and enable them to make management decisions accordingly.

Hydrology Management

Given the data collected to date from groundwater monitoring, it is difficult to draw conclusions regarding how and if water levels can be managed to provide and maintain appropriate habitat for the orchids. The greatest need is for further groundwater monitoring to determine what relationships exist between orchid locations and groundwater levels. Long-term water level monitoring is necessary to account for short-term variations in climate and precipitation patterns. In addition, monitoring the variations in orchid location and elevation, and correlations with changes in water levels are important aspects for securing the survival and persistence of these populations.

Several observations regarding potential water management can be drawn from the information on hydrology gathered to date. Preliminary analyses of collected hydrology and elevation data suggest that groundwater hydrology in orchid locations is closely linked to water levels in the lake, at least in the early part of the growing season. Additionally, orchids are found in a relatively narrow range of hydrologic conditions. Field observations and monitoring indicate that flooding at orchid locations may have a negative impact on the persistence of orchid individuals. In 2004, during prolonged high water levels, 10 plants, which were observed in May, were not found in July after floodwaters receded from their location. None of the eight that were caged and tagged were observed in 2005. Finally, hydrologic changes can often enhance a site's susceptibility to invasion by non-native species, which could outcompete the rare, native orchids. Given the potential for correlations between lake water levels and groundwater levels and the narrow hydrologic range of the orchid plants it is highly recommended that further hydrologic monitoring and lake-groundwater modeling is conducted before any substantial modifications to the lake water levels occur.

Invasive Species Control

<u>Reed canary grass</u>
Reed canary grass likely poses the greatest current threat to the orchid populations. However, as previously mentioned in this report, many orchids are found within areas where reed canary grass dominates. Therefore, it is recommended that any management action that targets reed canary grass eradication be done on a small-scale for several years, and that any orchid population response to the eradication effort be monitored closely for several years following the treatment.

The reed canary grass management plan for Property A by Willis E. Brown recommends the following for areas that contain orchid (and lily) plants:

"Glyphosate herbicides will kill orchids and lilies, and the effects of grass-specific herbicides on these species have not been documented. Burn these areas in spring 2006. You could lower the rate of Vantage® to 0.25% (1/3 fl oz per gallon) and foliar apply herbicides prior to April 1st (before the orchids emerge), use a tied-stem application method, affix tarps or some other impermeable material to the plant enclosures during applications, or use a burn-interseed regime to reduce RCG abundance. One idea that may work is to plant *Carex tricocarpa* (contact AES for availability) plugs at random locations to provide competition for RCG. However, bear in mind that replacing RCG with another potentially aggressive native species can exclude RCG but may also exclude the orchids and lilies you are trying to save."

Buckthorn

Several of the locations where orchids are currently found on the properties were previously dominated by common buckthorn (*Rhamnus cathartica*). While buckthorn has been successfully controlled in these areas, managers must continue to monitor for resprouts and for seedlings, as buckthorn has the ability to resprout from seemingly dead roods and seeds can lie dormant in the soil for several years.

Both landowners have used a variety of techniques to eradicate and control buckthorn. Listed below are a few suggestions that have proven successful in buckthorn management on these properties in the past, and can be used as appropriate:

1. Mechanical removal of small buckthorn seedlings as soon as they are discovered (if there are few present).
2. Early spring or late fall burn can kill seedlings and prevent resprouting.
3. Application of appropriate herbicide such as Garlon 4 to resprouts.
4. For trees with a trunk diameter of greater than 4 inches, cut and treat stump with 20 percent Garlon 4 in Bark Oil Blue, or another appropriate herbicide
5. For trees with a trunk diameter of 2 to 4 inches, basal spray with 25 percent Garlon 4 in Bark Oil Blue. The bottom 18 inches of the tree is sprayed circumferentially. This technique is generally performed during the winter.

Herbicide and Pesticide Use

Note that the use of any pesticide near the orchid populations at Property A is regulated by the signed Pesticide Management Plan, which consists of four key elements:

1. The Landowners as well as staff and consultants will determine population size, distribution and habitat of *Platanthera leucophaea* as nearly as possible in July of each year.
2. Herbicide applications beyond 20 yards of *Platanthera* habitat edge will be made only when the wind is blowing from the habitat to the treatment area; otherwise a 100 yard buffer will be observed.
3. Within 20 yards of the plants, herbicide application will be made only with handheld equipment, with no pressure (e.g. wick, brush) under light wind conditions (<5 mph) only, by skilled staff who are familiar with the plants and pesticide use only. Beyond

20 yards from the plants and within 20 yards of the habitat, applications may be made with other handheld equipment.
4. If other pesticide needs arise, the owners or manager will contact DATCP's Endangered Species Program to discuss protection at 608 224-4538.

Herbivory Control

Deer populations are currently much above their historical densities in many regions, including Wisconsin, and the resulting increased herbivory pressure is evident in many habitats. Several studies have suggested that deer herbivory may influence species composition in various plant community types because they selectively browse on some species and leave others alone (e.g. Waller and Alverson 1997, Wiegmann and Waller 2006). In fact, lilies and orchids in general are likely preferred food for deer (Miller et al. 1992).

Observations by landowners and field workers at Lake Koshkonong indicate that deer and other herbivores do tend to browse on the orchids, and prevention measures have been taken. To the greatest extent possible, orchids are, and should continue to be, protected from herbivory by the placement of deer exclosure fencing around each orchid individual (or group of orchids if they are in very close proximity to each other). The fencing should be at least three feet tall, and wire mesh fencing with appropriate sized grid holes is preferred whenever possible. Grid holes should be large enough to allow pollinator access to the orchids, but small enough to prevent deer browsing. Hawkmoths in general are medium to large-sized moths, and the wingspan of three of the hawkmoth species identified as potential pollinators ranges in size from approximately 2.5 inches to 4.5 inches (BSI MSU). Additionally, the top of the fencing should remain open (approximately 18 to 24 inches in diameter) to allow easy pollinator access, yet should be tall enough to prevent browsing. It is important, also that the fencing be maintained throughout the year. This will protect the orchids throughout the season, from the time their leaves emerge from the ground. Additionally, it facilitates and simplifies tagging and locating already identified orchids for monitoring in subsequent years.

Annual Monitoring

Monitoring is the most important component of an adaptive management plan for the orchids. Periodic monitoring will enable land managers to identify potential problems and to take corrective measures as these issues occur. Additionally, it will enable managers to make decisions based upon what management actions or natural disturbances have had positive or negative effects.

The monitoring protocol for Eastern prairie fringed orchids was developed and is overseen by Ursula C. Peterson of the Wisconsin DATCP. Monitoring is done annually in July, when orchids are likely to be flowering, and utilizes landowners, botanists, and community volunteers. It is done in a systematic, repeatable way, and is designed to meet two objectives: to monitor existing (or previously existing) orchids and to identify

new orchid plants. Monitoring should be done within each management unit, so that the response of orchid individuals and populations to specific management actions utilized in that area can be assessed. Normally, field workers begin at one end of potential orchid habitat and then proceed forward on parallel transects. Each worker is responsible for monitoring and looking for orchids along and adjacent to their transects. Many of the orchids located in previous years have been assigned a number, tagged, and protected with deer exclosure fencing. Additionally, in 2005, orchids were located with a Global Positioning System (GPS) with sub-meter accuracy. Field workers revisit each previously identified orchid location and record the status of the orchid at the time of the survey—absent, flowering, or vegetative. If new orchids are found, their status is also recorded. All orchids should be flagged to avoid repeat counts, and new orchids should later be assigned a number and caged. Workers must also draw a rough map indicating all orchid locations with in each management unit. Other field notes regarding environmental conditions, potential threats (invasive species, shrub cover, flooding, etc.), and other observations (such as herbivory damage) should also be recorded. In addition to the intensive annual monitoring in July 2005, a survey was done in 2005 in late summer (August and September) on randomly selected individual orchids to assess pollination and seed set. These orchids were revisited and the number of seed capsules formed was recorded as well as whether they were full, partially full, or withered.

Habitats which do contain orchids should also be monitored carefully each year for the presence or spread of invasive species. This can be done at the same time as the orchid population survey, in order to minimize disturbance and to minimize the likelihood that an orchid will be crushed underfoot. The location and approximate density of invasive species should be documented and management actions taken, if necessary.

Early spring monitoring, after the plants have emerged but before they flower, can also be helpful in providing information on the orchids' life cycle and long-term persistence. Identified orchids would be counted and located using flagging or cages, where appropriate. This would make locating the orchids in July easier. Valuable information could be provided by spring monitoring including the number of orchids lost to herbivory, mold, etc., the percentage of orchids reaching maturity (flowering), the average number of years orchids remain vegetative before or between flowering(s), etc. Additionally, information could be gathered on the general environmental conditions in orchid locations at that time of year, as these may be important in the establishment and persistence of individuals (i.e. the depth and location of standing water due to spring rains/floods; the height of nearby vegetation and if this differs from sites where orchids are absent; etc.). An early spring survey will be easiest to implement in years following fire, flood, fall mowing, or other management activities which suppress plant density, so that the orchids can be more easily found among the existing vegetation.

It is of utmost importance that monitoring protocols be followed consistently and carefully. New field workers must be fully trained in orchid identification and in proper field techniques and data collecting. Whenever possible, it is best to maintain at least some personnel from year to year in order to maintain consistency.

New data should be summarized and analyzed soon after it is collected, so that it can be used to inform land managers and assist them with decision making. Qualified ecologists, conservation biologists, and other professionals should be consulted whenever possible and whenever needed to assist with analyses and decision making related to the development of an appropriate long term adaptive management plan for the orchids, using data collected during annual monitoring. A long term adaptive management plan should be developed following an additional 5-10 years of monitoring, depending on the consistency in response of orchids to various management techniques.

Other Monitoring and Management Suggestions

There are many other useful monitoring and management techniques that can be utilized by land managers depending on the need and the availability of personnel and/or funding.

Photomonitoring can be utilized in areas to document broad-scale changes in vegetation. Photos should be taken from a fixed point in a fixed direction at the same time of day. Time intervals between photos will depend on management or monitoring objectives. For example, a photo could be taken every week or once a month during a growing season to document seasonal changes in vegetation density, height, etc. Alternatively, a photo could be taken each year at the same time to document overall changes in vegetation communities or vegetation cover. Photomonitoring is most useful for documenting overall changes in vegetation density, dominance, or composition, for example, when a community begins to shift from wet prairie, dominated by native forbs and grasses, to wet meadow, dominated by reed canary grass.

Periodic plant surveys would also be beneficial in orchid habitat to determine what changes in species composition and floristic quality have occurred. Two approaches to plant surveys can be utilized. First, a meander technique, following the protocol used in 2005 and outlined above, can be used within areas already surveyed in order to document vegetation changes. This type of survey should be done approximately every 1-2 years. Another approach that can be utilized, but is more time and labor intensive, is the development of permanent quadrats within orchid habitat. These quadrats can be particularly useful in helping to quantify species diversity, floristic quality, and vegetation change in specific locations. The corners of a permanent quadrat can be marked using a surveyors stake or PVC pipe, and the quadrat location should be GPSed. Several non-overlapping quadrats can be placed in or near orchid locations (ideally some orchids will initially be located within the quadrats). A minimum of five quadrats should be surveyed in each management unit. Quadrats should be 1 meter by 1 meter, and within each, all vascular species will be identified and will be assigned a cover class, similar to the classes used for the meander survey technique. The data collected within each management area can then be used in conjunction with the management techniques utilized within each area to determine which techniques appear to be having either

desired or undesired effects on the orchids or the vegetation. Management will then be adapted appropriately.

Groundwater monitoring should be continued for as long as possible. Evidence suggests that orchids do not respond well to flooding, so it is imperative to better understand correlations between groundwater levels and elevation at orchid locations and water levels in the lake, particularly if lake levels are increased.

Vegetation management could be adjusted to incorporate the needs of potential pollinators in order to enhance the desirability of the area for these species. Host plant species for the larval stage of the Pandorus and Achemon sphinx moths identified as potential pollinators of the orchid include *Vitis* sp., *Parthenocissus* sp., and *Ampelopsis* sp. during their larval stage. The hermit sphinx feeds on *Monarda* sp., *Mentha* sp., *Lycopus* sp., and *Salvia* sp. during its larval stage. During their adult stages, adults of these species have been seen visiting many nectar-containing plants including honeysuckles (*Lonicera* sp.), petunias (*Petunia* sp.), and bouncing bet (*Saponaria officinalis*), among others (BSI MSU).

Finally, encouraging research by qualified scientists, such as graduate students, will be useful for the long-term management and conservation of this species. Several aspects of the Eastern prairie fringed orchid's life history, life cycle, ecology, and conservation are still poorly understood, and the species as a whole would benefit from quality research. Areas of investigation could include, but are not limited to, the following: dormancy—does it exist in these orchids, for how long, what triggers it, what causes them to be released from dormancy, etc.; population dynamics—what is the average age to maturity, how many flowers and seeds are normally produced, how many new seedlings become established each year, how many of these survive to reproductive maturity, etc.; plant community dynamics—what species are associated with orchids, what characterizes these species, what is the optimal plant cover for orchid establishment and persistence, etc.; mycorrhizae—what species are associated with these orchids, what are the optimal conditions for the persistence of these fungi, etc; hawkmoths—what species pollinate the orchids, what orchids do they tend to visit, what conditions are favorable for their coexistence with the orchids, etc.; genetics—is there inbreeding among these orchids, how might more outcrossing be encouraged, how does inbreeding affect the potential long-term persistence of these populations, etc; and management—how do orchid populations respond to specific management actions, which actions are resulting in desirable or undesirable effects, etc.. While this is by no means an exhaustive list, it does portray the need for further research on this species.

Summary and Conclusions

Several populations of the federally Threatened Eastern prairie fringed orchid have been discovered at two properties near Lake Koshkonong. The objective of this document is to develop an overall management strategy for these populations, incorporating monitoring protocols already utilized and overseen by DATCP, management agreements in place between landowners and DATCP, management techniques appropriate for the species and the habitat, and investigations undertaken on behalf of LKWA by NRC. The primary goal of the management plan is to maintain and enhance existing orchid habitat in order to protect and enhance the long-term persistence of these populations, to the greatest extent possible.

An experimental, adaptive approach to species management will be utilized to protect and enhance these populations of the orchid. Management will include prescribed fire, mowing, mechanical removal of shrubs, and control of invasive species. Most importantly, however, it will continue to incorporate intensive monitoring, which has been ongoing since the discovery of the orchids in 1996. Monitoring is designed both to gather information on the status of the orchid populations and to inform land managers of the influence and effects of certain management actions on the orchids. This information will be essential to developing and maintaining a successful adaptive management plan for this species near Lake Koshkonong.

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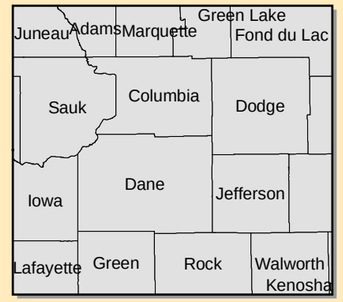
REPORT FIGURES

FIGURE 1. 2005 ORCHID LOCATIONS ON PROPERTIES A & B

Orchid Study Lake Koshkonong



Map Area Shown in Red

Location

No location data due to federally listed status

N

Project Information

NRC Project Number #: 03-189
Modified May 24, 2006

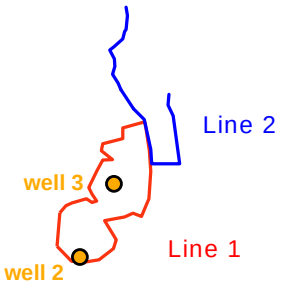
0 400 800 Feet

Legend

- Orchid Locations
- Well Locations

119 South Main Street
P.O. Box 128
Cottage Grove, WI 53527-0128
phone: 608-839-1998
fax: 608-839-1995
www.nrc-inc.net

Areas A & C/ Study Area 1



Area B/ Study Area 2

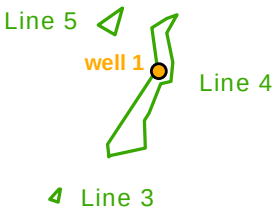
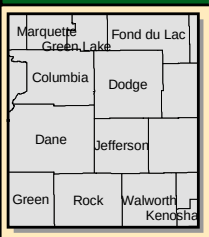


FIGURE 2. AREAS OF MANAGEMENT INTEREST
Property A - Orchid Study Lake Koshkonong



Map Area Shown in Red

N

Location

No location data due to federally listed status

Project Information

NRC Project Number #: 03-189
Modified December 15, 2006

0 200 400 Feet

Legend

- Well Locations
- Line 1 - Prairie Cord Grass Area
- Line 2 - Reed Canary Grass Area
- Lines 3-5 - Approximate Extent of Orchids Within Area B

NRC
Natural Resources Consulting, Inc.
119 South Main Street
P.O. Box 128
Cottage Grove, WI 53527-0128
phone: 608-839-1998
fax: 608-839-1995
www.nrc-inc.net

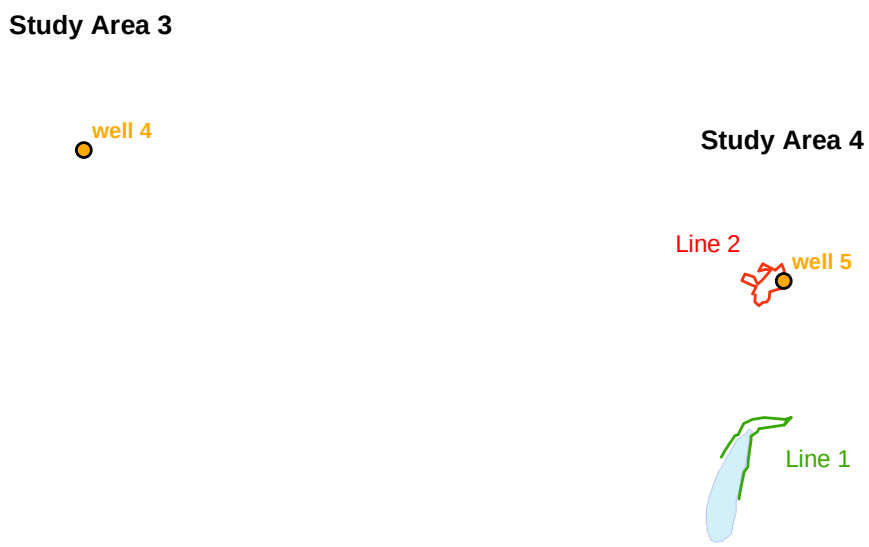
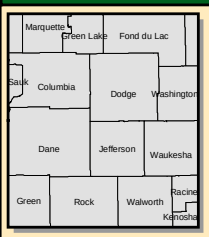


FIGURE 3. AREAS OF MANAGEMENT INTEREST
Property B - Orchid Study Lake Koshkonong



Map Area Shown in Red

N

Location

No location data due to federally listed status

Project Information

NRC Project Number #: 03-189
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0 200 400 Feet

Legend

- Line 1 - Extent of Orchids Near Wetland Scrape
- Line 2 - Reed Canary Grass Area
- Well Locations
- Wetland Scrape

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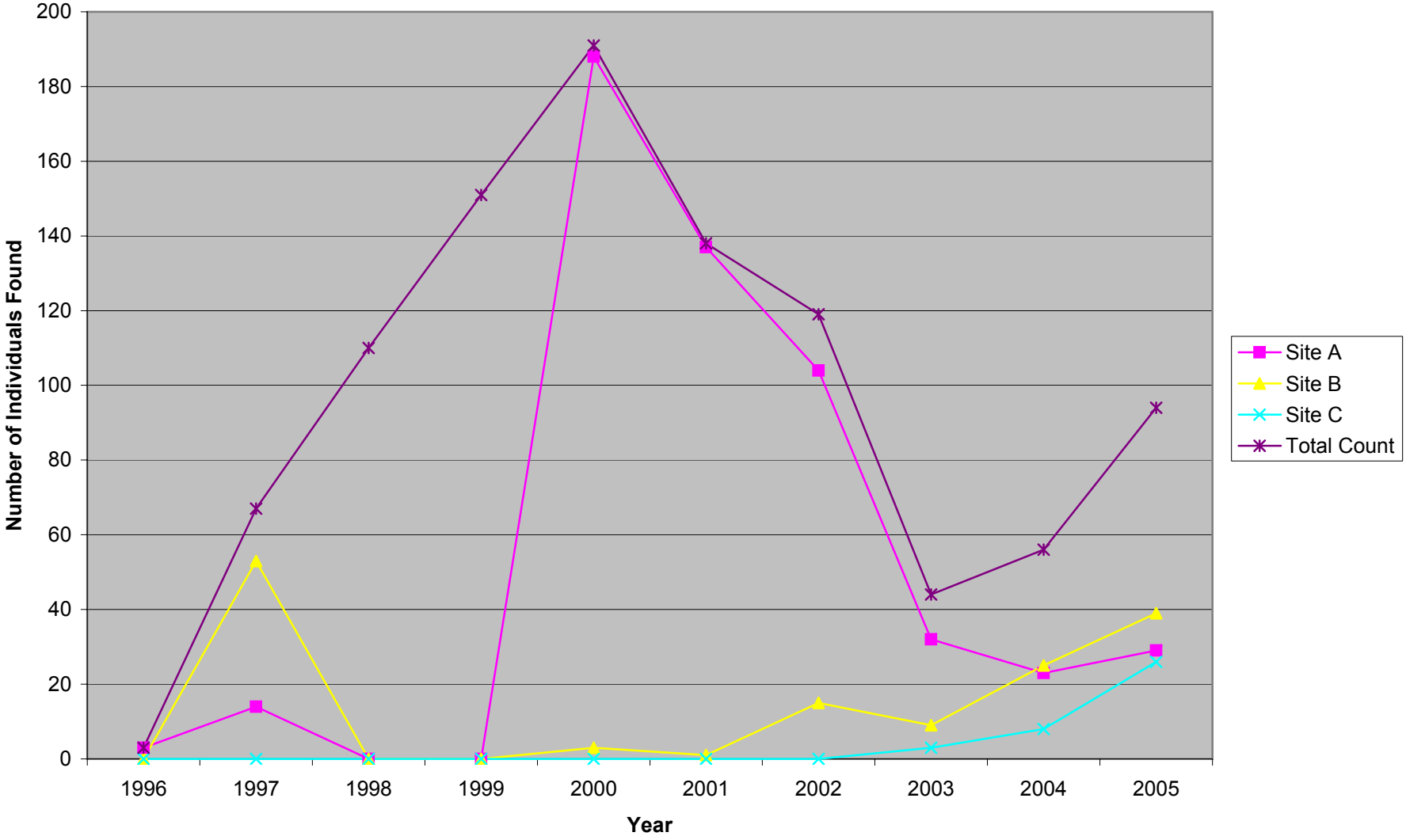
FIGURE 4:

Property A--Results of the Annual Eastern Prairie Fringed Orchid Count



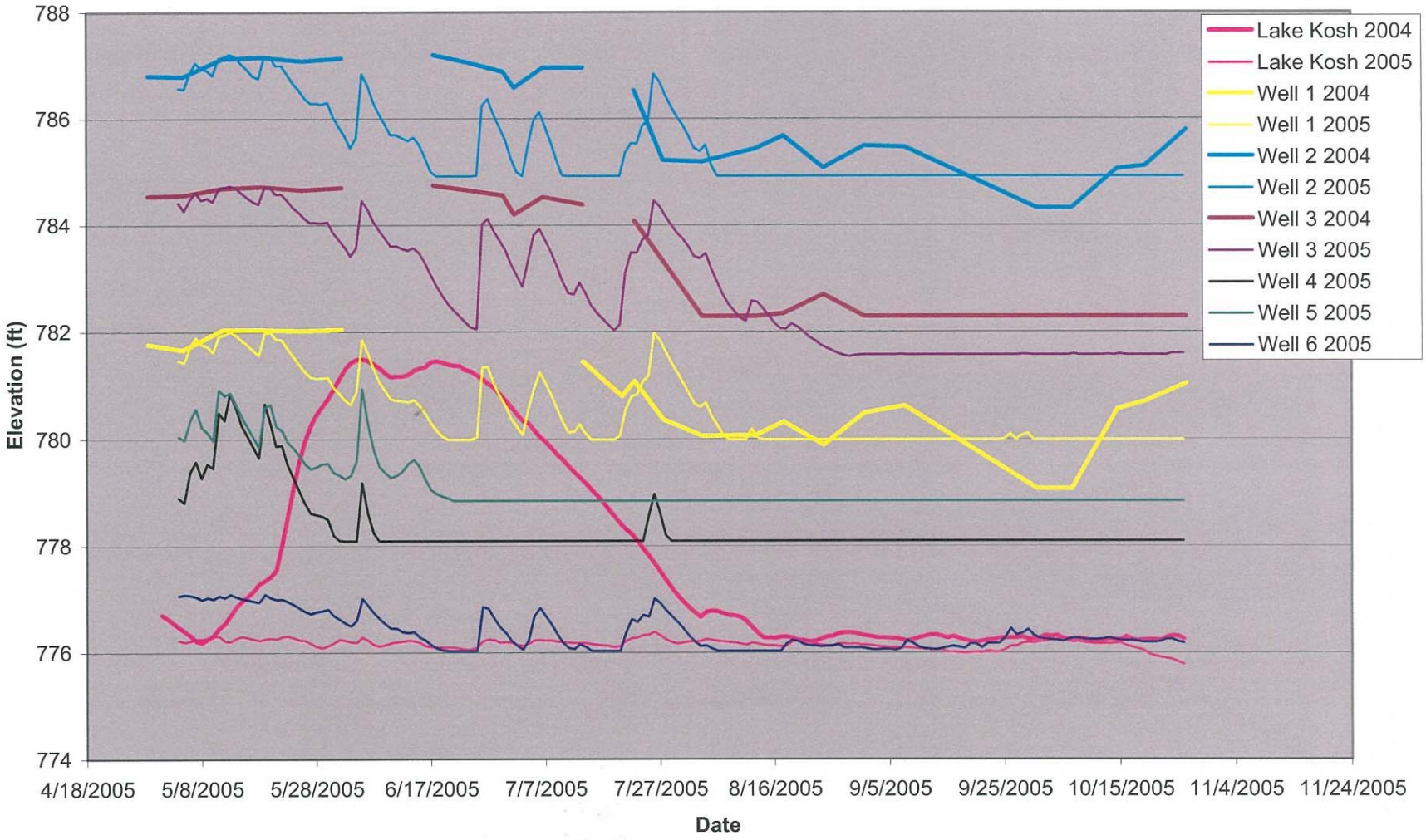
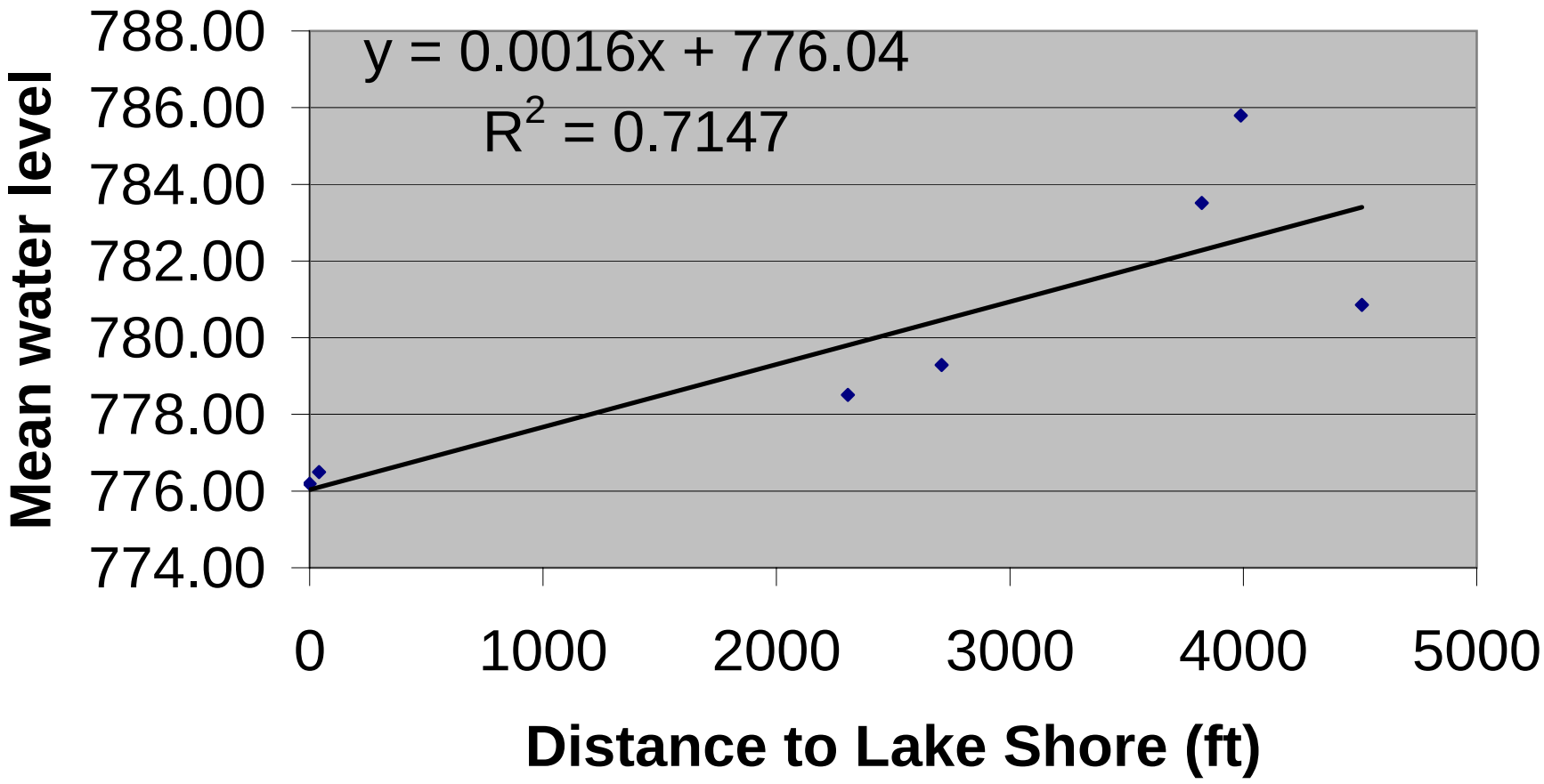


Figure 5. 2004 and 2005 Growing Seaon Water Level Elevation. 2004 growing season data is derived from weekly hand measurements. 2005 growing season data is a daily average derived from hourly data logger recordings.

Figure 6. Mean Water Level (May 5-August 15) vs Distance to Lake



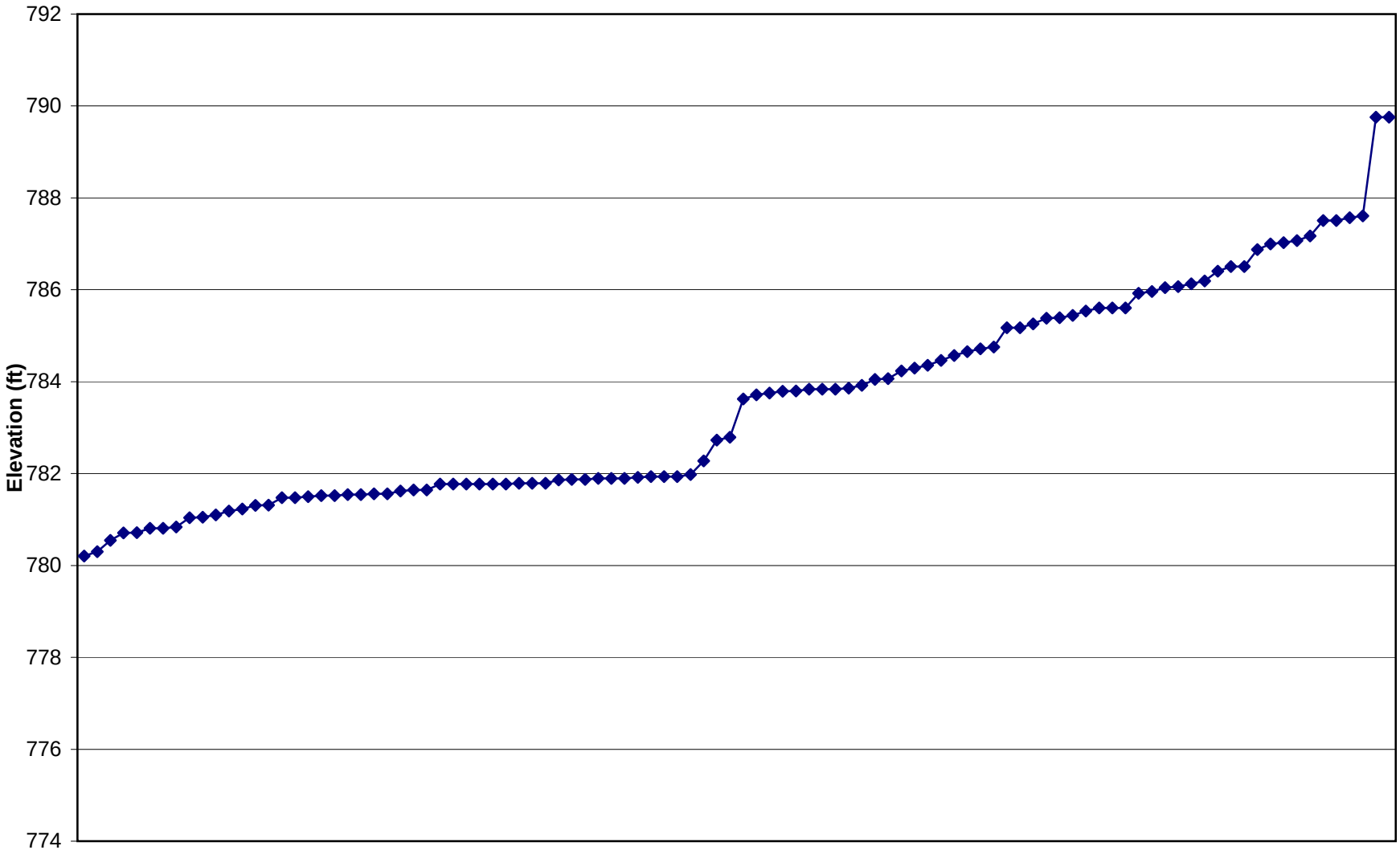
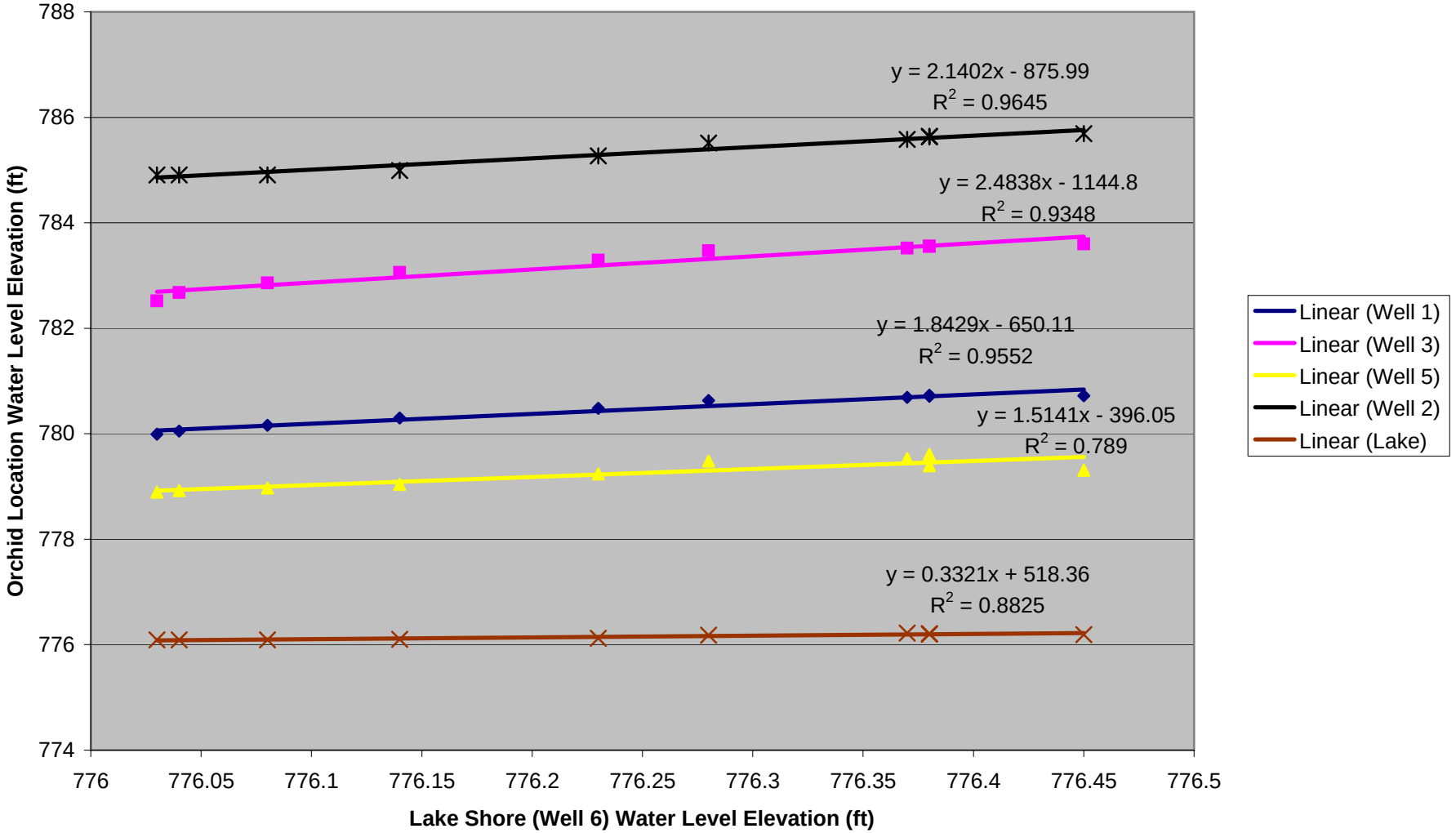


Figure 7. Ranked Elevation of Orchids at all Locations

Figure 8. Correlation between Wells at Orchid Locations and Well 6 (Lake Shore) during a dry period (6/11-6/20). Well 4 was dry during this period and was not analyzed.



REPORT TABLES

Table 1--Property A Areas A and C
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Achillea millefolium	1	1	N
Agalinis tenuifolia	1	6	N
Agrostis gigantea	2	0	I
Ambrosia artemesiifolia	1	0	N
Amorpha fruticosa	1	6	N
Amphicarpea bracteata	1	5	N
Andropogon gerardii	3	4	N
Asclepias syriaca	1	1	N
Aster novae-anglae	1	3	N
Baptesia alba	1	8	N
Boehmeria cylindrica	1	6	N
Bromus ciliatus	1	7	N
Carex cristatella	2	4	N
Circium muticum	1	8	N
Circium vulgare	1	0	I
Convolvulus arvensis	1	0	I
Coreopsis tripteris	1		N
Cornus stolonifera	1	3	N
Dianthus armeria	1	0	I
Dicanthelium sp.	1		
Eleocharis sp.	1		
Elymus virginicus	1	6	N
Equisetum arvense	1	1	N
Eupatorium maculatum	2	4	N
Eupatorium perfoliatum	1	6	N
Fraxinus pennsylvanica	1	2	N
Galium trifidum	1	6	N
Geum aleppicum	1	3	N
Geum canadense	1	2	N
Helenium autumnale	1	4	N
Helianthus grosseseratus	1	2	N
Juncus nodosus	1	6	N
Juncus tenuis	2	1	N
Lathyrus palustris	1	5	N
Liatris pychnostachya	1	7	N
Lilium michiganense	1	6	N
Liparis loeselii	1	7	N
Lobelia siphilitica	1	5	N
Lycopus americanus	2	4	N
Lycopus uniflorus	1	4	N
Lysimachia quadriflora	2	9	N
Lythrum alatum	2	6	N
Monarda fistulosa	1	3	N
Oxalis stricta	1	0	N
Panicum sp.	1		
Pedicularis lanceolata	1	8	N

Table 1--Property A Areas A and C
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Penstemon sp.	1		
Phalaris arundinacea	3	0	N
Phleum pratense	1	0	N
Physostegia virginiana	1	7	N
Platanthera leucophaea	1	10	N
Prunella vulgaris	1	1	N
Pycanthemum virginianum	2.5	6	N
Ratibida pinnata	1	4	N
Rhamnus cathartica	1	0	I
Rosa eglanteria	1	0	I
Rosa multiflora	1	0	I
Rudbeckia hirta	1	4	N
Scirpus atrovirens	1	3	N
Scirpus pendulus	1	4	N
Sium suave	1	5	N
Solanum dulcamara	1	0	I
Solidago canadense	2.5	1	N
Solidago gigantea	2.5	3	N
Solidago riddelii	2	7	N
Sorghastrum nutans	3	5	N
Spartina pectinata	2	5	N
Stachys tenuifolia	1	5	N
Verbena hastata	1	3	N
Vernonia fasciculata	1	5	N
Viola sp.	1		
Vitis riparia	1	2	N

Table 2--Property A Area B
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Achillea millefolium	1	1	N
Agalinis tenuifolia	1	6	N
Agrostis gigantea	1	0	I
Ambrosia artemesiifolia	1	0	N
Amorpha fruticosa	1	6	N
Asclepias syriaca	1	1	N
Aster ericoides	1	4	N
Boehmeria cylindrica	1	6	N
Carex vulpinoidea	1	2	N
Cirsium arvense	1	0	I
Cirsium muticum	1	8	N
Convolvulus arvensis	1	0	I
Cornus stolonifera	1	3	N
Cyperus strigosus	1	1	N
Daucus carota	3	0	I
Dianthus armeria	1	0	I
Epilobium sp.	1		
Erigeron annuus	1	0	N
Eupatorium maculatum	2	4	N
Eupatorium perfoliatum	1	6	N
Fraxinus pennsylvanica	1	2	N
Galium trifidum	1	6	N
Geum canadense	1	2	N
Helenium autumnale	1	4	N
Hypericum perforatum	1	0	I
Impatiens capensis	1	2	N
Juncus tenuis	1	1	N
Lobelia siphilitica	1	5	N
Lycopus americanus	1	4	N
Lysimachia quadriflora	1	9	N
Mentha arvensis	1	3	N
Oxalis stricta	1	0	N
Phalaris arundinacea	5	0	I
Phleum pratense	1	0	I
Physostegia virginiana	1	7	N
Pilea pumila	1	3	N
Platanthera leucophaea	1	10	N
Polygonum persicaria	1	0	I
Populus deltoides	1	2	N
Potentilla simplex	1	2	N
Pycanthemum virginianum	1	6	N
Rosa multiflora	1	0	I
Rubus sp.	1		
Rudbeckia hirta	1	4	N
Salix bebbiana	1	7	N

Table 2--Property A Area B
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Scirpus atrovirens	1	3	N
Scirpus cyperinus	1	4	N
Scirpus pendulus	1	4	N
Solidago canadensis	3	1	N
Solidago gigantea	1	3	N
Sonchus sp.	1	0	I
Stachys tenuifolia	2	6	N
Verbascum thapsus	1	0	I
Verbena hastata	1	3	N
Verbena urticifolia	1	2	N
Viola sp.	1		
Vitis riparia	1	2	N

Table 3--Property B
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Achillea millefolium	1	1	N
Agalinis tenuifolia	1	6	N
Agrimonia gryposepala	2	2	N
Agrostis gigantea	3	0	I
Ambrosia artemisiifolia	1	0	N
Amorpha fruticosa	1	6	N
Andropogon gerardii	1	4	N
Asclepias incarnata	1	5	N
Asclepias verticillata	1	2	N
Aster firmus	1	6	N
Aster novae-angliae	1	3	N
Aster simplex	1	4	N
Bidens frondosus	1	1	N
Boehmeria cylindrica	1	6	N
Carex bebbii	2	4	N
Carex cristatella	2	4	N
Carex stricta	1	7	N
Carex vulpinoidea	2	2	N
Chelone glabra	1	7	N
Cicuta maculata	1	6	N
Cirsium muticum	1	8	N
Cirsium vulgare	1	0	I
Convolvulus arvensis	1	0	I
Coreopsis tripteris	1		N
Cornus stolonifera	1	3	N
Cyperus strigosus	1	1	N
Daucus carota	1	0	I
Dicanthelium sp.	1		
Elymus virginicus	1	6	N
Equisetum hyemale	1	3	N
Eupatorium altissimum	1	4	N
Eupatorium maculatum	2	4	N
Eupatorium perfoliatum	1	6	N
Euthamia graminifolia	1	4	N
Fraxinus pennsylvanica	1	2	N
Gentiana andrewsii	2	6	N
Geum aleppicum	1	3	N
Geum canadense	1	2	N
Helenium autumnale	1	4	N
Helianthus giganteus	1	4	N
Impatiens capensis	1	2	N
Iris versicolor	1	5	N
Juncus canadensis	1	7	N
Juncus tenuis	3	1	N
Lycopus americanus	2	4	N

Table 3--Property B
Plant Species List

Species Name	Abundance	Coefficient of Conservatism	Native/ Introduced
Lycopus uniflorus	1	4	N
Pedicularis lanceolata	1	8	N
Phalaris arundinacea	2	0	I
Physostegia virginiana	1	7	N
Pilea pumila	1	3	N
Plantago major	1	0	I
Platanthera leucophaea	1	10	N
Poa pratensis	1	0	I
Polygonum amphibium	1	5	N
Prunella vulgaris	1	1	N
Pycnanthemum virginianum	2	6	N
Rhamnus cathartica	1	0	I
Rosa sp.	1		
Rubus flagellaris	1	3	N
Rudbeckia hirta	1	4	N
Salix bebbiana	1	7	N
Salix nigra	1	4	N
Scirpus acutus	1	6	N
Scirpus atrovirens	1	3	N
Setaria glauca	1	0	I
Silphium laciniatum	1	8	N
Silphium perfoliatum	1	4	N
Solidago canadensis	3	1	N
Solidago gigantea	3	3	N
Solidago riddellii	1	7	N
Sorghastrum nutans	3	5	N
Spartina pectinata	2	5	N
Spiranthes cernua	1	5	N
Stachys palustris	1	5	N
Verbena hastata	1	3	N
Vernonia fasciculata	1	5	N
Vitis riparia	1	2	N

Table 4. Mean Water Level in Each Monitoring Well from May 5 through August 15

ID	Distance from Lake Edge (ft)	Groundwater Elevation (ft)	Groundwater Depth Relative to Surface (ft)	Ground Elevation at Well (ft)
Well 1	4508	780.86	-1.03	781.89
Well 2	3989	785.79	-1.33	787.12
Well 3	3822	783.51	-1.01	784.52
Well 4	2306	778.51	-2.02	780.53
Well 5	2707	779.29	-1.80	781.09
Well 6	40	776.49	-1.69	778.18
Lake	0	776.19	-------	777.00

Table 5. Summary of Orchid Elevations and Water Levels

Site ID	Number of Plants	Mean Orchid Elevation (ft)	Maximum Orchid Elevation (ft)	Minimum Orchid Elevation (ft)	Std Dev. Of Orchid Elevation (ft)	Mean Early Season[1] Water Level from Surface (ft)	Mean Early Season[1] Water Level Elevation (ft)	Mean Late Season[2] Water Level From Surface (ft)	Mean Late Season[2] Water Level Elevation (ft)
1	41	785.56	789.76	783.71	1.58	-1.01	784.55	>-2.9	<782.66
2	41	782.50	787.00	780.21	1.71	-1.03	781.47	>-1.9	<780.60
3	11	781.39	781.93	780.81	0.37	-2.02	779.37	>-2.4	<778.99
4	7	781.08	782.28	780.30	0.72	-1.80	779.28	>-2.3	<778.78

[1] *Early season is May 5 through August 15.*

[2] *Late season is August 15 through October 31, however wells were dry during this period; only information available is that water-levels were below the listed depth/elevation during the entire late season period.*

Table 6. 2005 Growing Season Water Level Threshold Statistics.

Study Site	Percent of Orchids at Study Site	Mean Water Level Relative to Ground Surface (ft)	Percent of Time Soils are Inundated	Percent of Time Root Zone is Saturated
1	41%	-1.2	6.8	39.8
2	41%	-1.0	9.7	55.3
3	7%	-2.0	2.9	13.6
4	11%	-1.8	0.0	15.5
Mean		**-1.5**	**4.9**	**31.1**
Std Dev		**0.5**	**4.3**	**20.1**

Total Plants Surveyed	Mean Water Level between 1.0-1.5 feet below the Surface	Inundated Soils Between 1-10% of the Time	Saturated Root Zones Between 30-60% of the Time
100	82%	90%	85%