PEKIN LAKE STATE FISH AND WILDLIFE AREA
SOUTHERN UNIT
CRITICAL RESTORATION PROJECT
ILLINOIS RIVER BASIN RESTORATION STUDY, ILLINOIS

FEASIBILITY REPORT AND
ENVIRONMENTAL ASSESSMENT

APPENDIX C
GEOTECHNICAL CONSIDERATIONS

CONTENTS

CONTENTS (Continued)

Tables

Figures

Plates

PEKIN LAKE SOUTHERN UNIT
(ECOSYSTEM RESTORATION) STUDY, ILLINOIS

FEASIBILITY REPORT WITH INTEGRATED
ENVIRONMENTAL ASSESSMENT

APPENDIX C
GEOTECHNICAL CONSIDERATIONS

STUDY PURPOSE

The study purpose is to evaluate the Federal and State interest in enhancing aquatic and terrestrial habitat and reducing sediment delivery and deposition within the Pekin lake area. The development of appropriate ecosystem restoration measures involves a comprehensive examination of the problems contributing to the system degradation and development of alternative solutions. This appendix presents site geology and specific geotechnical analyses relevant to the study. To support the preparation of this appendix, Rock Island District, Engineering Division, Geotechnical Branch personnel reviewed literature, obtained soil borings, performed laboratory analysis and interpretation, and provided geotechnical analyses and recommendations.

PROJECT LOCATION

Pekin Lake is a backwater lake complex located adjacent to the Illinois River between approximate river miles (RM) 153 and 156. The site encompasses approximately five hundred acres. The area of consideration for this restoration project is generally the Pekin Lake State Fish & Wildlife Area. This area is located along the Illinois River immediately downstream of Peoria Lock and Dam and adjacent to and west of the communities of Pekin, North Pekin, and Marquette Heights, IL. The area is generally bounded by the Illinois River to the west, the communities mentioned above to the east, and Illinois Highway Route 9 to the south. The northern boundary of the site is the Central Illinois Light Company (CILCO) high voltage transmission lines. An inactive, privately owned sand and gravel quarry, located immediately east of the project site, is also being considered as part of the project.

PROJECT FEATURES

The Pekin Lake Southern Unit consists of Soldwedal Lake and Lake of the Woods. The proposed project features include the following alternatives:

1. Various channel dredging scenarios in Lake of the Woods and Soldwedal Lake areas to maximum depths of approximately 12 feet. The dredged material will be placed onsite in select areas. The purpose of channel dredging is to enhance aquatic habitat. Terrestrial habitat benefits are also expected where the material is placed onsite as islands.
2. Installation of 45-foot-circumference, sediment-filled, geotextile containers. The purpose of this feature is to provide containment for high-solids dredged material placement for the formation of small islands, thereby enhancing terrestrial habitat.

PHYSIOGRAPHY

In central Illinois, glacial features are the major landforms of the flat topography of the lower Illinois River basin, generally that area below the city of Hennepin. Geologic evidence indicates that four glacial advances have occurred over what is now the State of Illinois. In order of occurrence, they were the Nebraskan, Kansan, Illinoisan, and Wisconsinan glacial epochs. The two most recent glacial advances, the Illinoisan and Wisconsinan, are largely responsible for the uniform flatness that now characterizes much of the state. The basin is located in the Till Plains section of the Central Lowland physiographic province. The Galesburg Plain, Springfield Plain, and Bloomington Ridged Plain are subsections within the Till Plain. Peoria lies along the southwestern edge of the Bloomington Ridge Plain. This Plain includes the Wisconsinan glacial moraines and associated glacial topography. The altitude of land surface in the basin is generally from 600 to 800 feet above sea level. The area of greatest topographic relief is along the river valley, where elevation changes can range from 200 to as much as 400 feet near the confluence of the Illinois and Mississippi Rivers. The majority of the rest of the basin is extremely flat with less than 20 feet of relief. The distinction in topography between the older Illinoisan drift (Galesburg and Springfield Plains) and the Wisconsinan drift(Bloomington Ridged Plain) is the morainic ridges in the Wisconsinan drift areas. The morainic ridges are generally from 50 to 100 feet high, 1 to 2 miles wide, and 100 to 500 miles long. The moraines are separated by areas with more subdued, undulating or “rolling” topography. The type of bedrock divides the pre-glacial physiographic provinces. Subsequent glacial deposits also are controlled by bedrock lithology and structure. The Illinois Basin is underlain by Pennsylvanian age deposits of carbonates, sandstones and shales with interbedded coals. In the areas where the Pennsylvanian Upland and Lowland are covered by the Illinoisan drift, the surface topography reflects bedrock surface. The area covered by Wisconsinan drift reflects glacial depositional features. The various glacial advances were responsible for numerous drainage changes, which can be related in part to features of the bedrock topography. The lowlands are areas where the bedrock surface has been eroded below the surrounding area. The broad Havana Lowland was developed at the junction of three important ancient drainage ways, one of which was the ancient Illinois Valley where the project site lies. This pre-glacial valley was carved by the ancient Mississippi River before it was diverted by advancing glaciers to its more western present day course. This accounts for a valley that is too large for the present day river. This, in turn, results in many bottomland lakes along the lower valley.

GEOLOGY

Many geologic processes have shaped the drainage pattern of the Illinois basin. The bedrock distribution and topography affected subsequent glacial depositional processes; and, glacial processes have strongly affected the hydrology of the basin. For example, at the beginning of the Pleistocene Epoch (approximately 1.7 million years ago, or 1.7 MYBP), the rivers and streams in Illinois were not deeply entrenched in bedrock, but Pleistocene glaciation diverted the Mississippi River to its present position and scoured the bedrock surface. In the Pekin area, the present Illinois River occupies the valley of the Ancient Mississippi River, and above Pekin the Illinois River became established in its present position during the later Wisconsinan glaciation.

The uppermost bedrock is mostly carbonate rock of Mississippian (325-360 MYBP) and Pennsylvanian age (280-325 MYBP). Mississippian and Pennsylvanian bedrock are present throughout Illinois, but in most areas it is concealed by recent unconsolidated deposits up to 500 feet thick. Many of the Mississippian- and Pennsylvanian-aged formations are made of cyclic beds of sandstone, siltstone, shale, limestone, coal, and clay. These rocks contain 1% to 2% of coal by volume. There are 75 identified coal beds in Illinois. The Herrin (Number 6) Coal Member of the Pennsylvanian Carbondale Formation mined at two active underground mines in Illinois, ranges from 200 ft below land surface in the northern and western part of the basin to 800 ft in Shelby County (southeastern part of the basin) and is mostly from 28 to 42 inches thick. Coal beds range from 0 to 150 feet thick. The Mississippian bedrock is mostly shale and limestone. The altitude of the bedrock surface changes as much as 600 feet across the basin. Erosion, prior to and during glaciation, from large rivers and tributaries cut two major bedrock valleys that dominate the bedrock topography—the Mahomet system from the east and the Ancient Mississippi system from the north. The pre-glacial Illinois Valley was part of the ancient Mississippi River. The Princeton Buried Bedrock Valley is a large bedrock valley that connects to the Illinois River Valley in the northern part of the area in and near Bureau County. The bedrock valleys are filled by overlying glacial drift. The time of formation of the bedrock valleys is not well defined. The glacial materials in these valleys are some of the most productive aquifers in the basin. The Illinois and Mackinaw Buried Bedrock Valleys underlie the present Illinois River.

SUBSURFACE EXPLORATION

Subsurface exploration was done to obtain foundation and borrow material samples for determination of their engineering characteristics. Personnel from the Rock Island District, Geotechnical Branch, and the Illinois State Water Survey (ISWS) performed subsurface exploration during April 2002. All boring locations are shown on PLATE C-1 and the logs are shown on PLATE C-2. The exploration was done in accordance with Engineer Manual 1110-1-1804.

Nine offshore borings (PEK-02-11 through PEK-02-19) were taken by vibrocore methods in April 2002. The ISWS used a model P-3c manufactured by Rossfelder Corporation of Ponway, California. The vibrocoring unit is submersible, weighs 150lbs and is powered by a three phase, 240volt 60Hz generator. Sediment penetration was achieved through a method known as vibro-percusive, where the unit delivers 16-24 KN (1 KN= 225 lbs) of force and a vibration frequency of 3,450 vibrations per minute to the core tube. Therefore the best results were obtained in saturated, unconsolidated, and heterogeneous sediments. Penetration depth prediction is difficult due to the varying subsurface conditions. However, typical lake sediments (loams or sands and gravels) generally allow for complete penetration. Complete penetration depth was not achieved for all vibrocores taken at the complex.

Rossfelder Model P-3c Vibrocore

The set-up for the core tube included the use a 10 ft section of 3.5" IPS schedule 5 black iron pipe, with an OD of 4.0", a wall thickness of .083" and an ID of 3.834". The core tube was equipped with a cutter nose fabricated from 303 stainless steel and incorporates a stainless steel core catcher to help ensure retention of the sample. The core tube also incorporated an extruded High Density Polyethylene (HDPE) liner to allow collected cores to be transported easily. As an alternative, 4" thin wall aluminum pipe can be used as the core tube. This would allow dispensing with the HDPE liner and increasing the length the core tube to approximately 15'. The vibrocoring was conducted from a trailered, 18'x 8' pontoon boat, with a draft of approximately 18" when outfitted for coring operations. A 16'deck mounted tetrapod and electric winch facilitate deployment of the corer.


Illinois State Water Survey Vibrocore Plant

LABORATORY TESTING

The results of the laboratory testing are listed with each individual boring log. All laboratory testing on samples taken from the borings located and the logs shown on PLATES C-1 and C-2, respectively, was done in accordance with Engineer Manual 1110-2-1906. The continuous samples taken from borings PEK-02-11 through PEK–02-19 consisted almost entirely of clays (CL, CH, and CL-CH). These borings were taken from the sediment surface to depths of up to ten feet using the vibrocore. Organic layers were found throughout much of this upper stratum. The approximate average water content of clay samples taken from borings located in areas proposed for dredging is 58%. Pocket penetrometer tests were done throughout the continuous samples, and these results are shown on the boring logs. The clay consistency ranged between 'soft' and 'firm' throughout the stratum. Since these borings were taken underwater, groundwater elevation information was not available.

A 15-gallon composite bucket sample was taken from borings PEK-02-12, 13, 15, 16, 17, 18, and 19 and sent to an independent laboratory for flocculent and zone/compression settling analyses. The analyses were conducted in accordance with procedures outlined in EM-1110-2-5027, and the results are presented on PLATES C-3 and C-4. The composite sand content was 3.2%.

GROUNDWATER CONDITIONS

General

In order to determine the feasibility of project features, it was necessary to describe the groundwater conditions at the project site. Stephen Burch (2001) has provided information concerning the immediate project area groundwater and related subsurface geology in his *GROUND-WATER CONDITIONS IN THE VICINITY OF PEKIN AND WORLEY LAKES* report. The remaining subsections of this section are taken directly from Burch's work.

Aquifer Characteristics

A very productive aquifer underlies the Peoria-Pekin area. This aquifer is comprised of the Sankoty sand that fills a buried bedrock valley called the "Pekin-Sankoty Channel." The Pekin-Sankoty Channel extends from above Peoria where this smaller valley leaves the ancestral Mississippi Valley and extends southwest under the upland northwest of Peoria, to the mouth of Kickapoo Creek, and southward along the present Illinois Valley past Pekin (Figure C-1).

The Sankoty sand is missing on the bedrock uplands south of East Peoria and in the western part of the area. The Sankoty sand is named from the Sankoty water-well field north of Peoria. The sand differs from most glacial sands and is typically composed of 70 to 90 percent quartz grains. The texture is medium-grained but varies from silty fine sand to coarse gravelly sand (Horberg et al., 1950)

The Sankoty sand is very permeable and yields large quantities of ground water to wells. Pump tests and aquifer tests in the area frequently have estimated hydraulic conductivity between 3,000 and 8,000 gallons per day per square foot. Yields from these wells often range from several hundred gallons per minute (gpm) to as much as 1,500 gpm. Saturated thicknesses of 71 and 65 feet have been reported at North Pekin Well #2 and Pekin Well #6, respectively.

Ground-Water Levels

Water levels in wells tapping the Sankoty Sand have been measured periodically for almost 60 years by the ISWS. Ground-water levels generally recede in the late-spring, summer, and fall when evapotranspiration and pumping losses are greater than recharge from precipitation. Ground-water levels generally begin to recover in the early winter months and are most pronounced during the spring months.

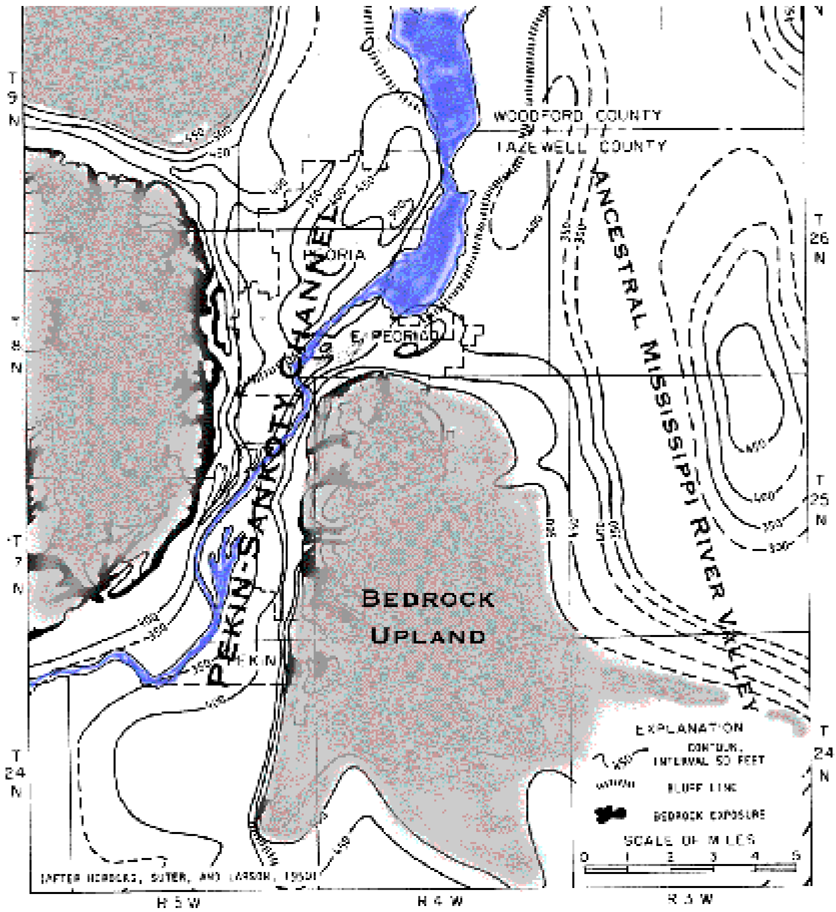

Figure C-1. Buried bedrock valley in the Peoria-Pekin area.

Observation wells have been constructed throughout the aquifer to monitor changes in ground-water levels. Hollinger et al., (1999) reported the levels in observation wells close to the Illinois River fluctuate in apparent response to river stage. Annual peak water levels often occur within a month of the peak river stage. Ground-water levels in wells more distant from the Illinois River are more subdued in their responses to the river and are influenced more by precipitation and pumpage. An examination of these more distant wells, but still within the unconfined area of Mason and Tazewell Counties revealed a relationship between ground-water levels and precipitation. It was observed that there is a two-to-three month lag from the time the rainfall is received at the surface of the earth and the time that is observed in the ground-water levels (Hollinger et al., 1999).

Several observation wells have been constructed in the Pekin area by ISWS investigators. Particularly relevant to this discussion are TAZ-90I and TAZ-90J because they are immediately adjacent to the area in question (Figure C-2). Both were constructed by Burch and Kelly (1993) and encountered a medium to coarse-grained quartz sand immediately below the surface. The upper 25 to 35 feet of sand was unsaturated (dry). Depths to water below the top of the casing are about 25 and 39 feet, respectively (Table C-1).

The elevation of the water table in observation well TAZ-90I is approximately 438 feet while the stage of the Illinois River is about 435 feet or less. The well is located at the junction of Highway Routes 29 and 98, immediately east of Worley Lake. On the topographic map for the area, Worley Lake is shown to be at an elevation of 439 feet, which is also higher than the river (although that elevation may be high and should be verified).

Water levels in the observation well at the foot of the Route 9 bridge, TAZ-90J, are also higher than the level of the Illinois River. This observation well is located perhaps only 200 feet from the river in an area where the hydraulic gradient of the water table is typically steepest. Site-specific surveying could quickly determine the difference between the water levels in the observation wells and that of the Illinois Rive

Two other observation wells were constructed in the area by Varljen in 1991. Elevations for the measuring points of these wells, TAZ-91A and TAZ-91, are not known. The depths to water in these wells, 61.39 and 34.18 feet, respectively, are consistent with a general ground-water flow pattern toward the Illinois River.

Table C-1. Observation Wells and Ground-Water Levels in the Pekin Area

Well Identification	**Measuring Point Elevation**	**Depth to Water (ft)**	**Elevation of Water Table**	**Date of Measurement**
TAZ-90I	464.50	25.75	438.75	9/30/1992
TAZ-91A	~500	61.53	~438	9/30/1992
TAZ-91B	~470	34.18	~436	9/30/1992
TAZ-90J	474.30	39.83	434.47	9/30/1992

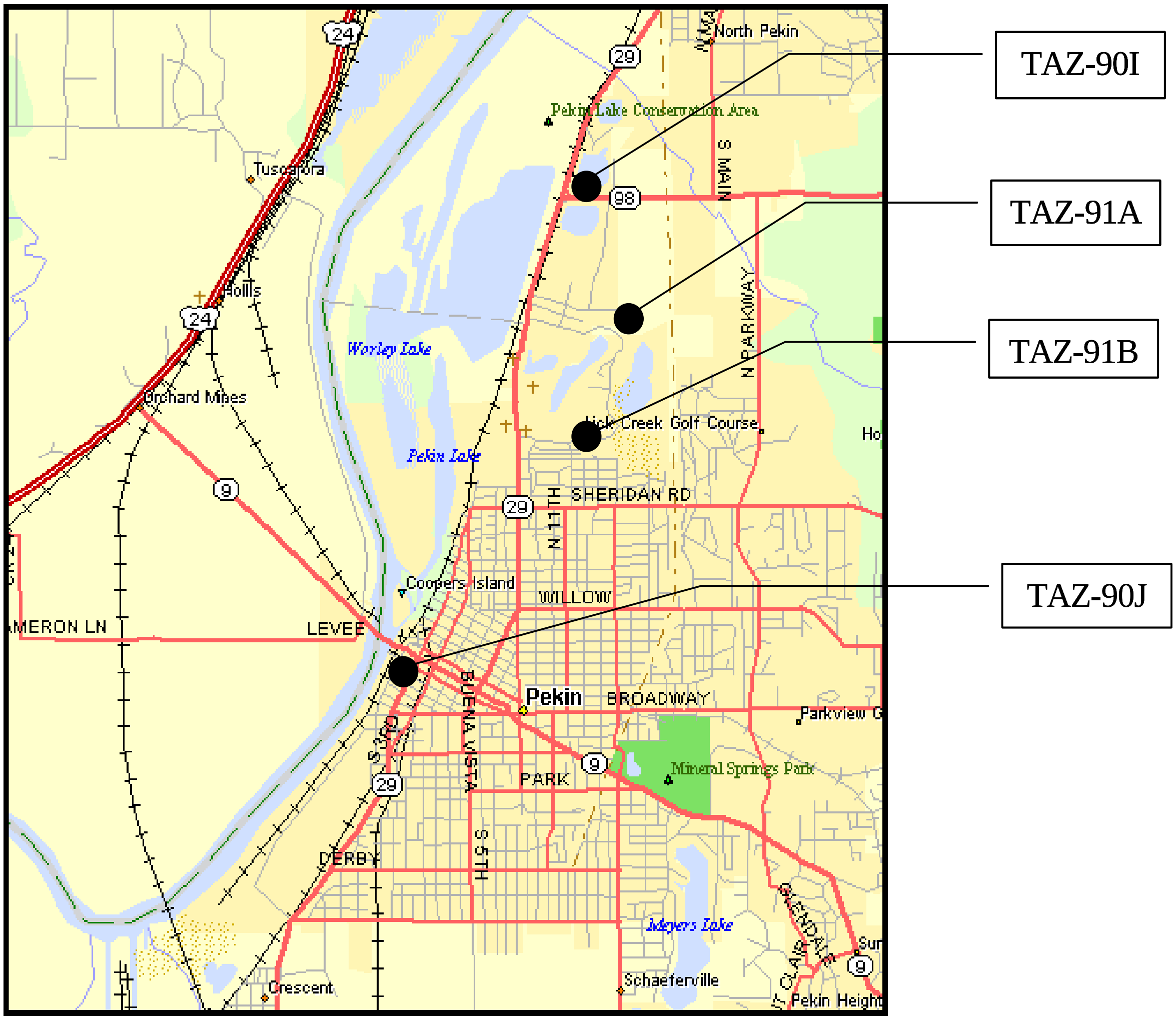

Figure C-2. ISWS observation well locations in the Pekin and Worley Lakes area.

Ground-Water Flow Patterns

It has been observed that the general pattern of ground-water flow in this area is toward the Illinois River. The river serves as a regional discharge boundary for the Mahomet and Sankoty aquifers that underlie hundreds of square miles in central Illinois. Over much of Mason and Tazewell Counties, where the aquifer occurs under water-table (unconfined) conditions, the average slope of the ground-water surface is about 5 feet per mile. However, Marino and Schicht (1969, p. 26) reported the slope can be about 30 feet per mile in the immediate proximity of the Illinois River. Further south, Walker et al., 1965 illustrated the hydraulic gradient was toward the Illinois River when studying irrigation in the early 1960's near Havana (Figure C-3).

Besides a regional horizontal gradient toward the river, there is also an upward vertical gradient from the aquifer that lies beneath the floodplain. An observation well nest (MTOW-9) just south of Havana, consisting of wells completed at 27, 54, and 83 feet depths, has provided data that allows calculations of the vertical hydraulic gradient. It has been observed that the water level in the deepest well is 0.85-ft higher than that in the shallowest well, indicating an upward hydraulic gradient. The resulting upward gradient to the Illinois River is 0.015 ft/ft, equivalent to 80 feet per mile, more than two times the steepest horizontal gradient reported.

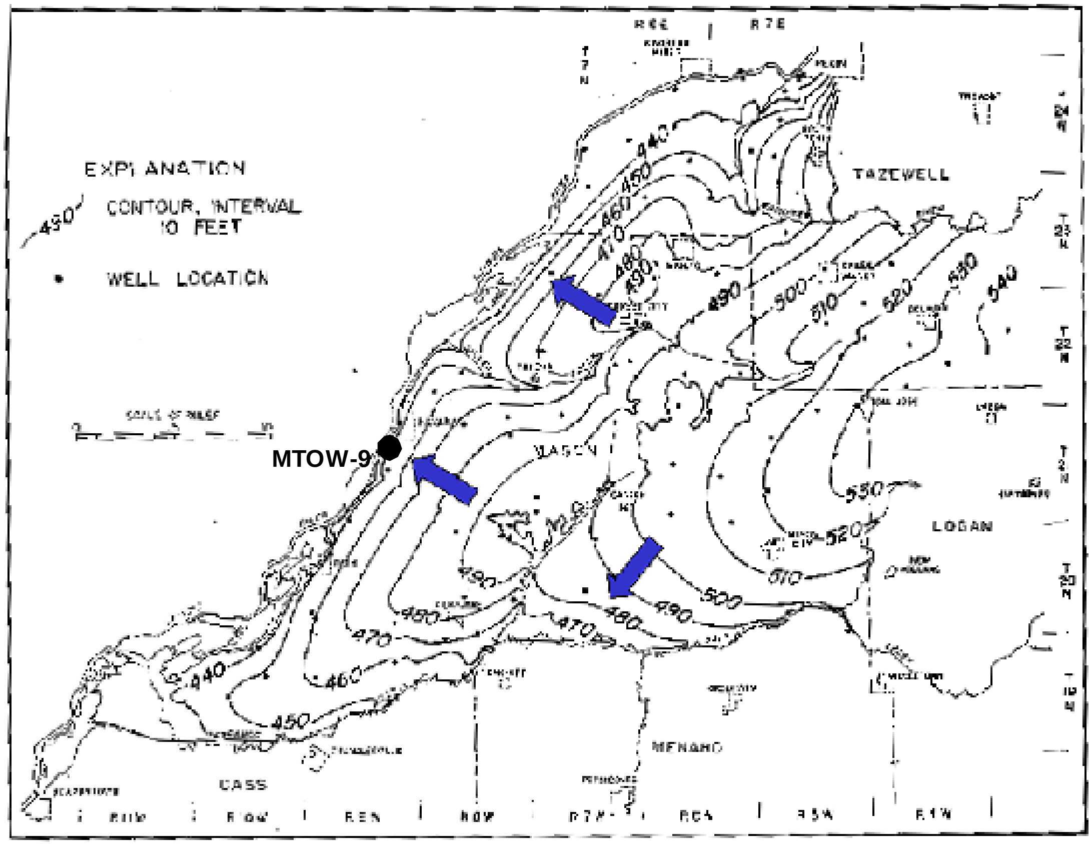

Figure C-3. Potentiometric surface in Mason and Southern Tazewell Counties, 1960 (from Walker et. al., 1965)

PROJECT FEATURES DESIGN

General

The project features that require geotechnical evaluation have been previously described in the main report and this appendix. They include channel dredging and island construction. Detailed drawings of the proposed features are found in the main report. The main project feature, deepwater habitat construction (channel dredging), will be accomplished by some combination of ‘high solids’ dredging, mechanical dredging, and conventional hydraulic dredging. ‘High solids’ dredging could include several methods currently in use that are capable of moving sediment without appreciable water addition. These may include filter press, bucket-auger, or other techniques.

The following is a general scenario for project feature construction: (1) Move fine-grained sediment from the channels to the adjacent island construction sites using mechanical dredging.

(2) Build an on-site sediment confinement structure as shown in the main report drawings by placement of the material dredged from the channels using conventional earth-moving equipment.
(3) Move fine-grained sediment from the deepwater channels to the sediment confinement structure via conventional hydraulic dredging.

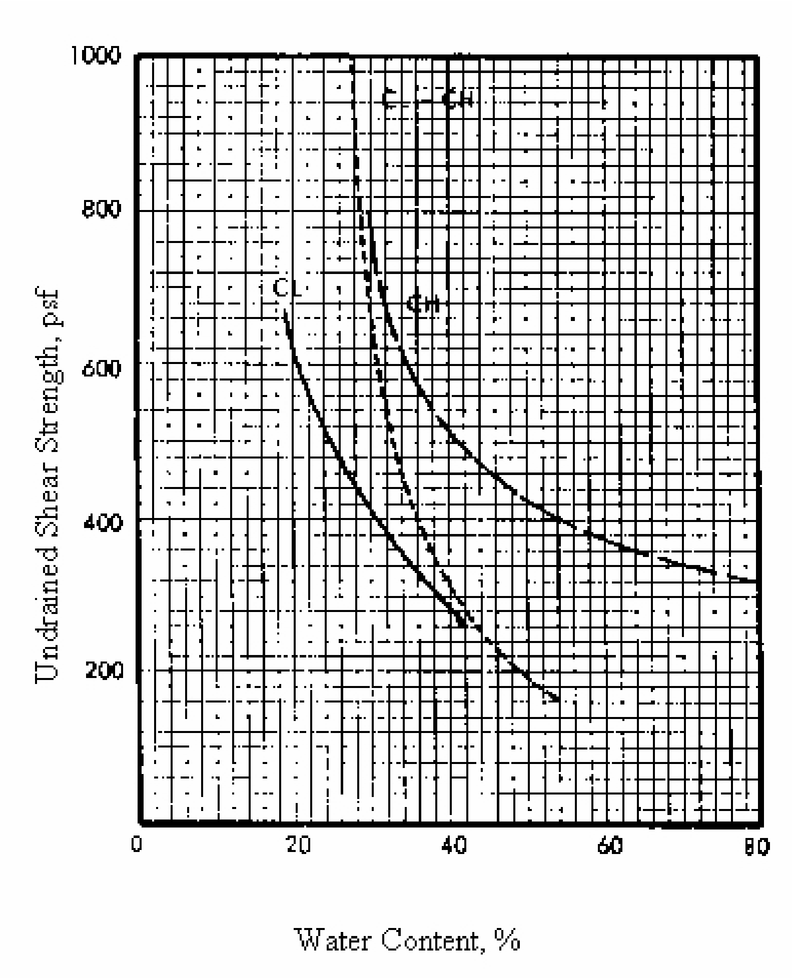

Figure C-4. Water content versus undrained shear strength

Channel Dredging

The subsurface exploration and laboratory testing was described previously in this appendix. The correlation presented in Figure C-4 represents a compilation of data from normally consolidated Rock Island District river valley clays. From Figure C-4, the average undrained shear strength of the foundation clays located in channel areas ranges between 150 and 400 psf for average moisture content of 58%. The strength of this material is taken as 300 psf for this analysis. Selection of undrained strength is considered appropriate here since the sediment is normally consolidated. Normally consolidated clays develop positive pore water pressures upon unloading, as opposed to over-consolidated clays, where the opposite is true. Increased pore water pressure induces a decrease in effective strength, and the undrained strength is the most critical in this case. An idealized channel dredge cut section was developed to determine stability using the UTexas4 slope stability package. The dredge-excavated slope was analyzed in accordance with Engineer Manual 1110-2-1902 and will not be subjected to pool fluctuation, seepage, or earthquake forces. The stability analysis resulted in a factor of safety for the 4H:1V cut slopes of approximately 3.0. The UTexas4 program was run in the search mode, and numerous other surfaces were calculated, but only the model scenario depicted on PLATE C-5 and is considered relevant.

Non-uniform, or “stepped,” dredge cuts are planned for most of the channels, as depicted in the main report drawings, and associated minor surface sloughing is expected to occur during dredging of the deepwater habitat. However, “stepped” dredge cuts are not expected to affect the overall stability of the deepwater habitat channels with generalized 4H:1V slopes.

The top of dredged channel slopes should be placed no closer than 25 feet from proposed island toes in order to avoid influence on the stability of both the island embankments and the dredged channels.

Island Construction

Islands will be constructed to maximum heights of 18 feet by moving fine sediment from channel locations to island locations using either mechanical dredging by large clamshell bucket or ‘high solids’ techniques (or, a combination). Due to the large footprints and heights of the proposed islands, coupled with the limited reaches of even the largest capacity crane booms, conventional earth-moving equipment will be required to move material regardless of the method chosen to initially stockpile material at the island sites.

Placement of sediment embankments by large clamshell has been accomplished at the Peoria Lake Enhancement project site, located approximately 25 miles upstream of the Pekin Lake site. This placement did not include the use of conventional earth-moving equipment due to the limited height and width of the embankment. The geotechnical design for the project is included in the *References* section of this appendix. It is considered useful here to discuss the design and construction of the Peoria Lake embankments as a model for the design and construction of the Pekin Lake Southern Unit islands. The foundation sediments at the Peoria Lake site were characterized as a three-layer system using vane shear data-the upper 5-foot-thick layer (“fluff”) assigned a 50 psf undrained strength, the second 15-foot-thick layer assigned a 320 psf undrained strength, and the foundation assigned a 600 psf undrained strength. The upper weak 5-foot-thick layer was excavated and side cast prior to placement of the 12-foot-high embankment on the lower 320-psf material (the lower 320 psf material was also used to build the embankment). Construction of the majority of the 6H:1V-sloped embankment was completed successfully in three passes of a 7 cuyd clamshell bucket (contrary to original design, which recommended two passes based on bearing capacity). The contract also required a 30-day minimum wait between passes to enable consolidation and strength gain. Sufficient strength to support the successive lifts was generally available in less than 30 days, and the contractor was allowed to proceed ahead of schedule. The average liquid limit of the 320 psf material was 54% and the average water content was 41%. The clay sediments at the Pekin Lake site are generally comparable in consistency, but exhibit higher average moisture contents and liquid limits. The embankment strength at Peoria Lake was preserved by various construction techniques. The contractor was not allowed to ‘throw’ the material from the clamshell, but was required to ‘place’ the clamshell and then release the material in order to preserve the maximum strength of the sediment. Isolated embankment and shallow foundation failures occurred due to the unpredictable nature of the sediment strength and placement method. The embankment and foundation soils gained strength and greater stability with time as the cohesive soils were allowed to consolidate and drain.

The Pekin Lake Southern Unit foundation soil undrained cohesive strength is again taken as 300 psf (as with the channel stability, previously described), a choice appropriate for the end-of-construction case analyzed here. The undrained shear strength is also considered applicable for island embankment design, since generally undisturbed foundation soils would be used to build at least the first stages of the islands. The undrained embankment cohesive strength will be reduced to 250 psf to account for the remolding process expected to occur with placement by clamshell bucket. The slope stability package UTexas4 was used to determine sliding factors of safety of the island embankment and foundation. UTexas4 was run in the search mode and numerous failure surfaces were examined, but the model scenario depicted on PLATE C-5 is considered the most critical. This scenario resulted in a factor of safety of 1.13, occurring mostly through the embankment and near-surface foundation.

Ideally, the islands would be constructed entirely of material initially moved onsite via large clamshell bucket so that in situ soil strength is preserved as much as possible during the construction process (as with the Peoria Lake Enhancement project). Movement of material by 'high-solids' methods would tend to remold soils and add water, thus reducing soil strength. The movement of high-solids-placed soils by conventional earth-moving equipment during initial phases of island construction will not be possible until drying and consolidation has occurred. This drying and consolidation process could take several months, and potentially longer during initial stages when the material is placed beneath the water surface. If this study indicates that islands built entirely of material removed mechanically is uneconomical, then it is recommended that, at a minimum, the initial phases of island construction include embankments built with mechanically-removed material so that a base with sufficient bearing capacity to support conventional earth-moving equipment is available within a reasonable time period. Once a sufficient base is established, conventional earth-moving equipment will be able to operate to move and compact soils stockpiled by 'high solids' methodology as the drying of these soils allow. The final island embankments will in this way be characterized as 'semi-compacted'.

The islands will be overbuilt by 10% to account for material desiccation and embankment and near-surface foundation consolidation settlement. Appreciable overall foundation settlement is not expected to occur, since the coarse grained Sankoty aquifer lies very near the surface at approximate elevation 420.0. Any long-term differential settlement is acceptable due to the intended purpose of the structure as a habitat feature and a placement site.

Island embankment protection from wind-generated wave attack is not considered due to minimal wind fetch in the southern lakes area. Also, since the embankments will be placed on relatively flat slopes (4H:1V), they will be comprised mainly of erosion-resistant plastic clays, and they are expected to produce vegetative cover immediately, material loss from wave attack erosion is not considered to be problematic. Potential island embankment erosion resulting from water current attack is not addressed in this appendix (refer to the Hydraulics Appendix).

The use of geotextile containers as a method of sediment confinement for island construction is also considered. Geotextile containers have been similarly applied elsewhere as described by Fowler (1994) for shoreline protection, dredge disposal containment, breakwaters, scour protection, sedimentation prevention, and river training. The containers proposed for Pekin Lake would be approximately 6.5 feet high and 20 feet wide. They would be built by placing fine sediments removed from channel locations into each individual container, and each container would be sequentially connected to form the perimeter of the island. Since the containers will be filled with fine-grained material, the material will be placed in the containers at very near in situ water contents using a 'high solids' technique. In this way, the containers will retain their original geometry.

After placement of the geotextile containers to form the island perimeters, adjacent fine sediments can be moved to the interiors of the islands using a either mechanical or 'high-solids' dredging technique. The final island ground surface elevations will lie approximately 18 inches below the top of the geotextile container perimeter. Refer to the main report drawings for details.

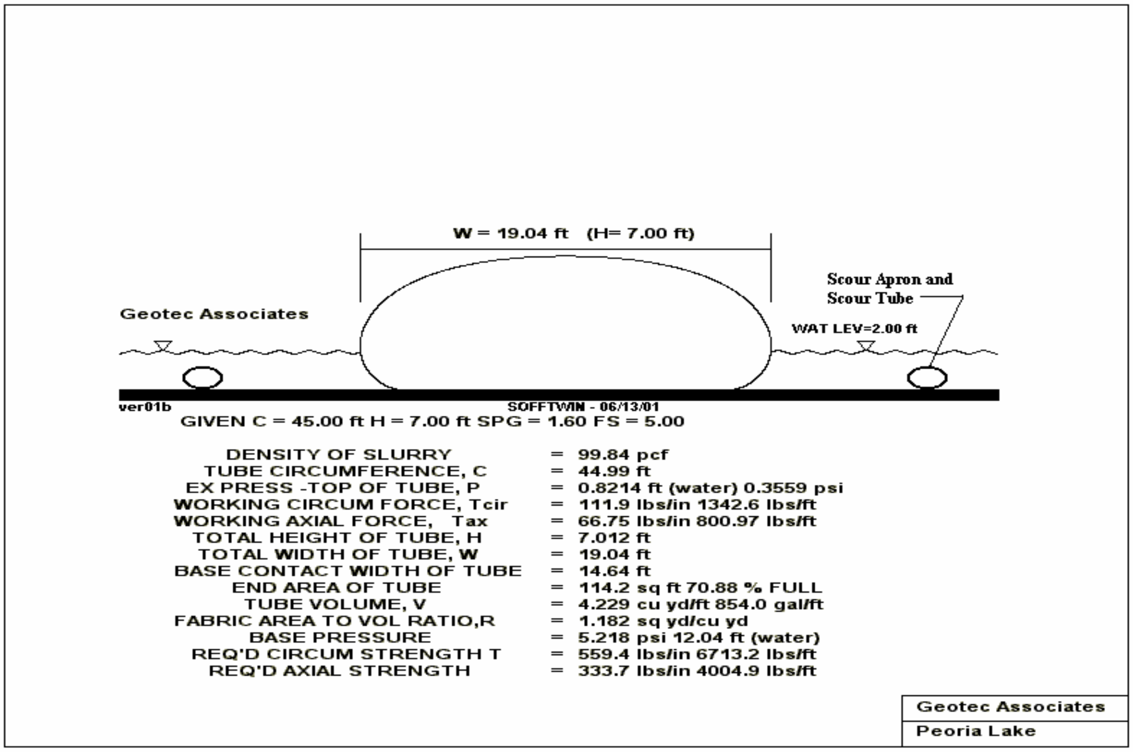

Figure C-5. Geotextile container design (courtesy of Jack Fowler, Geotec Associates)

A geotextile container design typical to what is proposed for Pekin Lake is shown in Figure C-5. The base pressure (or allowable bearing pressure) of the geotextile container is 5.218 psi, or 751.4 psf. The ultimate bearing capacity of the sediment foundation is expressed as:

$$q_{ult} = cN_c = (300 \text{ psf})(5.14) = 1542 \text{ psf}$$

where; c = soil undrained cohesive strength

N_c = bearing capacity factor for undrained clay (ϕ=0)

The factor of safety for bearing failure of the geotextile container is expressed as;

$$\text{Safety Factor} = q_{ult}/q_{allow} = 1542 \text{ psf} / 751.4 \text{ psf} = 2.05$$

The geotextile material selection is made based on the desired height of the structure and the forces exerted by the material placed in the container. The geotextile system selected to withstand the forces listed in Figure C-5 will be extremely durable. These types of systems have resisted waves, current, ultraviolet light attack, and vandalism for 10 or more years in a variety of harsh environments. The container will also be chosen so that the contained material will naturally vegetate for erosion resistance well beyond the life of the container. The T. C. Mirafi-manufactured GC500 *Geotube*, or its equivalent, is an appropriate product for this application. The geotextile container will be fabricated with a scour apron on both sides, as shown in Figure C-5. The scour apron will serve to protect the foundation from undermining due to wave and current erosion.

Sediment Confinement

Approximately 270,000 cubic yards (cyd) of material will be moved to the sediment placement site via hydraulic dredging. For dredging fine-grained materials in the retention of solids and initial storage scenarios, experience has been a 1.5-2.0 : 1.0 ratio of VOL_{CDF} : $VOL_{DREDGING}$. This ‘rule of thumb’ would result in a need for an approximate CDF volume as determined here:

$$VOL_{CDF} = (1.75)(270{,}000\ yd^3) = 472{,}500\ yd^3$$

And approximate CDF height as determined here:

$$HT_{CDF} = [(270{,}000\ yd^3)]/[(4840 yd^2/ac)(30\ ac)] = 3.25\ yd = 9.75\ ft$$
$$HT_{CDF} = 9.75\ ft + 2\ ft\ freeboard = 11.75\ ft$$

The proposed volume of the CDF is approximately 420,000 yd^3 (including a 2-foot freeboard), and the proposed CDF embankment height is 12 feet, indicating that the CDF may be slightly undersized for a typical sustained dredging event of this magnitude.

Detailed CDF design will be done during preparation of plans and specifications for the construction contract. The CDF will be designed for retention and initial storage for the proposed one to two-year dredging event. For this short-term application, CDF design will be done using techniques described in EM 1110-2-5027, “Confined Disposal of Dredged Material”. The design methods described in EM 1110-2-5027 require flocculent and zone/compression settling data as input. This data is shown on PLATES C-3 and C-4. Many assumptions are required to make realistic use of the design procedures. Some of the assumptions are pre-determined for this project, such as the amount of material to be dredged (270,000 cyd), the CDF area ($\pm$30 acres), and the dredged material water content (58%). Other assumptions can be altered in order to use the design procedures to identify which settling process governs design and to determine the most optimal values for these assumptions. Examples of the variable assumptions include CDF depth and hydraulic efficiency, type of dredge used, and dredging days per week/hours per day. The main consideration at this stage of design is that the designated CDF will be marginally sufficient to contain a one-time sustained dredging event, particularly at high dredge effluent flows. Options that will serve to ensure that the CDF capacity is sufficient to hold 270,000 cyd of dredged material include: specification of a lower-capacity dredge, specification of limited hours of dredging per day or week, construction of CDF height to at least 12 feet, and construction of a cross dike for optimized effluent water quality.

REFERENCES

USACE (1970), “Engineer Manual EM 1110-2-1906: Laboratory Soils Testing,” U.S. Army Corps of Engineers, Washington, DC.

USACE (1984), “Engineer Manual EM 1110-1-1804: Geotechnical Investigations,” U.S. Army Corps of Engineers, Washington, DC.

Duncan, J.M., Horz, R.C., and Yang, T.L. (1989), “Shear Strength Correlations for Geotechnical Engineering,” Department of Civil Engineering, Virginia Polytechnic University, Blacksburg, VA.

Wright, Stephen G. (1999), “UTEXAS4 A Computer Program For Slope Stability Calculations,” Department of The Army, U.S. Army Corps of Engineers, Washington, DC.

USACE (1970), “Engineer Manual EM 1110-2-1902: Stability of Earth and Rockfill Dams,” U.S. Army Corps of Engineers, Washington, DC.

USACE (1992), “Automated Coastal Engineering System User’s Guide,” Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS.

USACE (1992), “Engineer Manual EM 1110-2-1905: Bearing Capacity of Soils,” U.S. Army Corps of Engineers, Washington, DC.

Das, B. (1995), Principles of Foundation Engineering, PWS Publishing Company, Boston, MA.

CEMVR (1990), “Peoria Lake Enhancement, Technical Appendices,” U.S. Army Corps of Engineers, Rock Island, IL.

USACE (1990), “Engineer Manual EM 1110-1-1904 Settlement Analysis,” U.S. Army Corps of Engineers, Washington, DC.

USACE (1987), “Engineer Manual EM 1110-2-5027: Confined Disposal of Dredged Material,” U.S. Army Corps of Engineers, Washington, DC.

CEMVS (1994), “Pool 8 Enhancement, Technical Appendices,” U.S. Army Corps of Engineers, St. Paul, MN.

NAVFAC (1986), “Soil Mechanics,” Naval Facilities Engineering Command, Alexandria, VA.

Fowler, J., Sprague, C. J., and Toups, D. (2001). “Dredged Material-Filled Geotextile Containers, Environmental Effects of Dredging Technical Notes,” U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Burch, S. (2001). “Groundwater Conditions in the Vicinity of Solwedel and Worley Lakes,” Illinois State Water Survey, Groundwater Section, Champaign, IL.

Bhowmik, N. and Slowikowski, J.A. (2001). "Soldwedel and Worley Lakes: Topographic Features and Preliminary Sediment Characteristics," Illinois State Water Survey, Watershed Science Section, Champaign, IL.

Powers, J. (1992), Construction Dewatering, Wiley & Sons, New York, NY.

Bureau of Reclamation, 1978. Drainage Manual. A Water Resources Technical Publication, First Edition, U.S. Department of Interior, Washington, D.C.

Cartwright, K., Krapac, I.G., Panno, S. Herzog, B., Hensel, B., and K. Rehfeld, 1990. Field Study of Transit Time Through Compacted Clays. Interim Annual Report July 1, 1989 to June 30, 1990. Illinois State Geological Survey Open File Series 1990-11, Champaign, IL.

Hollinger, S.E., Wehrmann, H.E., Olson, R.D., Scott, R.W., and R. Xia, 1999. Operation of Rain Gauge and Ground-Water Monitoring Networks for the Imperial Valley Water Authority. Illinois State Water Survey Contract Report 646, Champaign, IL.

Horberg, L., Suter, M, and T.E. Larson, 1950. Groundwater in the Peoria Region. Illinois State Water Survey Bulletin 39 and also as Illinois State Geological Survey Bulletin 75, Champaign, IL.

Marino, M.A. and R.J. Schicht, 1969. Groundwater Levels and Pumpage in the Peoria-Pekin Area, Illinois, 1890-1966. Illinois State Water Survey Report of Investigation 61, Champaign, IL.

Suter, M. 1959. Artificial Ground Water Recharge at Peoria, Illinois. Transactions of the Illinois Academy of Science, vol.52, nos. 3 and 4.

Schroeder, P.R. SETTLE – Confined Disposal Facility (CDF) Design Model (ver 3.0). Environmental Laboratory, Waterways Experiment Station, Vicksburg, MS.

Hayes, D.F., and Schroeder, P.R., 1992. Documentation of the SETTLE Retention and Initial Storage, Technical Note EEDP-06-18. U.S. Army Waterways Experiment Station, Vicksburg, MS.

Thackston, E.L., Palermo, M.R., and Schroeder, P.R., 1988. Refinement and simplification of Column Settling Tests for Design of Dredged Material Confinement Areas, Technical Note EEDP-02-5. U.S. Army Waterways Experiment Station, Vicksburg, MS.